Pine Hill Public Schools Curriculum			
Content Area:	Science		
Course Title/ Grade Level:	AP Physics 2 / Gr. 11 & 12		
Unit 1:	Electrostatics	Duration:	7 week
Unit 2:	Electric Circuits	Duration:	2 week
	Benchmark Exam #1	Duration:	1 day (Administered on the 9th instructional Week)
Unit 2:	Electric Circuits	Duration:	3 week
Unit 3:	Magnetism and Electromagnetic Induction	Duration:	5 weeks
Unit 4:	Thermodynamics	Duration:	1 weeks
	Benchmark Exam #2	Duration:	1 day (Administered on the 18th instructional Week)
Unit 4:	Thermodynamics	Duration:	3 weeks
Unit 5:	Fluids	Duration:	2 weeks
Unit 6:	Geometric and Physical Optics	Duration:	4 weeks
	Benchmark Exam #3	Duration:	1 day (Administered on the 27th instructional Week)
Unit 6:	Geometric and Physical Optics	Duration:	2 weeks
Unit 7:	Quantum, Atomic, and Nuclear Physics	Duration:	6 week
Unit 8	Astrophysics and Cosmology	Duration:	2.5 week
Unit 9	Final Project	Duration:	2.5 week
	Benchmark Exam #4	Duration:	3 day (Administered on the 36th instructional Week)
BOE Approved date:	06/29/16		

<table>
<tr><td colspan="4">Pine Hill Public Schools Science Curriculum</td></tr>
<tr><td colspan="3">Unit Title: Electrostatics (Ch's16,17)</td><td>Unit #1</td></tr>
<tr><td colspan="3">Course or Grade Level: AP Physics 2</td><td>Length of Time: 7 weeks</td></tr>
<tr><td>NGSS Performance Expectations (PE's)</td><td colspan="3">
- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
- HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
- HS-PS1-3. 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.
- 2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
- HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
- HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
- HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
- HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
- HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.
- HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
- HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
- HS-PS4-5. 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.*
</td></tr>
<tr><td colspan="2">Cross Cutting Concepts</td><td colspan="2">Science and Engineering Practices</td></tr>
<tr><td colspan="2">☒Patterns
☒Cause and Effect
☒Scale, Proportion, and Quantity
☒Systems and Systems Models</td><td colspan="2">☒Asking questions and defining problems
☒Developing and using models
☒Planning and carrying out investigations
☒Analyzing and interpreting data</td></tr>
</table>

☐Energy and Matter in Systems ☐Structure and Function ☐Stability and Change in Systems Nature of Science (NOS) ☒NOS-Science is a Way of Knowing ☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems ☒NOS-Science is a Human Endeavor ☒NOS-Science Addresses Questions About the Natural and Material World	☒Using mathematics and computational thinking ☒Constructing explanations and designing solutions ☐Engaging in argument from evidence ☒Obtaining, evaluating, and communicating information Nature of Science (NOS) ☒Scientific Investigations Use a Variety of Methods ☒Scientific Knowledge is Based on Empirical Evidence ☒Scientific Knowledge is Open to Revision in Light of New Evidence ☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Content	- Static Electricity; Electric Charge and Its Conservation - Electric Charge in the Atom - Insulators and Conductors - Induced Charge; the Electroscope - Coulomb's Law - Solving Problems Involving Coulomb's Law and Vectors - The Electric Field - Electric Field Lines - Electric Fields and Conductors - Electric Forces in Molecular Biology: - Photocopy Machines and Computer Printers Use Electrostatics - Gauss's Law - Electric Potential Energy and - Potential Difference - Relation between Electric Potential - and Electric Field - Equipotential Lines and Surfaces - The Electron Volt, a Unit of Energy - Electric Potential Due to Point Charges - Potential Due to Electric Dipole Dipole Moment - Capacitance - Dielectrics - Storage of Electric Energy - Digital; Binary Numbers, Signal Voltage - TV and Computer Monitors: CRTs, Flat Screens - Electrocardiogram (ECG or EKG)
Skills	- BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure. - 1.B.1.1: The student is able to make claims about natural phenomena based on conservation of electric charge. [SP 6.4] - 1.B.1.2: The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. [SP 6.4, 7.2] - 1.B.2.2: The student is able to make a qualitative prediction about the distribution of positive and negative electric charges within neutral systems as they undergo various processes. [SP 6.4, 7.2] - 1.B.2.3: The student is able to challenge claims that polarization of electric charge or separation of charge must result in a net charge on the object. [SP6.1]

	- 1.B.3.1: The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated. [SP 1.5, 6.1, 7.2] - BIG IDEA 2: Fields existing in space can be used to explain interactions. - 2.C.1.1: The student is able to predict the direction and the magnitude of the force exerted on an object with an electric charge q placed in an electric field E using the mathematical model of the relation between an $F = q E$ - electric force and an electric field: F = q E ; a vector relation.[SP 6.4, 7.2] - 2.C.1.2: The student is able to calculate any one of the variables — electric force, electric charge, and electric field — at a point given the values and sign or direction of the other two quantities.[SP 2.2] - 2.C.2.1: The student is able to qualitatively and semi-quantitatively apply the vector relationship between the electric field and the net electric charge creating that field. [SP 2.2, 6.4] - 2.C.3.1: The student is able to explain the inverse square dependence of the electric field surrounding a spherically symmetric electrically charged object. [SP 6.2] - 2.C.4.1: The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semiquantitative arguments based on vector addition of fields due to each point source, including identifying the locations and signs of sources from a vector diagram of the field. [SP 2.2, 6.4, 7.2] - 2.C.4.2: The student is able to 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. [SP 1.4, 2.2] - 2.C.5.1: The student is able to create representations of the magnitude and direction of the electric field at various distances (small compared to plate size) from two electrically charged plates of equal magnitude and opposite signs, and is able to recognize that the assumption of uniform field is not appropriate near edges of plates. [SP 1.1, 2.2] - 2.C.5.2: The student is able to 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. [SP 2.2] - 2.C.5.3: The student is able to represent the motion of an electrically charged particle in the uniform field between two oppositely charged plates and express the connection of this motion to projectile motion of an object with mass in the Earth's gravitational field. [SP 1.1, 2.2, 7.1] - 2.E.1.1: The student is able to construct or interpret visual representations of the isolines of equal gravitational potential energy per unit mass and refer to each line as a gravitational equipotential. [SP 1.4, 6.4, 7.2] - 2.E.2.1: The student is able to determine the structure of isolines of electric potential by constructing them in a given electric field. [SP 6.4, 7.2] - 2.E.2.2: The student is able to predict the structure of isolines of electric potential by constructing them in a given electric field and make

	connections between these isolines and those found in a gravitational field. [SP 6.4, 7.2] - 2.E.2.3: The student is able to qualitatively use the concept of isolines to construct isolines of electric potential in an electric field and determine the effect of that field on electrically charged objects. [SP 1.4] - 2.E.3.1: The student is able to apply mathematical routines to calculate the average value of the magnitude of the electric field in a region from a description of the electric potential in that region using the displacement along the line on which the difference in potential is evaluated. [SP 2.2] - 2.E.3.2: The student is able to apply the concept of the isoline representation of electric potential for a given electric charge distribution to predict the average value of the electric field in the region. [SP 1.4, 6.4] - BIG IDEA 3: The interactions of an object with other objects can be described by forces. - 3.A.2.1: The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [SP 1.1] - 3.A.3.2: The student is able to challenge a claim that an object can exert a force on itself. [SP 6.1] - 3.A.3.3: The student is able to describe a force as an interaction between two objects and identify both objects for any force. [SP 1.4] - 3.A.3.4: The student is able to make claims about the force on an object due to the presence of other objects with the same property: mass, electric charge. [SP 6.1, 6.4] - 3.A.4.1: The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. [SP 1.4, 6.2] - 3.A.4.2: The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [SP 6.4, 7.2] - 3.A.4.3: The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. [SP 1.4] - 3.B.1.3: The student is able to reexpress a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. [SP 1.5, 2.2] - 3.B.1.4: The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations. [SP 6.4, 7.2] - 3.B.2.1: The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. [SP 1.1, 1.4, 2.2] - LO 3.C.2.1: The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges. [SP 2.2, 6.4] - 3.C.2.2: The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [SP 7.2] - 3.C.2.3: The student is able to use mathematics to describe the electric force that results from the interaction of several separated point charges (generally 2 to 4 point charges, though more are permitted in situations of high symmetry). [SP 2.2]

	- 3.G.1.2: The student is able to connect the strength of the gravitational force between two objects to the spatial scale of the situation and the masses of the objects involved and compare that strength to other types of forces. [SP 7.1] - LO 3.G.2.1: The student is able to connect the strength of electromagnetic forces with the spatial scale of the situation, the magnitude of the electric charges, and the motion of the electrically charged objects involved. [SP 7.1] - BIG IDEA 4: Interactions between systems can result in changes in those systems. - 4.E.3.1: The student is able to make predictions about the redistribution of charge during charging by friction, conduction, and induction. [SP 6.4] - 4.E.3.2: The student is able to make predictions about the redistribution of charge caused by the electric field due to other systems, resulting in charged or polarized objects. [SP 6.4, 7.2] - 4.E.3.3: The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors. [SP 1.1, 1.4, 6.4] - 4.E.3.4: The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors that predicts charge distribution in processes involving induction or conduction. [SP 1.1, 1.4, 6.4] - 4.E.3.5: The student is able to plan and/or analyze the results of experiments in which electric charge rearrangement occurs by electrostatic induction, or is able to refine a scientific question relating to such an experiment by identifying anomalies in a data set or procedure. [SP 3.2, 4.1, 4.2, 5.1, 5.3] - BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws. - 5.A.2.1: The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [SP 6.4, 7.2] - 5.B.2.1: The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system. [SP 1.4, 2.1] - 5.C.2.1: The student is able to predict electric charges on objects within a system by application of the principle of charge conservation within a system. [SP 6.4] - 5.C.2.2: The student is able to design a plan to collect data on the electrical charging of objects and electric charge induction on neutral objects and qualitatively analyze that data. [SP 4.2, 5.1] - 5.C.2.3: The student is able to justify the selection of data relevant to an investigation of the electrical charging of objects and electric charge induction on neutral objects. [SP 4.1]
Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly Project Grade

Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study
Lesson resources/Activities	- Hands on activities - Chapter study guides - Oral presentation of chapter concepts - Laboratory exercises related to subject matter • Electric Forces: Straws and Pens • Electric Charges: Charges and Sticky Tape • An Electrostatics Puzzler • Research based labs created by students (Once a week project day) • Van de Graff Generator Demonstrations • Electroscope Investigation • Creating Qualitative-Prediction Questions • Coulomb's Law Investigation • Solving Electric Force Problems • Electric Field Simulations • Electric Field Mapping • Electric Field Between Parallel Plates • Electric Potential • Analyzing Equipotential Lines • Equipotential Mapping Investigation • Point Charges

Pine Hill Public Schools Science Curriculum	
Unit Title: Electric Circuits (Ch's 18 & 19)	Unit #2
Course or Grade Level: AP Physics 2	Length of Time: 5 weeks
NGSS Performance Expectations (PE's)	- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. - HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. - HS-PS1-3. 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. - HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. - HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. - 2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. - HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. - HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. - HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. - HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* - HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. - HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). - HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* - HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

	- HS-PS4 Waves and their Applications in Technologies for Information Transfer - HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. - HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. - HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. - HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. - HS-PS4-5. 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.*

Cross Cutting Concepts	Science and Engineering Practices
☒Patterns ☒Cause and Effect ☒Scale, Proportion, and Quantity ☒Systems and Systems Models ☐Energy and Matter in Systems ☐Structure and Function ☐Stability and Change in Systems Nature of Science (NOS) ☒NOS-Science is a Way of Knowing ☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems ☒NOS-Science is a Human Endeavor ☒NOS-Science Addresses Questions About the Natural and Material World	☒Asking questions and defining problems ☒Developing and using models ☒Planning and carrying out investigations ☒Analyzing and interpreting data ☒Using mathematics and computational thinking ☒Constructing explanations and designing solutions ☐Engaging in argument from evidence ☒Obtaining, evaluating, and communicating information Nature of Science (NOS) ☒Scientific Investigations Use a Variety of Methods ☒Scientific Knowledge is Based on Empirical Evidence ☒Scientific Knowledge is Open to Revision in Light of New Evidence ☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Content	- The Electric Battery - Electric Current - Ohm's Law: Resistance and Resistors - Resistivity - Electric Power - Power in Household Circuits - Alternating Current - Microscopic View of Electric Current - Superconductivity - Electrical Conduction in the Human Nervous System - EMF and Terminal Voltage - Resistors in Series and in Parallel - Kirchhoff's Rules - EMFs in Series and in Parallel; - Charging a Battery

	- Circuits Containing Capacitors in Series and in Parallel - RC Circuits—Resistor and Capacitor in Series - Electric Hazards - Ammeters and Voltmeters—Measurement Affects the Quantity Being Measured
Skills/Learning Objectives	- BIG IDEA 4: Interactions between systems can result in changes in those systems. - 4.E.4.1: The student is able to make predictions about the properties of resistors and/or capacitors when placed in a simple circuit, based on the geometry of the circuit element and supported by scientific theories and mathematical relationships. [SP 2.2, 6.4] - 4.E.4.2: The student is able to design a plan for the collection of data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors. [SP 4.1, 4.2] - 4.E.4.3: The student is able to analyze data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors. [SP 5.1] - 4.E.5.1: The student is able to make and justify a quantitative prediction of the effect of a change in values or arrangements of one or two circuit elements on the currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel. [SP 2.2, 6.4] - BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws. - 5.B.9.4: The student is able to analyze experimental data including an analysis of experimental uncertainty that will demonstrate the validity of Kirchhoff's loop rule.[SP 5.1] - 5.B.9.5: The student is able to use conservation of energy principles (Kirchhoff's loop rule) to describe and make predictions regarding electrical potential difference, charge, and current in steady-state circuits composed of various combinations of resistors and capacitors. [SP 6.4] - 5.B.9.6: The student is able to mathematically express the changes in electric potential energy of a loop in a multiloop electrical circuit and justify this expression using the principle of the conservation of energy. [SP 2.1, 2.2] - 5.B.9.7: The student is able to refine and analyze a scientific question for an experiment using Kirchhoff's Loop rule for circuits that includes determination of internal resistance of the battery and analysis of a non-ohmic resistor. [SP 4.1, 4.2, 5.1, 5.3] - 5.B.9.8: The student is able to translate between graphical and symbolic representations of experimental data describing relationships among power, current, and potential difference across a resistor. [SP 1.5] - 5.C.3.4: The student is able to predict or explain current values in series and parallel arrangements of resistors and other

	branching circuits using Kirchhoff's junction rule and relate the rule to the law of charge conservation. [SP 6.4, 7.2] - 5.C.3.5: The student is able to determine missing values and direction of electric current in branches of a circuit with resistors and NO capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule. [SP 1.4, 2.2] - 5.C.3.6: The student is able to determine missing values and direction of electric current in branches of a circuit with both resistors and capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule. [SP 1.4, 2.2] - 5.C.3.7: The student is able to determine missing values, direction of electric current, charge of capacitors at steady state, and potential differences within a circuit with resistors and capacitors from values and directions of current in other branches of the circuit. [SP 1.4, 2.2]
Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly Projects
Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study
Lesson resources/Activities	- Hands on activities - Laboratory exercises related to subject matter • Resistance and Resistivity Investigation • Capacitor Lab • DC Circuits and Brightness Investigation • DC Circuits Simulation • DC Circuits and Resistors Investigation • Kirchhoff's Loop and Junction Rules • RC Circuit Investigation - Chapter study guides - Oral presentation of chapter concepts

<table>
<tr><td colspan="3">Pine Hill Public Schools Science Curriculum</td></tr>
<tr><td colspan="2">Unit Title: Magnetism and Electromagnetic Induction (Ch’s 20,21,&22)</td><td>Unit #3</td></tr>
<tr><td colspan="2">Course or Grade Level: AP Physics 2</td><td>Length of Time: 5 weeks</td></tr>
<tr><td>NGSS Performance Expectations (PE’s)</td><td colspan="2">
- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
- HS-PS1-3. 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.
- 2-1. Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
- HS-PS2-4. Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects.
- HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
- HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*
- HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*
- HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
- HS-PS4 Waves and their Applications in Technologies for Information Transfer
- HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.
- HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
</td></tr>
</table>

	- HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. - HS-PS4-5. 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.*

Cross Cutting Concepts	Science and Engineering Practices
☒Patterns ☒Cause and Effect ☒Scale, Proportion, and Quantity ☐Systems and Systems Models ☐Energy and Matter in Systems ☐Structure and Function ☐Stability and Change in Systems Nature of Science (NOS) ☒NOS-Science is a Way of Knowing ☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems ☒NOS-Science is a Human Endeavor ☒NOS-Science Addresses Questions About the Natural and Material World	☒Asking questions and defining problems ☒Developing and using models ☒Planning and carrying out investigations ☒Analyzing and interpreting data ☒Using mathematics and computational thinking ☒Constructing explanations and designing solutions ☒Engaging in argument from evidence ☒Obtaining, evaluating, and communicating information Nature of Science (NOS) ☒Scientific Investigations Use a Variety of Methods ☒Scientific Knowledge is Based on Empirical Evidence ☒Scientific Knowledge is Open to Revision in Light of New Evidence ☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Content	
	- Magnets and Magnetic Fields - Electric Currents Produce Magnetic Fields - Force on an Electric Current in a Magnetic Field; Definition of B - Force on an Electric Charge Moving in a Magnetic Field - Magnetic Field Due to a Long Straight Wire - Force between Two Parallel Wires - Solenoids and Electromagnets - Ampere's Law - Torque on a Current Loop; - Magnetic Moment - Applications: Motors, Loudspeakers, Galvanometers - Mass Spectrometer - Ferromagnetism: Domains and Hysteresis - Induced EMF - Faraday's Law of Induction; Lenz's Law - EMF Induced in a Moving Conductor - Changing Magnetic Flux Produces an Electric Field - Electric Generators - Back EMF and Counter Torque; - Eddy Currents - Transformers and Transmission of Power - Information Storage: Magnetic and Semiconductor; Tape, Hard Drive, RAM - Applications of Induction: Microphone, Seismograph, GFCI - Inductance - Energy Stored in a Magnetic Field

	- LR Circuit - AC Circuits and Reactance - LRC Series AC Circuit - Resonance in AC Circuits - Changing Electric Fields Produce Magnetic Fields; Maxwell's Equations - Production of Electromagnetic Waves - Light as an Electromagnetic Wave and the Electromagnetic Spectrum - Measuring the Speed of Light - Energy in EM Waves - Momentum Transfer and Radiation Pressure - Radio and Television; Wireless Communication
Skills/Learning Objectives	- BIG IDEA 2: Fields existing in space can be used to explain interactions. - 2.C.4.1: The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semi-quantitative arguments based on vector addition of fields due to each point source, including identifying the locations and signs of sources from a vector diagram of the field. [SP 2.2, 6.4, 7.2] - 2.D.1.1: The student is able to apply mathematical routines to express the force exerted on a moving charged object by a magnetic field. [SP 2.2] - 2.D.2.1: The student is able to create a verbal or visual representation of a magnetic field around a long straight wire or a pair of parallel wires. [SP 1.1] - 2.D.3.1: The student is able to describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet. [SP 1.2] - BIG IDEA 3: The interactions of an object with other objects can be described by forces. - 3.A.2.1: The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [SP 1.1] - 3.A.3.2: The student is able to challenge a claim that an object can exert a force on itself. [SP 6.1] - 3.A.3.3: The student is able to describe a force as an interaction between two objects and identify both objects for any force. [SP 1.4] - 3.A.4.1: The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. [SP 1.4, 6.2] - 3.A.4.2: The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [SP 6.4, 7.2]

	- 3.A.4.3: The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. [SP 1.4] - 3.C.3.1: The student is able to 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. [SP 1.4] - 3.C.3.2: The student is able to plan a data collection strategy appropriate to an investigation of the direction of the force on a moving electrically charged object caused by a current in a wire in the context of a specific set of equipment and instruments and analyze the resulting data to arrive at a conclusion. [SP 4.2, 5.1] - BIG IDEA 4: Interactions between systems can result in changes in those systems. - 4.E.1.1: The student is able to use representations and models to qualitatively describe the magnetic properties of some materials that can be affected by magnetic properties of other objects in the system. [SP 1.1, 1.4, 2.2] - 4.E.2.1: The student is able to 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. [SP 6.4]
Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly projects
Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study

Lesson resources/Activities	- Hands on activities
	- Laboratory exercises related to subject matter
	  • Visualizing Magnetism
	  • Magnet and Compass Simulation
	  • Earth's Magnetic Field Investigation
	  • Magnetic Force on a Current-Carrying Wire Investigation
	  • Magnetic Fields
	  • Magnetic Flux
	  • Electromagnetic Induction Investigation
	- Chapter study guides
	- Oral presentation of chapter concepts

Pine Hill Public Schools Science Curriculum		
Unit Title: Thermodynamics (Ch's 13,14,&15)		Unit #4
Course or Grade Level: AP Physics 1		Length of Time: 4 weeks
NGSS Performance Expectations (PE's)	- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. - HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. - HS-PS2 Motion and Stability: Forces and Interactions - 2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship amongthe net force on a macroscopic object, its mass, and its acceleration. - HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. - HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* - HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. - HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* - HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). - HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*	

<table>
<tr><td></td><td colspan="2">

- HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
- HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
- HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

</td></tr>
<tr><td colspan="2">Cross Cutting Concepts</td><td>Science and Engineering Practices</td></tr>
<tr><td colspan="2">☒Patterns
☒Cause and Effect
☒Scale, Proportion, and Quantity
☒Systems and Systems Models
☒Energy and Matter in Systems
☒Structure and Function
☐Stability and Change in Systems

Nature of Science (NOS)
☒NOS-Science is a Way of Knowing
☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems
☒NOS-Science is a Human Endeavor
☒NOS-Science Addresses Questions About the Natural and Material World</td><td>☒Asking questions and defining problems
☒Developing and using models
☒Planning and carrying out investigations
☒Analyzing and interpreting data
☒Using mathematics and computational thinking
☒Constructing explanations and designing solutions
☒Engaging in argument from evidence
☒Obtaining, evaluating, and communicating information

Nature of Science (NOS)
☒Scientific Investigations Use a Variety of Methods
☒Scientific Knowledge is Based on Empirical Evidence
☒Scientific Knowledge is Open to Revision in Light of New Evidence
☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</td></tr>
<tr><td>Content</td><td colspan="2">

- Atomic Theory of Matter
- Temperature and Thermometers
- Thermal Equilibrium and the Zeroth Law of Thermodynamics
- Thermal Expansion
- The Gas Laws and Absolute Temperature
- The Ideal Gas Law
- Problem Solving with the Ideal Gas Law
- Ideal Gas Law in Terms of Molecules: Avogadro's Number
- Kinetic Theory and the Molecular Interpretation of Temperature
- Distribution of Molecular Speeds
- Real Gases and Changes of Phase
- Vapor Pressure and Humidity
- Diffusion
- HEAT
- Heat as Energy Transfer
- Internal Energy

</td></tr>
</table>

	- Specific Heat - Calorimetry—Solving Problems - Latent Heat - Heat Transfer: Conduction - Heat Transfer: Convection - Heat Transfer: Radiation - The First Law of Thermodynamics - Thermodynamic Processes and - the First Law - Human Metabolism and the First Law - The Second Law of - Thermodynamics—Introduction - Heat Engines - Refrigerators, Air Conditioners, and - Heat Pumps - Entropy and the Second Law of - Thermodynamics - Order to Disorder - Unavailability of Energy; Heat Death - Statistical Interpretation of Entropy - and the Second Law - Thermal Pollution, Global Warming, and Energy Resources
Skills/Learning Objectives	- BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws. - 5.A.2.1: The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [SP 6.4, 7.2] - 5.B.4.1: The student is able to describe and make predictions about the internal energy of systems. [SP 6.4, 7.2] - 5.B.4.2: The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. [SP 1.4, 2.1, 2.2] - 5.B.5.4: The student is able to make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy). [SP 6.4, 7.2] - 5.B.5.5: The student is able to predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance. [SP 2.2, 6.4] - 5.B.5.6: The student is able to design an experiment and analyze graphical data in which interpretations of the area under a pressure-volume curve are needed to determine the work done on or by the object or system. [SP 4.2, 5.1] - 5.B.6.1: The student is able to 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. [SP 1.2] - 5.B.7.1: The student is able to 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. [SP 6.4, 7.2] - 5.B.7.2: The student is able to create a plot of pressure versus volume for a thermodynamic process from given data. [SP 1.1] - 5.B.7.3: The student is able to use a 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). [SP 1.1, 1.4, 2.2] - BIG IDEA 7: The mathematics of probability can be used to describe the behavior of complex systems and to interpret the behavior of quantum mechanical systems. - 7.A.1.1: The student is able to make claims about how the pressure of an ideal gas is connected to the force exerted by molecules on the walls of the container, and how changes in pressure affect the thermal equilibrium of the system. [SP 6.4, 7.2] - 7.A.1.2: Treating a gas molecule as an object (i.e., ignoring its internal structure), the student is able to analyze qualitatively the collisions with a container wall and determine the cause of pressure, and at thermal equilibrium, to quantitatively calculate the pressure, force, or area for a thermodynamic problem given two of the variables. [SP 1.4, 2.2] - 7.A.2.1: The student is able to qualitatively connect the average of all kinetic energies of molecules in a system to the temperature of the system. [SP 7.1] - 7.A.2.2: The student is able to connect the statistical distribution of microscopic kinetic energies of molecules to the macroscopic temperature of the system and to relate this to thermodynamic processes. [SP 7.1] - 7.A.3.1: The student is able to extrapolate from pressure and temperature or volume and temperature data to make the prediction that there is a temperature at which the pressure or volume extrapolates to zero. [SP - 6.4, 7.2] - 7.A.3.2: The student is able to design a plan for collecting data to determine the relationships between pressure, volume, and temperature, and amount of an ideal gas, and to refine a scientific question concerning a proposed incorrect relationship between the variables. [SP 3.2, 4.2] - 7.A.3.3: The student is able to analyze graphical representations of macroscopic variables for an ideal gas to determine the relationships between these variables and to ultimately determine the ideal gas law PV = nRT. [SP 5.1] - 7.B.1.1: The student is able to extrapolate from pressure and temperature or volume and temperature data to make the prediction that there is a temperature at which the pressure or volume extrapolates to zero. [SP - 6.4, 7.2] - 7.B.2.1: The student is able to connect qualitatively the second law of thermodynamics in terms of the state function called entropy and how it (entropy) behaves in reversible and irreversible processes. [SP 7.1]

Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly projects
Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study
Lesson resources/Activities	- Hands on activities - Laboratory exercises related to subject matter • Gas Laws Investigation • Kinetic Theory of Matter • Thermal Conductivity Investigation • Introduction to P–V Diagrams • Heat Engine Investigation • Introduction to the Second Law of Thermodynamics - Chapter study guides - Oral presentation of chapter concepts

Pine Hill Public Schools Science Curriculum	
Unit Title: Fluids	Unit #5
Course or Grade Level: AP Physics 2	Length of Time: 2 weeks
NGSS Performance Expectations (PE's)	- HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. - 2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. - HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. - HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* - HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. - HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). - HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a

	closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Cross Cutting Concepts	Science and Engineering Practices
☒Patterns ☒Cause and Effect ☒Scale, Proportion, and Quantity ☒Systems and Systems Models ☐Energy and Matter in Systems ☐Structure and Function ☐Stability and Change in Systems Nature of Science (NOS) ☒NOS-Science is a Way of Knowing ☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems ☒NOS-Science is a Human Endeavor ☒NOS-Science Addresses Questions About the Natural and Material World	☒Asking questions and defining problems ☒Developing and using models ☒Planning and carrying out investigations ☒Analyzing and interpreting data ☒Using mathematics and computational thinking ☒Constructing explanations and designing solutions ☐Engaging in argument from evidence ☒Obtaining, evaluating, and communicating information Nature of Science (NOS) ☒Scientific Investigations Use a Variety of Methods ☒Scientific Knowledge is Based on Empirical Evidence ☒Scientific Knowledge is Open to Revision in Light of New Evidence ☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Content	- Phases of Matter - Density and Specific Gravity - Pressure in Fluids - Atmospheric Pressure and - Gauge Pressure - Pascal's Principle - Measurement of Pressure; - Gauges and the Barometer - Buoyancy and Archimedes' Principle - Fluids in Motion; Flow Rate and - the Equation of Continuity - Bernoulli's Equation - Applications of Bernoulli's Principle: - Torricelli, Airplanes, Baseballs, - Blood Flow - Viscosity - Flow in Tubes: Poiseuille's Equation, - Blood Flow - Surface Tension and Capillarity - Pumps, and the Heart
Skills/Learning Objectives	- BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure. - 1.E.1.1: The student is able to predict the densities, differences in densities, or changes in densities under different conditions for natural phenomena and design an investigation to verify the prediction. [SP 4.2, 6.4] - 1.E.1.2: The student is able to select from experimental data the information necessary to determine the density of an object and/or compare densities of several objects. [SP 4.1, 6.4]

	- BIG IDEA 3: The interactions of an object with other objects can be described by forces. - 3.C.4.1: The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces. [SP 6.1] - 3.C.4.2: The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. [SP 6.2] - BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws. - 5.B.10.1: The student is able to use Bernoulli's equation to make calculations related to a moving fluid. [SP 2.2] - 5.B.10.2: The student is able to use Bernoulli's equation and/or the relationship between force and pressure to make calculations related to a moving fluid. [SP 2.2] - 5.B.10.3: The student is able to use Bernoulli's equation and the continuity equation to make calculations related to a moving fluid. [SP 2.2] - 5.B.10.4: The student is able to construct an explanation of Bernoulli's equation in terms of the conservation of energy. [SP 6.2] - 5.F.1.1: The student is able to make calculations of quantities related to flow of a fluid, using mass conservation principles (the continuity equation). [SP 2.1, 2.2, 7.2]
Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly projects
Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study

Lesson resources/Activities	- Hands on activities
	- Laboratory exercises related to subject matter
	  • Archimedes' Principle InvestigationCircular motion lab
	  • Research Presentation
	  • Torricelli's Theorem Investigation
	  • Ideal Fluid Flow
	  • Water Fountain Investigation
	- Chapter study guides
	- Oral presentation of chapter concepts

Pine Hill Public Schools Science Curriculum	
Unit Title: Geometric and Physical Optics (Ch's 23,24,&25)	Unit #6
Course or Grade Level: AP Physics 2	Length of Time: 6 weeks
NGSS Performance Expectations (PE's)	- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. - HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. - 2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. - HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. - HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* - HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. - HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. - HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* - HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. - HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). - HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* - HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. - HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. - HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

	- HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. - HS-PS4-5. 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.*

Cross Cutting Concepts	Science and Engineering Practices
☒Patterns ☒Cause and Effect ☒Scale, Proportion, and Quantity ☒Systems and Systems Models ☒Energy and Matter in Systems ☒Structure and Function ☒Stability and Change in Systems Nature of Science (NOS) ☒NOS-Science is a Way of Knowing ☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems ☒NOS-Science is a Human Endeavor ☒NOS-Science Addresses Questions About the Natural and Material World	☒Asking questions and defining problems ☒Developing and using models ☒Planning and carrying out investigations ☒Analyzing and interpreting data ☒Using mathematics and computational thinking ☒Constructing explanations and designing solutions ☐Engaging in argument from evidence ☒Obtaining, evaluating, and communicating information Nature of Science (NOS) ☒Scientific Investigations Use a Variety of Methods ☒Scientific Knowledge is Based on Empirical Evidence ☒Scientific Knowledge is Open to Revision in Light of New Evidence ☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Content	- The Ray Model of Light - Reflection; Image Formation by a - Plane Mirror - Formation of Images by Spherical - Mirrors - Index of Refraction - Refraction: Snell's Law - Total Internal Reflection; Fiber Optics - Thin Lenses; Ray Tracing - The Thin Lens Equation - Combinations of Lenses - Lensmaker's Equation - Waves vs. Particles; Huygens' Principle - and Diffraction - Huygens' Principle and the Law of - Refraction - Interference—Young's Double-Slit - Experiment - The Visible Spectrum and Dispersion - Diffraction by a Single Slit or Disk - Diffraction Grating - The Spectrometer and Spectroscopy - Interference in Thin Films - Michelson Interferometer - Polarization - Liquid Crystal Displays (LCD)

	- Scattering of Light by the Atmosphere - Cameras: Film and Digital - The Human Eye; Corrective Lenses - Magnifying Glass - Telescopes - Compound Microscope - Aberrations of Lenses and Mirrors - Limits of Resolution; Circular Apertures - Resolution of Telescopes and Microscopes; the A Limit - Resolution of the Human Eye and Useful Magnification - Specialty Microscopes and Contrast - X-Rays and X-Ray Diffraction - Ray Imaging and Computed - Tomography (CT Scan)
Skills/Learning Objectives	- BIG IDEA 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena. - 6.A.1.2: The student is able to describe representations of transverse and longitudinal waves. [SP 1.2] - 6.A.1.3: The student is able to analyze data (or a visual representation) to identify patterns that indicate that a particular mechanical wave is polarized and construct an explanation of the fact that the wave must have a vibration perpendicular to the direction of energy propagation. [SP 5.1, 6.2] - 6.A.2.2: The student is able to contrast mechanical and electromagnetic waves in terms of the need for a medium in wave propagation. [SP 6.4, 7.2] - 6.B.3.1: The student is able to construct an equation relating the wavelength and amplitude of a wave from a graphical representation of the electric or magnetic field value as a function of position at a given time instant and vice versa, or construct an equation relating the frequency or period and amplitude of a wave from a graphical representation of the electric or magnetic field value at a given position as a function of time and vice versa. [SP 1.5] - 6.C.1.1: The student is able to make claims and predictions about the net disturbance that occurs when two waves overlap. Examples should include standing waves. [SP 6.4, 7.2] - 6.C.1.2: The student is able to construct representations to graphically analyze situations in which two waves overlap over time using the principle of superposition. [SP 1.4] - 6.C.2.1: The student is able to make claims about the diffraction pattern produced when a wave passes through a small opening, and to qualitatively apply the wave model to quantities that describe the generation - of a diffraction pattern when a wave passes through an opening whose dimensions are comparable to the wavelength of the wave. [SP 1.4, 6.4, 7.2]

	- 6.C.3.1: The student is able to qualitatively apply the wave model to quantities that describe the generation of interference patterns to make predictions about interference patterns that form when waves pass through a set of openings whose spacing and widths are small compared to the wavelength of the waves. [SP 1.4, 6.4] - 6.C.4.1: The student is able to predict and explain, using representations and models, the ability or inability of waves to transfer energy around corners and behind obstacles in terms of the diffraction property of waves in situations involving various kinds of wave phenomena, including sound and light. [SP 6.4, 7.2] - 6.E.1.1: The student is able to 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. [SP 6.4, 7.2] - 6.E.2.1: The student is able to make predictions about the locations of object and image relative to the location of a reflecting surface. The prediction should be based on the model of specular reflection with all angles measured relative to the normal to the surface. [SP 6.4, 7.2] - 6.E.3.1: The student is able to describe models of light traveling across a boundary from one transparent material to another when the speed of propagation changes, causing a change in the path of the light ray at the boundary of the two media. [SP 1.1, 1.4] - 6.E.3.2: The student is able to 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). [SP 4.1, 5.1, 5.2, 5.3] - 6.E.3.3: The student is able to make claims and predictions about path changes for light traveling across a boundary from one transparent material to another at non-normal angles resulting from changes in the speed of propagation. [SP 6.4, 7.2] - LO 6.E.4.1: The student is able to plan data collection strategies, and perform data analysis and evaluation of evidence about the formation of images due to reflection of light from curved spherical mirrors. [SP 3.2, 4.1, 5.1, 5.2, 5.3] - LO 6.E.4.2: The student is able to 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. [SP 1.4, 2.2] - LO 6.E.5.1: The student is able to 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. [SSP 1.4, 2.2] - LO 6.E.5.2: The student is able to plan data collection strategies, perform data analysis and evaluation of evidence, and refine scientific questions about the formation of images due to refraction for thin lenses. [SP 3.2, 4.1, 5.1, 5.2, 5.3]

	- 6.F.1.1: The student is able to make qualitative comparisons of the wavelengths of types of electromagnetic radiation. [SP 6.4, 7.2] - 6.F.2.1: The student is able to describe representations and models of electromagnetic waves that explain the transmission of energy when no medium is present. [SP 1.1]
Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly projects
Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study
Lesson resources/Activities	- Hands on activities - Laboratory exercises related to subject matter • Wave Interference • Polarization Simulation • Real-World Use of Electromagnetic Radiation • Mirrors Investigation • Concave Mirror Investigation • Index of Refraction Investigation • Thin Lenses Investigation • Conflicting Contentions • Double-Slit Interference and Diffraction Investigations • Human Eye Investigation (Lab Practicum) - Chapter study guides - Oral presentation of chapter concepts

Pine Hill Public Schools Science Curriculum		
Unit Title: Quantum, Atomic, and Nuclear Physics		Unit #7
Course or Grade Level: AP Physics 2		Length of Time: 6 weeks
NGSS Performance Expectations (PE's)	- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. - HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. - HS-PS1-3. 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. - HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. - HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. - HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. - HS-PS2 Motion and Stability: Forces and Interactions - 2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. - HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. - HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* - HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. - HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	

	- HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* - HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. - HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). - HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* - HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). - HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. - HS-PS4 Waves and their Applications in Technologies for Information Transfer - HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. - HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. - HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. - HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. - HS-PS4-5. 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.*

Cross Cutting Concepts	Science and Engineering Practices
☒Patterns ☒Cause and Effect ☒Scale, Proportion, and Quantity ☒Systems and Systems Models ☒Energy and Matter in Systems ☒Structure and Function ☒Stability and Change in Systems Nature of Science (NOS) ☒NOS-Science is a Way of Knowing	☒Asking questions and defining problems ☒Developing and using models ☒Planning and carrying out investigations ☒Analyzing and interpreting data ☒Using mathematics and computational thinking ☒Constructing explanations and designing solutions ☐Engaging in argument from evidence ☒Obtaining, evaluating, and communicating information

<table>
<tr><td colspan="2">☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems
☒NOS-Science is a Human Endeavor
☒NOS-Science Addresses Questions About the Natural and Material World</td><td>Nature of Science (NOS)
☒Scientific Investigations Use a Variety of Methods
☒Scientific Knowledge is Based on Empirical Evidence
☒Scientific Knowledge is Open to Revision in Light of New Evidence
☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</td></tr>
<tr><td>Content</td><td colspan="2">Structure and Properties of the Nucleus
Binding Energy and Nuclear Forces
- Radioactivity
- Alpha Decay
- Beta Decay
- Gamma Decay
- Conservation of Nucleon Number and
- Other Conservation Laws
- Half-Life and Rate of Decay
- Calculations Involving Decay Rates and Half-Life
- Decay Series
- Radioactive Dating
- Stability and Tunneling
- Detection of Particles
- Nuclear Reactions and the Transmutation of Elements
- Nuclear Fission: Nuclear Reactors
- Nuclear Fusion
- Passage of Radiation Through Matter; Biological Damage
- Measurement of Radiation Dosimetry
- Radiation Therapy
- Tracers in Research and Medicine
- Emission Tomography: PET and SPECT
- Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI)
- High-Energy Particles and Accelerators
- Beginnings of Elementary Particle
- Physics—Particle Exchange
- Particles and Antiparticles
- Particle Interactions and Conservation Laws
- Neutrinos
- Particle Classification
- Particle Stability and Resonances
- Strangeness? Charm?
- Towards a New Model
- Quarks
- The Standard Model: QCD and Electroweak Theory
- Grand Unified Theories
- Strings and Supersymmetry
Possibly Touch upon these topics:
• Galilean-Newtonian Relativity
• Postulates of the Special Theory
• of Relativity
• Simultaneity
• Time Dilation and the Twin Paradox
• Length Contraction</td></tr>
</table>

	• Four-Dimensional Space-Time • Relativistic Momentum • The Ultimate Speed • E = mc2; Mass and Energy • Relativistic Addition of Velocities • The Impact of Special Relativity • Discovery and Properties of the Electron • Blackbody Radiation; • Planck's Quantum Hypothesis • Photon Theory of Light and the Photoelectric Effect • Energy, Mass, and Momentum of a Photon • Compton Effect • Photon Interactions; Pair Production • Wave-Particle Duality; the Principle of Complementarity • Wave Nature of Matter • Electron Microscopes • Early Models of the Atom • Atomic Spectra: Key to the Structure of the Atom • The Bohr Model • de Broglie's Hypothesis Applied to Atoms • Quantum Mechanics—A New Theory • The Wave Function and Its Interpretation; • the Double-Slit Experiment • The Heisenberg Uncertainty Principle • Philosophic Implications; • Probability versus Determinism • Quantum-Mechanical View of Atoms • Quantum Mechanics of the Hydrogen Atom, Quantum Numbers • Multielectron Atoms; the Exclusion Principle • The Periodic Table of Elements
Skills/Learning Objectives	- BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure. - 1.A.2.1: The student is able to construct representations of the differences between a fundamental particle and a system composed of fundamental particles and to relate this to the properties and scales of the systems being investigated. [SP 1.1, 7.1] - 1.A.4.1: The student is able to construct representations of the energy-level structure of an electron in an atom and to relate this to the properties and scales of the systems being investigated. [SP 1.1, 7.1] - 1.C.4.1: The student is able to articulate the reasons that the theory of conservation of mass was replaced by the theory of conservation of mass-energy. [SP 6.3] - 1.D.1.1: The student is able to 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. [SP 6.3]

	- 1.D.3.1: The student is able to articulate the reasons that classical mechanics must be replaced by special relativity to describe the experimental results and theoretical predictions that show that the properties of space and time are not absolute. [Students will be expected to recognize situations in which nonrelativistic classical physics breaks down and to explain how relativity addresses that breakdown, but students will not be expected to know in which of two reference frames a given series of events corresponds to a greater or lesser time interval, or a greater or lesser spatial distance; they will just need to know that observers in the two reference frames can "disagree" about some time and distance intervals.] [SP 6.3, 7.1] - BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws. - 5.B.8.1: The student is able to 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. [SP 1.2, 7.2] - 5.B.11.1: The student is able to apply conservation of mass and conservation of energy concepts to a natural phenomenon and use the equation E = mc2 to make a related calculation. [SP 2.2, 7.2] - 5.C.1.1: The student is able to analyze electric charge conservation for nuclear and elementary particle reactions and make predictions related to such reactions based upon conservation of charge. [SP 6.4, 7.2] - 5.D.1.6: The student is able to make predictions of the dynamical properties of a system undergoing a collision by application of the principle of linear momentum conservation and the principle of the conservation of energy in situations in which an elastic collision may also be assumed. [SP 6.4] - 5.D.1.7: The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values. [SP 2.1, 2.2] - 5.D.2.5: The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values. [SP 2.1, 2.2] - 5.D.2.6: The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. [SP 6.4, 7.2]

	- 5.D.3.2: The student is able to make predictions about the velocity of the center of mass for interactions within a defined one-dimensional system. [SP 6.4] - 5.D.3.3: The student is able to make predictions about the velocity of the center of mass for interactions within a defined two-dimensional system. [SP 6.4] - 5.G.1.1: The student is able to apply conservation of nucleon number and conservation of electric charge to make predictions about nuclear reactions and decays such as fission, fusion, alpha decay, beta decay, or gamma decay. [SP 6.4] - BIG IDEA 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena. - 6.F.3.1: The student is able to support the photon model of radiant energy with evidence provided by the photoelectric effect. [SP 6.4] - 6.F.4.1: The student is able to select a model of radiant energy that is appropriate to the spatial or temporal scale of an interaction with matter. [SP 6.4, 7.1] - 6.G.1.1: The student is able to make predictions about using the scale of the problem to determine at what regimes a particle or wave model is more appropriate. [SP 6.4, 7.1] - 6.G.2.1: The student is able to articulate the evidence supporting the claim that a wave model of matter is appropriate to explain the diffraction of matter interacting with a crystal, given conditions where a particle of matter has momentum corresponding to a de Broglie wavelength smaller than the separation between adjacent atoms in the crystal. [SP 6.1] - 6.G.2.2: The student is able to 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.) [SP 6.4] - BIG IDEA 7: The mathematics of probability can be used to describe the behavior of complex systems and to interpret the behavior of quantum mechanical systems. - 7.C.1.1: The student is able to use a graphical wave function representation of a particle to predict qualitatively the probability of finding a particle in a specific spatial region. [SP 1.4] - 7.C.2.1: The student is able to use a standing wave model in which an electron orbit circumference is an integer multiple of the de Broglie wavelength to give a qualitative explanation that accounts for the existence of specific allowed energy states of an electron in an atom. [SP 1.4] - 7.C.3.1: The student is able to 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. [SP 6.4]

	- 7.C.4.1: The student is able to construct or interpret representations of transitions between atomic energy states involving the emission and absorption of photons. [For questions addressing stimulated emission, students will not be expected to recall the details of the process, such as the fact that the emitted photons have the same frequency and phase as the incident photon; but given a representation of the process, students are expected to make inferences such as figuring out from energy conservation that since the atom loses energy in the process, the emitted photons taken together must carry more energy than the incident photon.] [SP 1.1, 1.2]
Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly projects
Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study
Lesson resources/Activities	- Hands on activities - Laboratory exercises related to subject matter • Atomic Structure Review • Models of the Hydrogen Atom • Spectroscopy Investigation • Modern Physics — Graphing Analysis • Laser Research Project • Photoelectric Effect Simulation • Photoelectric Effect Investigation #2 • Diffraction of Matter • Quantum Mechanics Simulations • Quantum Wave Interference Simulation • Relativity Research Paper and Presentation • Radioactive Decay Simulations and Investigation • Radioactive Decay Problem Set • Radioactive Decay and Nuclear Reaction Problems • Research and Debate on Nuclear Energy - Chapter study guides - Oral presentation of chapter concepts

Pine Hill Public Schools Science Curriculum	
Unit Title: Astrophysics and Cosmology (Ch 33)	Unit #8
Course or Grade Level: AP Physics 2	Length of Time: 2.5 weeks
NGSS Performance Expectations (PE's)	HS-ESS1 Earth's Place in the Universe HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. HS-ESS1-2. 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-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. HS-ESS2-7. Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth.
Cross Cutting Concepts	Science and Engineering Practices

☒Patterns ☒Cause and Effect ☒Scale, Proportion, and Quantity ☒Systems and Systems Models ☒Energy and Matter in Systems ☒Structure and Function ☒Stability and Change in Systems Nature of Science (NOS) ☒NOS-Science is a Way of Knowing ☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems ☒NOS-Science is a Human Endeavor ☒NOS-Science Addresses Questions About the Natural and Material World	☒Asking questions and defining problems ☒Developing and using models ☒Planning and carrying out investigations ☒Analyzing and interpreting data ☒Using mathematics and computational thinking ☒Constructing explanations and designing solutions ☐Engaging in argument from evidence ☒Obtaining, evaluating, and communicating information Nature of Science (NOS) ☒Scientific Investigations Use a Variety of Methods ☒Scientific Knowledge is Based on Empirical Evidence ☒Scientific Knowledge is Open to Revision in Light of New Evidence ☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Content	- Stars and Galaxies - Stellar Evolution: Birth and Death - of Stars, Nucleosynthesis - Distance Measurements - General Relativity: Gravity and the - Curvature of Space - The Expanding Universe: Redshift and - Hubble's Law - The Big Bang and the Cosmic - Microwave Background - The Standard Cosmological Model: - Early History of the Universe - Inflation: Explaining Flatness, - Uniformity, and Structure - Dark Matter and Dark Energy - Large-Scale Structure of the Universe - Finally …
Skills/Learning Objectives	
Assessments	- Teacher evaluation of special projects - Quizzes and chapter tests - Homework/class work assignments - Experiments/lab reports - Weekly projects
Interventions/ differentiated instruction	- Provide advanced notice for tests - Present materials suitable to student's level of functioning - Include hands on activities - Provide options for independent study
Lesson resources/Activities	- Hands on activities - Laboratory exercises related to subject matter • Research stellar formation • Dark matter lab • Open Project • Write a program using Newton's Gravitation law

	- Chapter study guides - Oral presentation of chapter concepts

Pine Hill Public Schools Science Curriculum	
Unit Title: Final Projects	Unit #9
Course or Grade Level: AP Physics 2	Length of Time: 2.5 weeks

NGSS Performance Expectations (PE's)	NOTE: Student projects may touch upon any or all of the Next Generation Science Standards - HS-PS1 Matter and its Interactions - HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. - HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. - HS-PS1-3. 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. - HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. - HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. - HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* - HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

	- HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. - HS-PS2 Motion and Stability: Forces and Interactions - 2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship amongthe net force on a macroscopic object, its mass, and its acceleration. - HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. - HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* - HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. - HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. - HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* - HS-PS3 Energy - HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. - HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). - HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* - HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). - HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. - HS-PS4 Waves and their Applications in Technologies for Information Transfer

	- HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. - HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. - HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. - HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-PS4-5. 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.* - HS-LS2 Ecosystems: Interactions, Energy, and Dynamics - HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. - HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. - HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. - HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. - HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. - HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. - HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* - HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. - HS-ESS1 Earth's Place in the Universe - HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. - HS-ESS1-2. 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.

<table>
<tr><td></td><td colspan="2">- HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.
- HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
- HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
- HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.</td></tr>
<tr><td colspan="2">Cross Cutting Concepts</td><td>Science and Engineering Practices</td></tr>
<tr><td colspan="2">☒Patterns
☒Cause and Effect
☒Scale, Proportion, and Quantity
☒Systems and Systems Models
☒Energy and Matter in Systems
☒Structure and Function
☒Stability and Change in Systems

Nature of Science (NOS)
☒NOS-Science is a Way of Knowing
☒NOS-Scientific Knowledge Assumes an Order and Consistency in Natural Systems
☒NOS-Science is a Human Endeavor
☒NOS-Science Addresses Questions About the Natural and Material World</td><td>☒Asking questions and defining problems
☒Developing and using models
☒Planning and carrying out investigations
☒Analyzing and interpreting data
☒Using mathematics and computational thinking
☐Constructing explanations and designing solutions
☐Engaging in argument from evidence
☐Obtaining, evaluating, and communicating information

Nature of Science (NOS)
☒Scientific Investigations Use a Variety of Methods
☒Scientific Knowledge is Based on Empirical Evidence
☒Scientific Knowledge is Open to Revision in Light of New Evidence
☒Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</td></tr>
<tr><td>Content</td><td colspan="2">- Final Projects</td></tr>
<tr><td>Skills/Learning Objectives</td><td colspan="2"></td></tr>
<tr><td>Assessments</td><td colspan="2">- Teacher evaluation of special projects
- Quizzes and chapter tests
- Homework/class work assignments
- Experiments/lab reports
- Weekly projects</td></tr>
<tr><td>Interventions/ differentiated instruction</td><td colspan="2">- Provide advanced notice for tests
- Present materials suitable to student's level of functioning
- Include hands on activities
- Provide options for independent study</td></tr>
<tr><td>Lesson resources/Activities</td><td colspan="2">- Hands on activities
- Laboratory exercises related to subject matter
• Student based research labs
• Student presentations
• Student stand alone project
- Chapter study guides
- Oral presentation of chapter concepts</td></tr>
</table>

Resources

Textbook

Giancoli, Douglas C. *Physics: Principles With Applications.* Boston, MA: Pearson, 2014.

Equipment

- Computers
- Motion Detectors
- Internet
- Microsoft Office (Excel, Word, and PowerPoint)
- Multi-meters
- Breadboards
- Power Supplies
- Resistors, LED's, and Capacitors
- Logger Pro Software
- Capital or Budget for projects
- Calculators
- Stop watches
- Photo-gates and accompanying software
- Sticky tape, straws, pens, assorted cloth (wool, silk, fur), PVC rod, metal can, commercial electrostatics kit (optional
- "Electric Forces: Straws and Pens"
- "Electric Charges: Charges and Sticky Tape
- "An Electrostatics Puzzler
- Van de Graff generator, packing peanuts, polystyrene cup, string, paper towel, soap bubbles, aluminum foil, fluorescent tube
- Electroscope, electrophorus, strips of transparent acetate, strips of opaque vinyl, light- colored silk or cotton, dark- colored wool, PVC tube, metal tube
- Small balloons, string, analytical balance, meterstick
- DC power supply (6V output), digital multimeter, conductive ink, conductive paper, graph paper
- Small light bulbs, light bulb sockets, wires, batteries
- Assorted resistors or a variable resistor, batteries or DC power supply, wires, digital or analog voltmeter and ammeter
- Assorted resistors, capacitor, wires, batteries, digital multimeter or analog voltmeter and ammeter
- Assorted resistors, wires, batteries, digital multimeter or analog voltmeter and ammeter
- Web
- Castro, "Kirchhoff's Gambit"
- DC power supply, triple-beam balance, 12-inch dowels (with clips that are conducting and nonmagnetic), ring stand with three clamps and crossbar, three insulated wires and two alligator clips, magnetic compass, straight bare (uninsulated) wire, 0.5-ohm resistor (10 W), three horseshoe magnets clamped together (poles aligned)
- Commercial Boyle's law units, metal spheres, 1500 mL beakers, hot plates, thermometers, ice
- Plane mirrors, concave and convex mirrors, pins, rulers, protractors, light source
- Concave mirrors, screens, lit candles or other light sources, metersticks or commercial optic benches
- Acrylic blocks, commercial ray tables or printed protractors, light sources
- Converging lenses, diverging lenses, screens, light sources, metersticks or commercial optic benches
- Green lasers, red lasers, double slits, diffraction gratings, metersticks
- Converging lenses, diverging lenses, commercial eye model, rulers
- 10 cc low-friction glass syringe with ring stand support, flasks (test tube) with one-hole rubber stoppers, pressure sensors, temperature sensors, two insulated (e.g., polystyrene) containers, two 400 mL glass beakers, several lengths of Tygon tubing, paper towels, rulers, 50 g masses, hot water, ice water
- Triple-beam balance, beakers, graduated cylinders, two objects of different densities, liquid
- of unknown density, string, overflow cans
- Clear 2 L plastic bottle, water, ruler, stopwatch, compass or other sharp object (for creating a small opening in the bottle)
- Water fountain, beakers, stopwatch, ruler
- Commercial diffraction gratings, spectroscopes, commercial spectrum tubes (argon, chlorine, iodine, hydrogen), spectrum tube power supply

- LED color strip, ammeter, wires, variable power source, resistor (1 k ohm), digital camera (optional)
- Shoe box with lid; 80 pennies, dice, or sugar cubes; 80 paper clips; graph paper; marker
- Bar magnet, solenoid, galvanometer
- Commercial Boyle's law units, metal spheres, 1500 mL beakers, hot plates, thermometers, ice3
- Shot plates, Vernier calipers, ice, plates of various materials (e.g., Masonite, aluminum, plexiglass, plywood, or Teflon)

Web access for the following virtual labs:

- Wells, "Electric Potential and Potential Energy"
- Bertrand, "Conceptual Links in Electrostatics: Using a Visual Mnemonic for Electrostatic Relationships"
- "Charges and Fields" "Electric Field Hockey"
- Reif, "Modern-Day Faradays: Teaching Students to Visualize Electric Fields"
- "The Nature of Resistance"
- "Capacitor Lab"
- "Circuit Construction Kit (DC Only)"
- "Magnet and Compass"
- Solenoid, batteries, magnetic compass (or a commercial magnaprobe)
- "Estimated Values of Magnetic Field"
- "Magnetic Force on a Current- Carrying Wire"
- "Faraday's Electromagnetic Lab"
- "Gas Properties"
- "States of Matter"
- Mooney, "The First Law of Thermodynamics and P–V Diagrams"
- "Balloons & Buoyancy"
- "Polarised Wave"
- "Wave Interference"
- "Isotopes and Atomic Mass" "Build an Atom"
- "Models of the Hydrogen Atom"
- "A CD Spectrometer"
- Gende, "Graphing Analysis in Modern Physics"
- "Lasers"
- "Photoelectric Effect"
- "Quantum Tunneling and Wave Packets"
- "Quantum Bound States"
- "Quantum Wave Interference"
- "Einstein Light"
- "Alpha Decay" "Beta Decay"
- "The Dating Game"