Bloomfield Public Schools
Bloomfield, New Jersey 07003

Curriculum Guide

AP Physics 2
Grades 11-12

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Conforms to the Next Generation Science Standards and the NJSLS Standards

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AP Physics 2
Grade 12

Introduction:

Students in the State of New Jersey and enrolled in Bloomfield High School must successfully complete three year-long science courses in order to meet the state mandated requirements for graduation. ***AP Physics 2 is*** available as an elective course, taken once graduation requirements have been met, to 12th grade students who have successfully completed AP Physics 1 and are either enrolled in or are concurrently taking pre-calculus. Students are expected to take the AP Physics 2 exam.

AP Physics 2 is an algebra-based, introductory college-level physics course. Students cultivate their understanding of Physics through inquiry-based investigations as they explore topics such as fluid statics and dynamics; thermodynamics with kinetic theory; PV diagrams and probability; electrostatics; electrical circuits with capacitors; magnetic fields; electromagnetism; physical and geometric optics; and quantum, atomic, and nuclear physics.

This curriculum is aligned with the ***Next Generation Science Standards***, the ***New Jersey Student Learning Standards for English Language Arts & Literacy in Science, the New Jersey Student Learning Standards for Math, and the New Jersey Core Curriculum Standards for Technology.***

This document is a tool that will provide an overview as to what to teach, when to teach it, and how to assess student progress. With considerations made for altered pacing, modifications, and accommodations; this document is to be utilized for all students enrolled in this course, regardless of ability level, native language, or classification. It is meant to be a dynamic tool that we, as educators, will revise and modify as it is used during the course of the school year.

Mapping/Sequence: The curriculum is written following the parameters of ***Understanding by Design*** using the New Jersey Model Curriculum for AP Physics 2. The document is written as a series of units containing established transfer goals, enduring understandings, essential questions, and the necessary skills and knowledge a student must attain in a school year. The document includes units of study so that all students that all teachers must follow. Culminating assessments are a method for students to show attainment of set goals.

Pacing: The AP Physics 2 course focuses on 5 topics:

Unit 1: Thermodynamics

Unit 2: Modern Physics

Unit 3: Optics

Unit 4: Fluids

Unit 5: Electricity and Magnetism

Resources: Electronic and text resources are listed in each unit. Teachers will be able to access the curriculum document on the district website.

Textbook: **Physics by Cutnell & Johnson**

Established Goals: New Jersey Student Learning Standards
Science: **http://www.nextgenscience.org/next-generation-science-standards**
New Jersey Student Learning Standards for Math: **http://www.state.nj.us/education/cccs/2016/math/standards.pdf**
New Jersey Student Learning Standards for ELA: **http://www.state.nj.us/education/cccs/2016/ela/**
Technology: **http://www.state.nj.us/education/cccs/2014/tech/**

Modifications:
- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.   - Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).   - Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).   - Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).   - Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.   - Use project-based science learning to connect science with observable phenomena.   - Structure the learning around explaining or solving a social or community-based issue.   - Provide ELL students with multiple literacy strategies.   - Collaborate with after-school programs or clubs to extend learning opportunities.   - Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

Unit #: 1	Unit Name: Thermodynamics	5 weeks

How can we actively take advantage of weather patterns and global energy differences to channel a precious energy resource to aid mankind?

This unit begins with fundamental descriptions of heat and internal energy, temperature, conductors, etc., and describes basic functions and applications. It proceeds to describe and quantify the outline of the thermodynamic processes, their relation to each other, and how they govern heat energy changes on the planet.

#	STUDENT LEARNING OBJECTIVES (SLO)	Corresponding DCIs and PEs And AP SLO's
1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]	**HS-PS3-1**
2	**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).** [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]	**HS-PS3-4**
3	The student is able to make predictions about the direction of energy transfer due to temperature differences based on interactions at the microscopic level	**4.C.3.1: [SP 6.4**]
4	The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.	**5.B.4.2**. **[SP 1.4, 2.1, 2.2**]

5	The student is able to create a plot of pressure versus volume for a thermodynamic process from given data.	**5.B.7.2: [SP 1.1**]
6	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.	**7.A.3.2: . [SP 3.2, 4.2]**

<table>
<tr><td colspan="3">The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:</td></tr>
<tr><td>Science and Engineering Practices</td><td>Disciplinary Core Ideas</td><td>Crosscutting Concepts</td></tr>
<tr><td>Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
● Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HS- PS3-5)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual,</td><td>PS3.A: Definitions of Energy
● Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2)
● At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS- PS3-2) (HS-PS3-3)
● These relationships are better understood at the microscopic scale,</td><td>Cause and Effect
● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

Systems and System Models
● When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
● Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the</td></tr>
</table>

mathematical, physical, and empirical models. ● Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4) **Using Mathematics and Computational** Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)	at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** ● Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) ● Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) ● Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged	assumptions and approximations inherent in models. (HS- PS3-1) **Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS- PS3-3) ● Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS- PS3-3)	particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) ● The availability of energy limits what can occur in any system. (HS-PS3-1) ● Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.C: Relationship Between Energy and Forces** ● When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **PS3.D: Energy in Chemical Processes** ● Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)	

New Jersey Student Learning Standards Connections:

ELA:

SL.11-12.1	Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with peers on ***grades 11–12 topics, texts, and issues,*** building on others' ideas and expressing their own clearly and persuasively. (HS-PS3-4)
L.11-12.6	Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (HS-PS3-4)
RST.9-10.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-PS3-4)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS3-3), (HS-PS3-4),(HS-PS3-5)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4),(HS-PS3-5)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1),(HS-PS3-2),(HS-PS3-5)

Math:

MP.2	Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)
MP.4	Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1),(HS-PS3-3)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

Technology Standards:

8.1.12.A.1	Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results.
9.1.12.A.1	Apply critical thinking and problem-solving strategies during structured learning experiences.

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**
Temperature Heat Internal Energy Specific Heat Conduct-Convect-Induct Kinetic Thermodynamic Adiabatic Isothermal Entropy Heat Engine	Analysis Available Concept Distribution Function Principle Response Transfer Variables	Simple Heat Apparatus Cans Calorimeters Thermometers Computers

	Examples of Learning Activities for the specified "E"	SLO's and Engineering Practices
ENGAGE	**Examples of Engaging Activities:**	
	Video (Heat and Thermodynamics)	1 Asking Questions and Defining Problems
	Demonstration by teacher (Heat and Pressure)	3 Asking Questions and Defining Problems
	Hot ring activity (Show ring expansion through heating)	3 Asking Questions and Defining Problems
	Popcorn Activity (Predict pressure of popping corn)	3 Asking Questions and Defining Problems
EXPLORE	**Examples of Exploring Activities:**	
	Heat of Fusion Lab (Heat exchange calculations)	1, 2, 5 Developing and Using Models Planning and Carrying Out Investigations
	Conservation of Heat Lab (Hot vs Cold)	1, 2, 3, 5 Developing and Using Models \ Planning and Carrying Out Investigations Analyzing and Interpreting Data
EXPLAIN	**Examples of Explaining Activities:**	
	Plot and Problem Analysis (Plotting heat vs time and calculation extrapolations)	3 Using Mathematics and Computational Thinking Analyzing and Interpreting Data

		Planning and Carrying Out Investigations Engaging in Argument from Evidence
	Calculation Evaluations (New heat values from Conservation)	6 Engaging in Argument from Evidence
ELABORATE	**Examples of Elaborating Activities:**	
	Interpretation of Heat results (Does Conservation happen?)	4 Analyzing and Interpreting Data – Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information
	Prediction of Graph Values (Did extrapolation work)	1 Developing and Using Models Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information
EVALUATE	**Examples of Evaluating Activities:**	
	Sketch description of heat conservation process (Show heat flow with direction)	3, 4, 6 – Constructing Explanations and Designing Solutions Engaging in Argument from Evidence

		Obtaining, Evaluating, and Communicating Information
	Identifies and adjusts his/her own learning path and addresses weaknesses	3, 6 – Constructing Explanations and Designing Solutions

Unit #: 2	**Unit Name: Modern Physics**	**5 weeks**

What are the possible ways and mechanisms that we can employ to harness the burgeoning field of solid state electronics to improve living standards across the globe?

Modern Physics stands in contrast to the traditionally taught Classical or Newtonian Physics. The latter is most valid for many, many applications that technology and research used in the past and use today. Modern Physics covers nuclear theory and applications, and the theory and reasoning behind different ways of observing and evaluating the behavior of light energy. This latter part has vast implications in science as it describes new ways of looking at energy and matter in the universe, the plausibility of different solid states applications, and new observational tools, in the least.

#	STUDENT LEARNING OBJECTIVES (SLO)	Corresponding DCIs and PEs AP 2 SLO's
1	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]	**HS-PS4-3**
2	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.	**5.B.8.1** **[SP 1.2, 7.2**]

3	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.	**1.D.1.1:** **[SP 6.3**]
4	The student is able to support the photon model of radiant energy with evidence provided by the photoelectric effect**.**	**6.F.3.1:** **[SP 6.4**
5	The student is able to apply mathematical routines to describe the relationship between mass and energy and apply this concept across domains of scale.]	**4.C.4.1:** **[SP 2.2, 2.3, 7.2**]
6	The student is able to apply conservation of mass and conservation of energy concepts to a natural phenomenon and use the equation $\boldsymbol{E} = \boldsymbol{mc}^2$ to make a related calculation.	**5.B.11.1:** **SP 2.2, 7.2**

The performance expectations above were developed using the following elements from the NRC document ***A Framework for K-12 Science Education***:		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)	**PS4.B: Electromagnetic Radiation** ● Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) ● When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can	**Influence of Engineering, Technology, and Science on Society and the Natural World** ● Modern civilization depends on major technological systems. (HS-PS4-2),(HS- PS4-5) ● Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)

Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. ● Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)	ionize atoms and cause damage to living cells. (HS-PS4-4) ● Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)	

New Jersey Student Learning Standards Connections:

ELA:

SL.11-12.1 Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with peers on ***grades 11–12 topics, texts, and issues,*** building on others' ideas and expressing their own clearly and persuasively. (HS-PS4-3)

L.11-12.6 Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (HS-PS4-3)

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2),(HS-PS4-3),(HS-PS4-4)

RST.9-10.1 Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-PS3-4)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1),(HS-PS4-4)

RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2),(HS-PS4-3),(HS-PS4-4)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS4-5)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS4-4)
Math:	
MP.2	Reason abstractly and quantitatively. (HS-PS4-1),(HS-PS4-3)
MP.4	Model with mathematics. (HS-PS4-1)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1),(HS-PS4-3)
HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS4-1),(HS-PS4-3)
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS4-1),(HS-PS4- 3)
Technology Standards:	
8.12.A.1	Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results.
9.1.12.A.1	Apply critical thinking and problem-solving strategies during structured learning experiences.

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**
Interference Mechanical Diffraction Superposition Wave Special Relativity Mass Equivalence Duality Photon Uncertainty Quantum Atomic Spectra Exclusion Principle Nucleus Mass Defect Radioactivity	Analysis Area Circumstances Concept Corresponding Data Equation Function Potential region Period Theory	Computer Appropriate software Multimeters Radioactive disks One Geiger counter

	Examples of Learning Activities for the specified "E"	**SLO's and Engineering Practices**
ENGAGE	**Examples of Engaging Activities:**	
	Video	1 Asking Questions and Defining Problems
	Discussion	1 Asking Questions and Defining Problems
	Radioactive Virtual Lab	3 Asking Questions and Defining Problems Developing and Using Models

EXPLORE	Examples of Exploring Activities:	
	Slit diffraction Lab	3 Asking Questions and Defining Problems Developing and Using Models
	Measuring Wavelength Lab	4 Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data Using Mathematics and Computational Thinking
	Photoelectric effect virtual lab	1, 4 Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data Using Mathematics and Computational Thinking
	Student prediction of these labs	5, 6 Constructing Explanations and Designing Solutions
	Group discussion of results	1 Constructing Explanations and Designing Solutions

EXPLAIN	**Examples of Explaining Activities:**	
	Lecture theory with student assistance	1, 4
	Comparison of predictions and theory	1 Analyzing and Interpreting Data Using Mathematics and Computational Thinking
	Emission spectrum lab and prediction	2 Analyzing and Interpreting Data
ELABORATE	Examples **of Elaborating Activities:**	
	Compare and contrast wave vs. particle	1, 3 Using Mathematics and Computational Thinking
	Re – label and re identify particle behavior	2, 5 Using Mathematics and Computational Thinking
	Calculations of Energy values	1, 6 Analyzing and Interpreting Data
EVALUATE	**Examples of Evaluating Activities:**	
	Modified Observation based test	1, 2 Using Mathematics and Computational Thinking
	Self-Evaluation of results	3, 4 Using Mathematics and Computational Thinking
	Quantitative Assessment of results	1, 5 Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information

Unit #: 3	Unit Name: Optics	5 weeks

How can we channel our knowledge and increasing improving technology of optics to aid both general and specific social needs of a society?

Optics begins with the general description and characterization of light as electromagnetic energy. It then continues to describe qualitatively and quantitatively one our most creative uses of light as energy in the science of optics. This field involves specific descriptions of light forming images in mirrors, lens or any reflecting surface. It follows with some special behaviors of light as in total internal reflection, diffraction and interference.

#	STUDENT LEARNING OBJECTIVES (SLO)	Corresponding DCIs and PEs And AP SLO's
1	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]	**HS-PS4-1**
2	The student is able to describe representations of transverse and longitudinal waves.	**6.A.1.2: [SP 1.2]**
3	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.	**6.E.2.1: [SP 6.4, 7.2]**
4	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).	**6.E.3.2: [SP 4.1, 5.1, 5.2, 5.3]**

5	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.	**6.E.3.3: [SP 6.4, 7.2]**
6	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.	**LO 6.E.4.1 [SP 3.2, 4.1, 5.1, 5.2, 5.3]**
7	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.	**LO 6.E.5.1 SSP 1.4, 2.2]**

The performance expectations above were developed using the following elements from the NRC document ***A Framework for K-12 Science Education***:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. ● Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and	**PS4.A: Wave Properties** ● The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1

model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)		

New Jersey Student Learning Standards Connections:

ELA:

SL.11-12.1 Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with peers

on ***grades 11–12 topics, texts, and issues,*** building on others' ideas and expressing their own clearly and persuasively. (HS-PS4-1)

L.11-12.6 Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (HS-PS4-1)

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2),(HS-PS4-3),(HS-PS4-4)

RST.9-10.1 Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-PS4-2),(HS-PS4-3),(HS-PS4-4)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1),(HS-PS4-4)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2),(HS-PS4-3),(HS-PS4-4)

WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS4-5)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS4-4)
Math:	
MP.2	Reason abstractly and quantitatively. (HS-PS4-1),(HS-PS4-3)
MP.4	Model with mathematics. (HS-PS4-1)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1),(HS-PS4-3)
HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS4-1),(HS-PS4-3)
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS4-1),(HS-PS4-3)
Technology Standards:	
8.1.12.A.1	Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results.
9.1.12.A.1	Apply critical thinking and problem-solving strategies during structured learning experiences.

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**

Reflection Image Mirror Focus Refraction Polarization Lens	Analysis Principle Assessment Theory Components Estimate Equation Period Range	Mirrors Lenses Simple Lens setup Computer

	Examples of Learning Activities for the specified "E"	SLO's and Engineering Practices
ENGAGE	**Examples of Engaging Activities:**	
	Video (Optics, Tricks, Magic)	3 Asking Questions and Defining Problems
	Discussion (What can we see and not see visually?)	5 Asking Questions and Defining Problems
	Visual Diagram & Image sketching	4 Asking Questions and Defining Problems
EXPLORE	**Examples of Exploring Activities:**	
	Image Sketching	3 Developing and Using Models
	Mirror Image Formation lab	2, 3, 4, 6 Developing and Using Models Planning and Carrying Out Investigations
	Refraction Image lab	1, 5, 6, 7

		Planning and Carrying Out Investigations Analyzing and Interpreting Data
	Convex Lens Image formation lab	3, 4 Planning and Carrying Out Investigations Analyzing and Interpreting Data
EXPLAIN	**Examples of Explaining Activities:**	
	Calculating Image focal lengths and dimensions	1, 3, 4 Using Mathematics and Computational Thinking
	Student input Lecture	2, 3, 6 Using Mathematics and Computational Thinking
	Video	3, 4 Developing and Using Models
ELABORATE	**Examples of Elaborating Activities:**	
	Student detailing of Image formations	2, 4, 5 Using Mathematics and Computational Thinking
	Student appraisal of other predictions	1, 2, 7 Constructing Explanations and Designing Solutions Developing and Using Models
EVALUATE	**Examples of Evaluating Activities:**	
	Student Comparative evaluation of Results	1, 3, 4, 5

		Constructing Explanations and Designing Solution Obtaining, Evaluating, and Communicating Information
	Student Self Evaluation of Unit	3, 4, 5 – Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information
	Quantitative/Qualitative Assessment from teacher with student input	, 2, 3, 7 Obtaining, Evaluating, and Communicating Information

Unit #: 4	Unit Name: Fluids	Unit Length: 5 weeks

How do we evaluate the properties of natural materials like a fluid, in order to use it to serve society? This unit deals with the general qualitative and quantitative description of substances defined as Fluids. Properties, description of fluids is followed by quantitative characterization of fluids and how their behavior and properties are predicted and evaluated, oftentimes for use by a technology, using the established principles of Archimedes, Pascal and Bernoulli.		
#	**STUDENT LEARNING OBJECTIVES (SLO)**	**Corresponding DCIs and PEs and AP SLO's**
1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]	**HS-PS3-1**
2	The student can generate and select from experimental data that which is need to calculate densities and fluid pressures	**[SP 4.1, 6.4]** **1.E.1.2**
3	The student will be able to use Bernoulli's equation to make calculations related to a moving fluid.	**[SP 2.2]** **5.B.10.1**
4	The will be 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]** **5.F.1.1**

The performance expectations above were developed using the following elements from the NRC document ***A Framework for K-12 Science Education***:		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. ● Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HS- PS3-5)	**PS3.B: Conservation of Energy and Energy Transfer** ● Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) ● Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) ● Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)	**Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS- PS3-3)

New Jersey Student Learning Standards Connections:

ELA:

SL.11-12.1 Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with peers

on ***grades 11–12 topics, texts, and issues,*** building on others' ideas and expressing their own clearly and persuasively. (HS-PS3-1)

L.11-12.6 Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (HS-PS3-1)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1)

Math:

MP.2 Reason abstractly and quantitatively. (HS-PS3-1)

MP.4 Model with mathematics. (HS-PS3-1)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1)

Technology Standards:

9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.

8.12.A.1 Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results.

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**

Fluid Pressure Buoyancy Flow Continuity Force Equilibrium	Approach Available Concept Data Equation Initial Method Primary Role Significant Variables	Overflow cans Force sensors Scales

	Examples of Learning Activities for the specified "E"	SLO's and Engineering Practices
ENGAGE	**Examples of Engaging Activities:**	
	Video on Fluid Behaviors	1 Asking Questions and Defining Problems
	Discussion – Why do we need Fluids?	2 Asking Questions and Defining Problems
	Activity – Crushing cans w/ Air – Air pressure is Real	3 Asking Questions and Defining Problems
EXPLORE	**Examples of Exploring Activities:**	
	Lab - Archimedes Density (Comparative density and buoyancy values)	2, 4 Developing and Using Models Analyzing and Interpreting Data
	Lab – Bernoulli Flows (Predicting different fluid speeds)	1, 2, 3 Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data
	Research – short report 'Fluids' (Descriptive nature of fluids)	2 Planning and Carrying Out Investigations
EXPLAIN	**Examples of Explaining Activities:**	
	Theoretical postulates of Fluids	1, 3 Analyzing and Interpreting Data
	Density and Force Calculations	2, 3, 4 Analyzing and Interpreting Data

		Using Mathematics and Computational Thinking
	Discourse and Questions on all Fluid Behavior	1, 4 Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions
ELABORATE	**Examples of Elaborating Activities:**	
	Archimedes densities and matching values	1, 2, 4 Using Mathematics and Computational Thinking
	Interpolation of results	1, 2 Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions Engaging in Argument from Evidence
	Comparison of force and density Bernoulli values	2, 4 Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions
EVALUATE	**Examples of Evaluating Activities:**	
	Theoretical and Quantitative Assessment of Fluid behaviors	2, 4 Using Mathematics and Computational Thinking Engaging in Argument from Evidence
	Self-Evaluation of process and results of theory and lab analysis	2, 4 Engaging in Argument from Evidence

	Comparison of graphing values	2, 4 Using Mathematics and Computational Thinking Engaging in Argument from Evidence
Unit #: 5	**Unit Name: Electricity and Magnetism**	**8 weeks**

How can we use our increasing knowledge of electro-magnetism and its behavior aid us to pursuing low cost solutions to energy deficits and energy challenges for a global community?

Electricity and Magnetism is a vast topic that considers Electricity first, then Magnetism, then Electromagnetism; all of which must be covered for understanding and application of the subject. Electric-magnetic fields, energies, forces, etc., are analyzed before simple and then more complex type of circuits are studied. In the latter part of Electro-Magnetism, circuits are constructed, and quantitatively evaluated for different values of circuits such as electromagnetic induction, self-induction, inductance, etc.

#	STUDENT LEARNING OBJECTIVES (SLO)	Corresponding DCIs and PEs And AP SLO's
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.	**4.E.4.1 [SP 2.2, 6.4]**
2	**Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.** [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]	**HS-PS2-5.**

3	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]	**HS-PS3-5.**
4	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.	**1.B.2.2:** **[SP 6.4, 7.2**]
5	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 electric force and an electric field: F = ***q***E; a vector relation.	**2.C.1.1:** **[SP 6.4, 7.2**
6	The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges.	**LO 3.C.2.1:** **[SP 2.2, 6.4]**
7	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.	**2.C.4.2:** **[SP 1.4, 2.2**]
8	The student is able to make predictions about the redistribution of charge during charging by friction, conduction, and induction.	**4.E.3.1** **[SP 6.4]**
9	The student is able to analyze experimental data including an analysis of experimental uncertainty that will demonstrate the validity of Kirchhoff's loop rule.	**5.B.9.4:** **[SP 5.1]**
10	The student is able to apply mathematical routines to express the force exerted on a moving charged object by a magnetic field.	**2.D.1.1:** **[SP 2.2**]
11	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.	**3.C.3.1:** **[SP 1.4]**

The performance expectations above were developed using the following elements from the NRC document ***A Framework for K-12 Science Education***:		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models. ● Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ● Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)	**PS2.B: Types of Interactions** ● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) ● Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) ● Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3)	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5) ● Systems can be designed to cause a desired effect. (HS-PS2-3)

Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student- generated sources of evidence consistent with scientific ideas, principles, and theories. ● Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)		

New Jersey Student Learning Standards Connections:

ELA:

RST.9-10.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions. (HS-PS2-1),(HS-PS2-6)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3),(HS-PS2-5)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS2-5)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Math:

MP.2	Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
MP.4	Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS- PS2-4),(HS-PS2-5),(HS-PS2-6)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)
HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4)

HSA-CED.A.1	Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2)
HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1),(HS-PS2-2)
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2)
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)
HSS-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)
Technology Standards:	
9.1.12.A.1	Apply critical thinking and problem-solving strategies during structured learning experiences.
8.1.12.A.1	Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results.

Unit Plan		
Content Vocabulary	**Academic Vocabulary**	**Required Resources**
Electric field-force Charge Conductor-Insulator Potential Capacitance Circuit Voltage-Current-Resistance Power Series-Parallel Magnetism Induction Reactance	Analysis Components Equation Function Potential Range Section Specific Variables	Circuits Computer Resistors and circuit elements Multi-meters

THE 5 "E"s	Examples of Learning Activities for the specified "E"	SLO's and Engineering Practices
ENGAGE	**Examples of Engaging Activities:**	
	Video – Electromagnetism	1,2 Asking Questions and Defining Problems
	Activity – Connect a Circuit	1, 2, 3 Asking Questions and Defining Problems
	Discussion – What is Electromagnetism Anyway?	1, 2, 8 Asking Questions and Defining Problems
EXPLORE	**Examples of Exploring Activities:**	
	Electric Field Lab	3, 4 Developing and Using Models
	Electric Circuits Lab	2

		Planning and Carrying Out Investigations
	Electromagnetic Lab	2, 4 Planning and Carrying Out Investigations
	Capacitor Lab	4 Planning and Carrying Out Investigations
EXPLAIN	**Examples of Explaining Activities:**	
	Prediction of Lab Results	1, 2, 3, 4 Analyzing and Interpreting Data
	Graphing one Value against another	4 Analyzing and Interpreting Data
	Interpolation of Data	1, 2, 3, 4 Analyzing and Interpreting Data Using Mathematics and Computational Thinking
ELABORATE	**Examples of Elaborating Activities:**	
	Comparing Theoretical and Actual lab values	1, 4, 7, 8 Using Mathematics and Computational Thinking
	Calculation of Electricity Values	11 Obtaining, Evaluating, and Communicating Information Using Mathematics and Computational Thinking Engaging in Argument from Evidence

		Obtaining, Evaluating, and Communicating Information
EVALUATE	**Examples of Evaluating Activities:**	
	Quantitative and Qualitative Assessment	1 Constructing Explanations and Designing Solutions Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information
	Self-Assessment on lab work, data and above Assessment results	9, 10, 11 Constructing Explanations and Designing Solutions Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information