FREEHOLD REGIONAL HIGH SCHOOL DISTRICT
OFFICE OF CURRICULUM AND INSTRUCTION
SCIENCE DEPARTMENT CURRICULUM

LAB PHYSICS

Grade Level: 11 - 12

Credits: 5

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FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

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Lab Physics
Course Description
“There is a rhythm and a pattern between the phenomenon of nature which is not apparent to the human eye but the eye of analysis. It is these rhythms and patterns which we call physical laws.” – Richard Feynman Lab Physics explores our place within the universe as it tells the story of the physical laws that the universe obeys. We begin by understanding the physical laws of our universe to explain the natural phenomena we witness and interactions with our environment. Laws are introduced using observation, experimentation, and student driven inquiry. These laws are then applied to the bigger picture including our home (Earth), our star (the Sun), and the universe as a whole. We investigate the Big Bang, the formation of stars, and orbits of the planets. We focus on Earth, its atmosphere, its surface, and inner workings. The story comes full circle as we investigate the effects that our society has on Earth’s systems and our understanding of the universe.

Course Sequence and Pacing

Unit Title	Essential Question	Suggested Pacing
Unit 1: Motion & Forces	Why do objects move the way they do?	35 Sessions
Unit 2: Momentum	How do you protect yourself in a collision?	15 Sessions
Unit 3: Energy	What does energy enable us to do?	20 Sessions
Unit 4: Electric Force and Field	Why do you sometimes get shocked when touching a doorknob?	15 Sessions
Unit 5: Waves & Particles	How can phenomena be waves, particles and neither?	20 Sessions
Unit 6: Geo- & Astrophysics	How did it all begin and where is it all going?	20 Sessions

Support Resources

The following supporting resources and appendices for this curriculum are available. These include a Resource Catalog of standards-aligned activities, common formative assessment and interdisciplinary items for the performance expectations and objectives in this course:

- Lab Physics Resource Catalog
- Appendix A: Accommodations and Modifications for Various Student Populations
- Appendix B: Assessment Evidence
- Appendix C: Interdisciplinary Connections

Lab Physics
Unit 1: Motion & Forces
Section: 1.1 **Suggested Unit Pacing: 35 Sessions**

Essential Question: Why do objects move the way they do?

NJSLS-S Performance Expectations

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

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-PS2-1 [1]
A. Organize the given data and/or description of the motion of an object to construct a motion diagram.
B. Identify the motion of an object given a motion diagram.

HS-PS2-1 [2]
A. Organize data of an object to construct a force diagram to find the net force exerted on the object.
B. Describe direction of change of velocity (acceleration) of the object.

HS-PS2-1 [3]
A. Organize data graphically using a Position vs. Time graph from the description of an object's motion.
B. Analyze the motion of an object by viewing a Position vs. Time graph and know the slope represents the rate of change of position (velocity). (Limited to: knowing meaning of slope, calculating [constant] slope, knowing the meaning of constant vs changing slope, and deriving $\Delta x / \Delta t = v$)
C. Calculate change in position and velocity of an object from its Position versus Time graph.

HS-PS2-1 [4]
A. Organize data graphically using a Velocity vs. Time graph from the description of an object's motion.
B. Analyze the motion of an object by viewing a Velocity vs. Time graph and know the slope represents the rate of change of velocity (acceleration).
C. Calculate change in velocity, acceleration, and displacement of an object from its Velocity vs. Time graph.

HS-PS2-1[5]
A. Identify and list basic variables of motion.
B. Manipulate and calculate kinematics equations from basic variables of motion (Use: $\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$ and $\Delta v / \Delta t = a$)

HS-PS2-1 [6] Organize data via tables, graphs, charts, or vector drawings that represent the net force on a macroscopic object, its mass (held constant), and its acceleration.

HS-PS2-1 [7] Using tools, technologies, and/or models, 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. Specifically, identify relationships within datasets, including:
A. a more massive object experiencing the same net force as a less massive object has a smaller acceleration.
B. a larger net force on a given object produces a correspondingly larger acceleration.

HS-PS2-1 [8] Using data, support the relationship between variables in the formula $a = F_{net}/m$ (e.g., double force yields double acceleration, etc.).

HS-PS2-1 [9] Distinguish between causal and correlational relationships linking force, mass, and acceleration using analyzed data to express the linear form of the relationship, $F_{net}=ma$, in terms of causality, namely that the net force on an object causes the object to accelerate.

HS-PS2-1 [10] Use tools, technologies, and/or models to analyze the data and identify relationships within datasets, including:
A. the ratio of the net gravitational force to mass remains constant.
B. the result of gravitational interaction near a planet's surface is a constant acceleration as evidence by the ratio of the net gravitational force to mass remaining constant. (Free fall vs. non-free fall as it relates to Velocity versus Time graph and discuss how N/kg can be m/s^2)

Lab Physics **Unit 1: Motion & Forces** **Section: 1.2**
Essential Question: Why do objects move the way they do?
NJSLS-S Performance Expectations
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.** (Bold only) [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.] **Note: HS-PS2-4 will be completed in Unit 4**
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS2-4 [1] Describe and predict the gravitational force between objects by defining variables of the system.
HS-PS2-4 [2] Use mathematical representations of Newton's Law of Gravitation to: A. predict the attractive gravitational force between two objects, where mass is directly proportional and distance follows the inverse square law. B. derive the Universal Law of Gravitation.
HS-PS2-4 [3] Using data, support the relationship between variables in the formula Gm1m2/r^2 (e.g., double the radial distance yields one-fourth the force, etc.).

Lab Physics **Unit 1: Motion & Forces** **Section: 1.3**
Essential Question: Why do objects move the way they do?
NJSLS-S Performance Expectations
HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's laws of orbital motions should not deal with more than two bodies, nor involve calculus.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-ESS1-4 [1] Identify and represent the qualitative and quantitative relationships among the magnitudes and directions of the vectors: tangential velocity, centripetal acceleration and force for an object moving in a circular path.
HS-ESS1-4 [2] Using graphical, mathematical, and written representations, identify and describe: A. the trajectories of orbiting bodies, including planets, moons, or human-made spacecraft, each of which depicts a revolving body's eccentricity. B. the relevant components in the equation e = f/d for orbiting system, where e is the orbiting body's eccentricity, f is the distance between the foci of an ellipse, and d is the ellipse's major axis (as related to Kepler's 1st Law).
HS-ESS1-4 [3] Predict the relationship between the distance between an orbiting body and its star, and the object's orbital velocity using Kepler's 2nd Law, including how to: A. describe that the motion of an orbiting body sweeps out equal areas in equal time. B. analyze sections of an elliptical orbit that are covered in the same amount of time to demonstrate that they have the same area.

HS-ESS1-4 [4] Depict that the square of an orbiting bodies period of revolution is proportional to the cube of the distance to a system's gravitational center of mass ($T2 \propto R3$) (Kepler's 3rd Law).
HS-ESS1-4 [5] Predict how either the orbital distance or orbital period changes given a change in the other variable according to Kepler's 3rd Law.
HS-ESS1-4 [6] Use Newton's Law of Gravitation, in addition to his 3rd Law of Motion, to: A. predict how the acceleration of a planet toward the sun varies with its distance from the sun. B. argue qualitatively about how this relates to the observed orbits.

Unit 1: Lab Physics **Science Support Resources / NJSLS Companion Standards /** **NJSLS Career Readiness and Preparation and Educational Technology**				
NJSLS Companion Standards		**HS-PS2-1**	**HS-PS2-4**	**HS-ESS 1-4**
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	X		
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.	X		
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.	X		
MP.2	Reason abstractly and quantitatively.	X	X	X
MP.4	Model with mathematics.	X	X	
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.	X	X	X
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.	X	X	X
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	X	X	X
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.	X	X	X
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.	X	X	
HSA-CED.A.1	Create equations and inequalities in one variable and use them to solve problems.	X		
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.	X		X
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.	X		X
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.	X		
HSS-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).	X		
NJSLS Career Readiness and Preparation and Educational Technology		**HS-PS2-1**	**HS-PS2-4**	**HS-ESS 1-4**
CRP 8	Utilize critical thinking to make sense of problems and persevere in solving them.			X
CRP 11	Use technology to enhance productivity.	X		
9.2.12.C.3	Identify transferable career skills and design alternate career plans.	X		

Unit 1: Lab Physics NGSS Practices / Components					
SCIENCE AND ENGINEERING PRACTICES **Full Description Available in NGSS Appendix F**			**HS-PS2-1**	**HS-PS2-4**	**HS-ESS1-4**
1	Asking questions (for science) and defining problems (for engineering)				
2	Developing and using models				
3	Planning and carrying out investigations				
4	Analyzing and interpreting data	Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	X		
5	Using mathematics and computational thinking	Use mathematical representations of phenomena to describe explanations.		X	X
6	Constructing explanations (for science) and designing solutions (for engineering)				
7	Engaging in argument from evidence				
8	Obtaining, evaluating, and communicating information				
CROSSCUTTING CONCEPTS **Full Description Available in NGSS Appendix G**			**HS-PS2-1**	**HS-PS2-4**	**HS-ESS1-4**
1	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.		X	
2	Cause and effect	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	X		
3	Scale, proportion, and quantity	The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).			X
4	Systems and system models				
5	Energy and matter				
6	Structure and function				
7	Stability and change				
CONNECTIONS TO THE NATURE OF SCIENCE **Full Description Available in NGSS Appendix H**			**HS-PS2-1**	**HS-PS2-4**	**HS-ESS1-4**
1	Scientific Investigations Use a Variety of Methods	Theories and laws provide explanations in science.	X	X	
2	Scientific Knowledge is Based on Empirical Evidence	Laws are statements or descriptions of the relationships among observable phenomena.	X	X	
3	Scientific Knowledge is Open to Revision in Light of New Evidence				

4	Scientific Models, Laws, Mechanisms & Theories Explain Natural Phenomena				
5	Science is a Way of Knowing				
6	Scientific Knowledge Assumes an Order & Consistency in Natural Systems				
7	Science is a Human Endeavor				
8	Science Addresses Questions About the Natural and Material World				
CONNECTIONS TO ENGINEERING TECHNOLOGY AND APPLICATION OF SCIENCE. Full Description Available in NGSS Appendix J			**HS-PS2-1**	**HS-PS2-4**	**HS-ESS1-4**
1	Interdependence of Science, Engineering, and Technology	Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.			X
2	Influence of Engineering, Technology, and Science on Society and the Natural World				

Lab Physics
Unit 2: Momentum
2.1 **Suggested Unit Pacing: 15 Sessions**

Essential Question: How do you protect yourself in a collision?

NJSLS-S Performance Expectations

HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.

Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-PS2-2 [1] Identify and describe the momentum of each object in a system as a product of mass and velocity, ρ = mv, using mathematical representations.

HS-PS2-2 [2a] Use the mathematical representations to model and describe:
Define a system of two interacting objects that is represented mathematically.

HS-PS2-2 [3a] Quantitatively identifies initial and final conditions of the system as well as the impulse on both objects in a system during a collision.

HS-PS2-2 [3b] Use the mathematical representations to model and describe:
the physical interaction of two objects in terms of the change in the momentum of each object as a result of the interaction.

HS-PS2-2 [4] Identify the claim that the total momentum of a system for two interacting objects is constant if there is no net force on the system.

HS-PS2-2 [5] Support the claim that:
A. that the total momentum of the system before and after an interaction within the system remains constant if there is no net force on the system.

B. any change in momentum of one object is balanced by a change in the momentum of the other object, so that the total momentum is constant.
HS-PS2-2 [6] Use the mathematical representations to model and describe: A change in momentum (impulse) requires an unbalanced force exerted over a period of time (this derivation relates to force and time) and force and time can change with impulse held constant.
HS-PS2-2 [7] Use the analysis of the motion of the objects before the interaction to identify a system with essentially no net force on it.

Lab Physics **Unit 2: Momentum** **2.2**
Essential Question: How do you protect yourself in a collision?
NJSLS-S Performance Expectations
HS-PS2-3* Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.] HS-ETS1.1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants HS-ETS1.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS2-3*[1] Analyze a major global problem resulting from collisions, including: A. a description of the challenge with a rationale for why it is a major global challenge (possible examples: car crash safety, sports equipment safety). B. a qualitative and quantitative description of the extent and depth of the problem and its major consequences to society and/or the natural world on both global and local scales if it remains unsolved. C. documented background research on the problem from two or more sources, including research journals.
HS-PS2-3* [2]Define the process or system boundaries and the components of the process or system by: A. identifying the physical system in which the problem is embedded, including the major elements and relationships in the system and boundaries so as to clarify what is and is not part of the problem; and B. describing the societal needs and wants that are relative to the problem.
HS-PS2-3* [3]Describe, both qualitatively and quantitatively, criteria and constraints for acceptable solutions to the problem.
HS-PS2-3* [4]Generate a finite set of two or more sub-problems (in writing, as a diagram, or flowchart) related to the original complex problem including two or more solutions that are based on student-generated data and/or scientific information from other sources (for at least one of the sub-problems) and descriptions of: A. how the solutions to the sub-problems are interconnected to solve all or part of the larger problem; B. the criteria and constraints for the selected sub-problem; C. the rationale for the sequence of how sub-problems are to be solved; and D. which criteria should be given highest priority if tradeoffs must be made.

HS-PS2-3* [5]Design a device that minimizes the force on a macroscopic object during a collision, including in the design: A. the concept that for a given change in momentum, force in the direction of the change in momentum is decreased by increasing the time interval of the collision ($F\Delta t = m\Delta v$). B. use of the principle above so that the device has the desired effect of reducing the net force exerted on the object by extending the time the force is exerted on the object during the collision. C. a description of the scientific rationale for their choice of materials and for the structure of the device.
HS-PS2-3* [6]Describe and quantify (when appropriate) the criteria and constraints, along with the tradeoffs implicit in the design solutions. Examples of constraints to be considered are: -cost -mass -the maximum force exerted on the object -requirements set by society for widely used collision-mitigation devices (e.g., seatbelts, football helmets, etc.)
HS-PS2-3* [7] Evaluate the proposed design or design solution for the device, including describing the rationale for the design: A. comparing the design to the list of criteria and constraints; B. testing the device based on its ability to minimize the force on the test object during a collision; C. identifying unanticipated effects or design performance issues that the device exhibits; and D. using testing results to improve the device performance by extending the impact time, reducing the device mass, and/or considering cost-benefit analysis.

UNIT 2: Lab Physics **Support Resources / NJSLS Companion Standards /** **NJSLS Career Readiness and Preparation and Educational Technology**			
NJSLS Companion Standards		**HS-PS2-2**	**HS-PS2-3** **HS-ETS1-1** **HS-ETS1-2**
MP.2	Reason abstractly and quantitatively.	X	X
MP.4	Model with mathematics.	X	X
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.	X	
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.	X	
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	X	
HSA.CED.A.1	Create equations and inequalities in one variable and use them to solve problems.	X	
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.	X	
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.	X	
WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating an understanding of the subject under investigation.		X
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.		X
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.		X
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent		X
NJSLS Career Readiness and Preparation and Educational Technology		**HS-PS2-2**	**HS-PS2-3**

			HS-ETS1-1 HS-ETS1-2
CRP 4	Communicate clearly and effectively and with reason	X	X
CRP 5	Consider the environmental, social and economic impacts of decisions.		X
CRP 6	Demonstrate creativity and innovation		X
CRP 7	Employ valid and reliable research strategies		X
CRP 8	Utilize critical thinking to make sense of problems and persevere in solving them.	X	X
9.2.12.C.3	Identify transferable career skills and design alternate career plans.	X	X

UNIT 2 Lab Physics **NGSS Practices / Components**				
SCIENCE AND ENGINEERING PRACTICES **Full Description Available in NGSS Appendix F**			**HS-PS2-2**	**HS-PS2-3** **HS-ETS1-1** **HS-ETS1-2**
1	Asking questions (for science) and defining problems (for engineering)			
2	Developing and using models			
3	Planning and carrying out investigations			
4	Analyzing and interpreting data			
5	Using mathematics and computational thinking	Use mathematical representations of phenomena to describe explanations.	X	
6	Constructing explanations (for science) and designing solutions (for engineering)	Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.		X
7	Engaging in argument from evidence			
8	Obtaining, evaluating, and communicating information			
CROSSCUTTING CONCEPTS **Full Description Available in NGSS Appendix G**			**HS-PS2-2**	**HS-PS2-3** **HS-ETS1-1** **HS-ETS1-2**
1	Patterns			
2	Cause and effect	Systems can be designed to cause a desired effect.		X
3	Scale, proportion, and quantity			
4	Systems and system models	When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.	X	
5	Energy and matter			
6	Structure and function			
7	Stability and change			
CONNECTIONS TO THE NATURE OF SCIENCE **Full Description Available in NGSS Appendix H**			**HS-PS2-2**	**HS-PS2-3** **HS-ETS1-1**

				HS-ETS1-2
1	Scientific Investigations Use a Variety of Methods			
2	Scientific Knowledge is Based on Empirical Evidence			
3	Scientific Knowledge is Open to Revision in Light of New Evidence			
4	Scientific Models, Laws, Mechanisms & Theories Explain Natural Phenomena			
5	Science is a Way of Knowing			
6	Scientific Knowledge Assumes an Order & Consistency in Natural Systems			
7	Science is a Human Endeavor			
8	Science Addresses Questions About the Natural and Material World			
CONNECTIONS TO ENGINEERING TECHNOLOGY AND APPLICATION OF SCIENCE. Full Description Available in NGSS Appendix J			**HS-PS2-2**	**HS-PS2-3 HS-ETS1-1 HS-ETS1-2**
1	Interdependence of Science, Engineering, and Technology			
2	Influence of Engineering, Technology, and Science on Society and the Natural World	New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.		X

Lab Physics
Unit 3: Energy
3.1 , 3.2 **Suggested Unit Pacing: 20 Sessions**

Essential Question: What does energy enable us to do?

NJSLS-S Performance Expectations

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).

[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

Phenomena - At what height would you need to drop your cell phone for your screen to crack?
(Shared with Chemistry*)

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

[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.]
[Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

Phenomena - The higher I jump from a diving board, the greater my speed when I hit the water.
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS3-1, 2 [1] Understand and describe the definition of work by using the computational model to describe the energy transfers.
HS-PS3-1, 2 [2] Develop models that include: A. a clear depiction of a macroscopic representation of the system objects, external objects, initial and final states, reference level (h = 0) B. kinetic energy associated with motion, gravitational potential energy associated with objects in gravitational fields, elastic potential energy associated with the stretch or compression of elastic objects, thermal energy. C. the energy transfers between the system and the surroundings
HS-PS3-1, 2 [3] Use their models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles/objects and energy associated with the relative positions of particles/objects on both the macroscopic and microscopic scales.
HS-PS3-1, 2 [4] Use their models to show that in closed systems the energy is conserved on both macroscopic and molecular/atomic scales, so that as one form of energy changes, the total system energy remains constant. This is evidenced by the other forms of energy changing only by the same amount or by the amount of energy that is transferred into or out of the system.
HS-PS3-1, 2 [5] Describe relationships between components in their models, including that: A. changes in the relative position of objects in gravitational or electrostatic fields can affect the amount of potential energy in the system. B. thermal energy includes both kinetic and potential energy of particle vibrations in solids or molecules; and the kinetic energy of freely moving particles in liquids and gasses. C. the total energy of the system and surroundings is conserved at a macroscopic and molecular level. D. as one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields.
HS-PS3-1, 2 [6] Use the algebraic descriptions of the initial and final energy states of the system, along with the energy transfers and transformations to create a computational model that is based on the principle of the conservation of energy. A. Utilize energy bar graphs. B. Recognize where the energy transfers are, whether or not energy is entering or leaving the system, and find missing variables based on the conservation of energy. C. Create the conservation equation using a bar graph. D. Identify objects in the system, initial and final states, energy types in initial and final states, and if energy has entered or left the system.
HS-PS3-1, 2 [7] Use the computational model to predict the maximum possible change in the energy of one component of the system for a given set of energy transfers and transformations.
HS-PS3-1, 2 [8] Identify and describe the limitations of the computational model, based on the assumptions that were made in creating the algebraic descriptions of energy changes and flows in the system.

Lab Physics **Unit 3: Energy** **3.3**
Essential Question: What does energy enable us to do?
NJSLS-S Performance Expectations

HS-PS3-3* Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.] HS-EST1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for solutions that account for societal needs and wants. **Note: Both Physics and Chemistry will address the entire standard. Physics will address energy conversion at the macroscopic level. Chemistry will address energy transformation on the microscopic level of chemical reactions.**
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS3-3* [1] Analyze a major global problem regarding energy conversion. Using qualitative and quantitative analysis: A. describe a major global challenge with a rationale. B. describe the major consequences to society and/or the natural world on both global and local scales if it remains unsolved. C. document background research on the problem from two or more sources, including research journals.
HS-PS3-3* [2] Identify in their analysis the physical system in which the problem is embedded, including A. the major elements, relationships, and boundaries in the system B. clarification of what is and is not part of the problem
HS-PS3-3* [3] Describe in their analysis the societal needs and wants that are relevant to the problem.
HS-PS3-3* [4] Specify qualitative and quantitative criteria and constraints for acceptable solutions to the problem.
HS-PS3-3* [5] Design a device that converts one form of energy into another form of energy.
HS-PS3-3* [6] Develop a plan for the device in which they: A. identify what scientific principles provide the basis for the energy conversion design. B. identify the forms of energy that will be converted from one form to another in the designed system. C. identify transfer of energy by the design to the surrounding environment. D. describe the scientific rationale for choices of materials and structure of the device, including how student-generated evidence influenced the design. E. describe that this device is an example of how the application of scientific knowledge and engineering design can increase benefits for modern civilization while decreasing costs and risks.
HS-PS3-3* [8] Build and test their devices according to the plan.
HS-PS3-3* [9] Evaluate quantitatively the performance of their device relative to criteria and constraints.
HS-PS3-3* [10] Use the results of their evaluation in order to create improvements for their device within the defined criteria and constraints, noting any modifications in tradeoffs.

UNIT 3: Lab Physics Science Support Resources / NJSLS Companion Standards / NJSLS Career Readiness and Preparation and Educational Technology				
NJSLS Companion Standards		**HS-PS3-2**	**HS-PS3-1**	**HS-PS3-3 HS-ETS1-1**
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;			X

	synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.			
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.	X	X	
MP.2	Reason abstractly and quantitatively.	X	X	X
MP.4	Model with mathematics.	X	X	X
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.		X	X
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.		X	X
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.		X	X
NJSLS Career Readiness and Preparation and Educational Technology		**HS-PS3-2**	**HS-PS3-1**	**HS-PS3-3** **HS-ETS1-1**
CRP 4	Communicate clearly and effectively and with reason			X
CRP 5	Consider the environmental, social and economic impacts of decisions.			X
CRP 6	Demonstrate creativity and innovation			X
CRP 7	Employ valid and reliable research strategies			X
CRP 8	Utilize critical thinking to make sense of problems and persevere in solving them.	X	X	X
9.2.12.C.3	Identify transferable career skills and design alternate career plans.			X

UNIT 3 Lab Physics Science **NGSS Practices / Components**					
SCIENCE AND ENGINEERING PRACTICES **Full Description Available in NGSS Appendix F**			**HS-PS3-2**	**HS-PS3-1**	**HS-PS3-3** **HS-ETS1-1**
1	Asking questions (for science) and defining problems (for engineering)				
2	Developing and using models	Develop a model based on evidence to illustrate the relationships between systems or between components of a system. Use a model to provide mechanistic accounts of phenomena.	X		
3	Planning and carrying out investigations				
4	Analyzing and interpreting data				
5	Using mathematics and computational thinking	Create a computational model or simulation of a phenomenon, designed device, process, or system.		X	
6	Constructing explanations (for science) and designing solutions (for engineering)	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 trade off considerations.			X
7	Engaging in argument from evidence				
8	Obtaining, evaluating, and communicating information				
CROSSCUTTING CONCEPTS **Full Description Available in NGSS Appendix G**			**HS-PS3-2**	**HS-PS3-1**	**HS-PS3-3** **HS-ETS1-1**

1	Patterns				
2	Cause and effect				
3	Scale, proportion, and quantity				
4	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. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.		X	
5	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. Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.	X		X
6	Structure and function				
7	Stability and change				
CONNECTIONS TO THE NATURE OF SCIENCE **Full Description Available in NGSS Appendix H**			**HS-PS3-2**	**HS-PS3-1**	**HS-PS3-3** **HS-ETS1-1**
1	Scientific Investigations Use a Variety of Methods				
2	Scientific Knowledge is Based on Empirical Evidence				
3	Scientific Knowledge is Open to Revision in Light of New Evidence				
4	Scientific Models, Laws, Mechanisms & Theories Explain Natural Phenomena				
5	Science is a Way of Knowing				
6	Scientific Knowledge Assumes an Order & Consistency in Natural Systems	Science assumes the universe is a vast single system in which basic laws are consistent.		X	
7	Science is a Human Endeavor				
8	Science Addresses Questions About the Natural and Material World				
CONNECTIONS TO ENGINEERING TECHNOLOGY AND APPLICATION OF SCIENCE. Full Description Available in NGSS Appendix			**HS-PS3-2**	**HS-PS3-1**	**HS-PS3-3** **HS-ETS1-1**
1	Interdependence of Science, Engineering, and Technology				
2	Influence of Engineering, Technology, and Science on Society and the Natural World	Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.			X

Lab Physics
Unit 4: Electric Force & Field
4.1 **Suggested Unit Pacing: 15 Sessions**

Essential Question: Why do you sometimes get shocked when touching a doorknob?

NJSLS-S Performance Expectations

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. (Bold only)**

[Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.]

[Assessment Boundary: Assessment is limited to systems with two objects.]

Note: HS-PS2-4 was started in Unit 1 with unpacked [1-3]

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-PS2-4 [4] In order to describe and predict the electrostatic force between objects, clearly define the system of interacting objects that are mathematically represented.

HS-PS2-4 [5] Use the given mathematical representation to:
A. identify and describe the electrostatic force between two objects is the product of their individual charges divided by the separation distance squared (Fe = k q1 q2/ d^2), where a negative force is
B. Clarification: - Force directions should be described (attractive/repulsive) and drawn (force diagrams).
C. recognize by what factor force will increase if the charge and/or distance is changed.
D. relate the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance.
E. quantitatively predict the electrostatic force between charged objects.

HS-PS2-4 [6] A. Describe that the mathematical representation of the electric field predicts both attraction and repulsion because electric charge can be either positive or negative.
B. Read and draw charges in a uniform E-field, and demonstrate the direction of the force exerted on the charge based on direction of the field, or vice versa.

HS-PS2-4 [7] Describe the cause and effect relationships between forces produced by electric or magnetic fields and the change of energy of objects in the system.

Lab Physics
Unit 4: Electric Force & Field
4.2

Essential Question: Why do you sometimes get shocked when touching a doorknob?

NJSLS-S Performance Expectations

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

[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.]

[Assessment Boundary: Assessment is limited to systems containing two objects.]

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-PS3-5 [1] Use the given formulas as evidence to describe that the change in the energy of objects interacting through electric forces depends on the distance between the objects.

HS-PS3-5 [2] Identify and describe relevant components to illustrate forces and changes in energy when two objects in a system

interact, including: A. the positions and velocities (limited to one dimension) at the initial and final states B. nature of interaction (electric or magnetic) C. relative magnitude and direction of the net forces D. representation of a field as a quantity that has magnitude and direction at all points in space
HS-PS3-5 [3] Develop a model to illustrate the forces and changes in energy involved when two objects interact, including: A. a drawing of the force exerted on a charge in the proper direction when it is placed in an E-field. For uniform E-fields, find out how much Electric Potential Energy is gained or lost ($U_e = -qE\Delta d$). B. an energy bar graph that can be used to create a conservation of energy equation C. ways to solve for a missing variable for a charge accelerating in an E-field D. a description of the relationships between components, including change in energy, given initial and final positions and velocities.
HS-PS3-5 [4] Determine whether electric potential energy increases, decreases, or remains the same when objects within a system interact.
HS-PS3-5 [5] Support the claim that the change in the electric potential energy (positive, negative, or zero) is consistent with the changes of energies of the objects in the system.

Lab Physics **Unit 4: Electric Force & Field** **4.3**
Essential Question: Why do you sometimes get shocked when touching a doorknob?
NJSLS-S Performance Expectations
HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS2-5 [1] Identify the data that will be collected and the evidence to be derived from the data about: A. an observable effect of a magnetic field that is uniquely related to the presence of an electric current in the circuit, and B. an electric current in the circuit that is uniquely related to the presence of a changing magnetic field near the circuit.
HS-PS2-5 [2] Plan for the investigation, to POTENTIALLY include: A. the use of an electric circuit through which electric current can flow, a source of electrical energy that can be placed in the circuit, the shape and orientation of the wire and the types and positions of detectors. B. a means to indicate or measure when electric current is flowing through the circuit. C. a means to indicate or measure the presence of a local magnetic field near the circuit. D. a design of a system to change the magnetic field in a nearby circuit and a means to indicate or measure when the magnetic field is changing. E. a statement of whether the investigation will be conducted individually or collaboratively.
HS-PS2-5 [3] Evaluate their investigation, including an evaluation of: A. the accuracy and precision of the data collected, as well as limitations of the investigations. B. the ability of the data to provide the evidence required. C. refine the investigation plan as needed to produce more accurate, precise, and useful data such that the measurements or indicators of the presence of an electric current in the circuit and a magnetic field near the circuit can provide the required evidence. D. why these observed effects must be causal and not correlational, citing specific cause-effect relationships

UNIT 4: Lab Physics **Support Resources / NJSLS Companion Standards /** **NJSLS Career Readiness and Preparation and Educational Technology**

NJSLS Companion Standards		HS-PS2-4	HS-PS3-5	HS-PS2-5
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.		X	
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 over reliance on any one source and following a standard format for citation.		X	X
WHST.9-12.9	Draw evidence from informational text to support analysis, reflection, and research.		X	
WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.			X
WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.			X
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		X	
MP.2	Reason abstractly and quantitatively.	X	X	X
MP.4	Model with mathematics.	X	X	X
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.	X		X
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.	X		X
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurements when reporting quantities.	X		X
HSN-SSE.A.1	Interpret expressions that represent a quantity in terms of its context	X		
HSN-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.	X		
NJSLS Career Readiness and Preparation and Educational Technology		**HS-PS2-4**	**HS-PS3-5**	**HS-PS2-5**
CRP6	Demonstrate creativity and innovation			X
CRP 8	Utilize critical thinking to make sense of problems and persevere in solving them	X	X	X
9.2.12.C.3	Identify transferable career skills and design alternate career plans.	X		X

UNIT 4 Lab Physics Science NGSS Practices / Components					
SCIENCE AND ENGINEERING PRACTICES **Full Description Available in NGSS Appendix F**			**HS-PS2-4**	**HS-PS3-5**	**HS-PS2-5**
1	Asking questions (for science) and defining problems (for engineering)				
2	Developing and using models	Develop a model based on evidence to illustrate the relationships between systems or between components of a system		X	
3	Planning and carrying out investigations	Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.			X

4	Analyzing and interpreting data				
5	Using mathematics and computational thinking	Use mathematical representations of phenomena to describe explanations	X		
6	Constructing explanations (for science) and designing solutions (for engineering)				
7	Engaging in argument from evidence	Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.			
8	Obtaining, evaluating, and communicating information				
CROSSCUTTING CONCEPTS Full Description Available in NGSS Appendix G			**HS-PS2-4**	**HS-PS3-5**	**HS-PS2-5**
1	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.	X		
2	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. Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.		X	X
3	Scale, proportion, and quantity				
4	Systems and system models				
5	Energy and matter	Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.			
6	Structure and function				
7	Stability and change				
CONNECTIONS TO THE NATURE OF SCIENCE Full Description Available in NGSS Appendix H			**HS-PS2-4**	**HS-PS3-5**	**HS-PS2-5**
1	Scientific Investigations Use a Variety of Methods				
2	Scientific Knowledge is Based on Empirical Evidence				
3	Scientific Knowledge is Open to Revision in Light of New Evidence				
4	Scientific Models, Laws, Mechanisms & Theories Explain Natural Phenomena				
5	Science is a Way of Knowing				
6	Scientific Knowledge Assumes an Order & Consistency in Natural Systems				
7	Science is a Human Endeavor				
8	Science Addresses Questions About the Natural and Material World				
CONNECTIONS TO ENGINEERING TECHNOLOGY AND APPLICATION OF SCIENCE. Full Description Available in NGSS Appendix J			**HS-PS2-4**	**HS-PS3-5**	**HS-PS2-5**

1	Interdependence of Science, Engineering, and Technology				
2	Influence of Engineering, Technology, and Science on Society and the Natural World				

Lab Physics
Unit 5: Waves & Particles
5.1 **Suggested Unit Pacing: 20 Sessions**

Essential Question: How can phenomena be waves, particles and neither?

NJSLS-S Performance Expectations

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

[Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.]

[Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-PS4-1[1]
-Identify and describe the basic attributes of periodic motion (i.e. $f = 1/T$).

HS-PS4-1[2] For waves propagating in various specified media,
- identify and describe the relevant components in the mathematical representation $v=\lambda f$ and the relationships between frequency, wavelength, and speed of waves.
-Identify the types and properties of physical waves.
a. Define a wave as a propagation of energy from one place to another.
b. Identify the core differences between mechanical and electromagnetic waves.
c. Identify the difference between transverse and longitudinal mechanical waves.
d. Identify the parts of a transverse (wavelength, amplitude, crest, trough) and longitudinal (compression, rarefaction) waves.
e. Define the definitions and relationship between frequency and period. ($f = 1/T$)

HS-PS4-1[3] Use the mathematical relationship $v=\lambda f$ to:
A. assess claims about any of the three quantities when the other two quantities are known (i.e., evaluate whether a claim is supported by evidence or empirical mathematical relationship - given two of the variables, students should be able to find the third).
B. distinguish between cause and correlation with respect to the supported claims.
C. demonstrate that the product of the frequency and the wavelength of a particular wave is the speed of the wave and is constant in a given medium.

HS-PS4-1[4] Use data to show that the wave speed for a particular type of wave changes as the medium through which the wave propagates changes.

HS-PS4-1[5] Predict the relative change in the wavelength of a wave when it moves from one medium to another and express the relative change in terms of cause (different media with different wave speed) and effect (different wavelengths but same frequency). $v/f = \lambda$

Lab Physics
Unit 5: Waves & Particles
5.2

Essential Question: How can phenomena be waves, particles and neither?

NJSLS-S Performance Expectations
HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS4-3[1] Identify the claims, evidence, and the reasoning behind the explanation that electromagnetic radiation can be described by either a wave model or a particle model.
HS-PS4-3[2] Analyze the given evidence for interference behavior of electromagnetic radiation to determine how it supports the argument that electromagnetic radiation can be described by a wave model.
HS-PS4-3[3] Analyze the phenomenon of the photoelectric effect to determine how it supports the argument that electromagnetic radiation can be described by a particle model.
HS-PS4-3[4] Evaluate the given claims and reasoning for modeling electromagnetic radiation as both a wave and a particle, considering: A. the transfer of energy and information within and between systems B. which model, wave or particle, is more useful to describe the transfer of energy and information.

Lab Physics **Unit 5: Waves & Particles** **5.3 s**
Essential Question: How can phenomena be waves, particles and neither?
NJSLS-S Performance Expectations
HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS4-4[1] Evaluate at least two provided claims proposed in published material regarding the effect of electromagnetic radiation that is absorbed by matter. A. Use two sources per claim. B. One source should address the effect of electromagnetic radiation on living tissue.
HS-PS4-4[2] Evaluate the validity and reliability about the data presented in the claims, including: A. the energies of the photons involved (i.e., relative wavelengths) B. the probability of ionization.
HS-PS4-4[3] Evaluate the validity and reliability of the sources of the claims.
HS-PS4-4[4] Describe the cause and effect reasoning in each claim, including the extrapolations to larger scales versus smaller scales.

Lab Physics

Unit 5: Waves & Particles
5.4

Essential Question: How can phenomena be waves, particles and neither?

NJSLS-S Performance Expectations

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.*

[Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that count for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-PS4-5* [1] Discuss the real-world problem the device solves or need it addresses, and how civilization now depends on each device.

HS-PS4-5* [2] Describe fully at least two devices and the physical principles upon which the devices depend.

HS-PS4-5* [3] Identify the wave behavior utilized by the device OR the absorption of photons and electrons for devices that rely on the photoelectric effect.

HS-PS4-5* [4] Propose a revision/improvement to the solution to improve effectiveness/increase efficiency and analyze its strengths and weaknesses.
This analysis should include:
A. cost
B. safety
C. reliability
D. aesthetics
E. environmental impacts

HS-PS4-5* [5] Evaluate the proposed solution including:
A. a list of three or more realistic criteria and two or more constraints
B. prioritization of the criteria and constraints
C. barriers to be overcome
D. parts of the complex real-world problem that may remain even if the proposed solution is implemented

Lab Physics
Unit 5: Waves & Particles
5.5

Essential Question: How can phenomena be waves, particles and neither?

NJSLS-S Performance Expectations

HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.

[Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-PS4-2 [1] A. Provide examples of features associated with digital transmission and storage of information. B. Describe the stability and importance of systems that employ digital information.
HS-PS4-2 [2] Discuss the relevance of digital transmission and storage of information to real-life examples (e.g. emailing your homework to a teacher copying music, using the internet for research, social media).
HS-PS4-2 [3] Given questions about the advantages of using digital transmission and storage of information, evaluate whether the questions are relevant and testable with empirical evidence.

UNIT 5: Lab Physics
Support Resources / NJSLS Companion Standards /
NJSLS Career Readiness and Preparation and Educational Technology

NJSLS Companion Standards		**HS-PS4-1**	**HS-PS4-3**	**HS-PS4-4**	**HS-PS4-5 HS-ETS1-3**	**HS-PS4-2**
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.		X	X		X
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.		X	X		X
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.	X		X	X	
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.		X	X	X	X
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.				X	
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.				X	
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 over reliance on any one source and following a standard format for citation.			X		
MP.2	Reason abstractly and quantitatively.	X	X		X	
MP.4	Model with mathematics.	X			X	
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.	X	X			
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.	X	X			
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.	X	X			
NJSLS Career Readiness and Preparation and Educational Technology		**HS-PS4-1**	**HS-PS4-3**	**HS-PS4-4**	**HS-PS4-5 HS-ETS1-3**	**HS-PS4-2**
CRP 4	Communicate clearly and effectively and with reason		X		X	

CRP 5	Consider the environmental, social and economic impacts of decisions.				X	
CRP 6	Demonstrate creativity and innovation				X	
CRP 7	Employ valid and reliable research strategies				X	
CRP 8	Utilize critical thinking to make sense of problems and persevere in solving them.	X	X		X	X
9.2.12.C.3	Identify transferable career skills and design alternate career plans.				X	X

UNIT 5 Lab Physics **NGSS Practices / Components**							
SCIENCE AND ENGINEERING PRACTICES **Full Description Available in NGSS Appendix F**			**HS-PS4-1**	**HS-PS4-3**	**HS-PS4-4**	**HS-PS4-5** **HS-ETS1-3**	**HS-PS4-2**
1	Asking questions (for science) and defining problems (for engineering)	Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.					X
2	Developing and using models						
3	Planning and carrying out investigations						
4	Analyzing and interpreting data						
5	Using mathematics and computational thinking	Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	X				
6	Constructing explanations (for science) and designing solutions (for engineering)	Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.				X	
7	Engaging in argument from evidence	Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.		X			
8	Obtaining, evaluating, and communicating information	Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).			X	X	
CROSSCUTTING CONCEPTS **Full Description Available in NGSS Appendix G**			**HS-PS4-1**	**HS-PS4-3**	**HS-PS4-4**	**HS-PS4-5** **HS-ETS1-3**	**HS-PS4-2**
1	Patterns						
2	Cause and effect	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. 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. Systems can be designed to cause a desired effect.	X		X	X	

3	Scale, proportion, and quantity						
4	Systems and system models	Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales.		X			
5	Energy and matter						
6	Structure and function						
7	Stability and change						
CONNECTIONS TO THE NATURE OF SCIENCE **Full Description Available in NGSS Appendix H**			**HS-PS4-1**	**HS-PS4-3**	**HS-PS4-4**	**HS-PS4-5** **HS-ETS1-3**	**HS-PS4-2**
1	Scientific Investigations Use a Variety of Methods						
2	Scientific Knowledge is Based on Empirical Evidence						
3	Scientific Knowledge is Open to Revision in Light of New Evidence						
4	Scientific Models, Laws, Mechanisms & Theories Explain Natural Phenomena	A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment. The science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.		X			
5	Science is a Way of Knowing						
6	Scientific Knowledge Assumes an Order & Consistency in Natural Systems						
7	Science is a Human Endeavor						
8	Science Addresses Questions About the Natural and Material World						
CONNECTIONS TO ENGINEERING TECHNOLOGY AND APPLICATION OF SCIENCE. Full Description Available in NGSS Appendix J			**HS-PS4-1**	**HS-PS4-3**	**HS-PS4-4**	**HS-PS4-5** **HS-ETS1-3**	**HS-PS4-2**
1	Interdependence of Science, Engineering, and Technology	Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. Science and engineering complement each other in the cycle known as research and development (R&D)				X	
2	Influence of Engineering, Technology, and Science on Society and the Natural World	Modern civilization depends on major technological systems. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.				X	X

		Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.						

Lab Physics **Unit 6: Geo- & Astrophysics** **6.1** **Suggested Unit Pacing: 20 Sessions**
Essential Question: How did it all begin and where is it all going?
NJSLS-S Performance Expectations
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. [Clarification Statement: Emphasis is on the astronomical evidence of the redshift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gasses (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-ESS1-2 [1] Construct an explanation that includes: A. how astronomical evidence from numerous sources is used collectively to support the Big Bang theory. B. the universe is expanding and that it was therefore hotter and denser in the past. C. that the entire visible universe emerged from a very tiny region and expanded.
HS-ESS1-2 [2] Identify and describe the astronomical evidence supporting the Big Bang Theory including: A. the composition of stars, the hydrogen-helium ratio of stars and interstellar gasses, the redshift of the majority of galaxies, and the existence of cosmic background radiation. B. the source of the evidence and the technology used to obtain that evidence. C. their own evidence-based investigations, models, simulations, and peer review.
HS-ESS1-2 [3] Use reasoning to connect evidence to their explanation, including: A. the observed background cosmic radiation and the ratio of hydrogen to helium have been shown to be consistent with a universe that was very dense and hot a long time ago. B. an expanding universe must have been smaller in the past and can be extrapolated back in time to a tiny size from which it expanded. C. why redshift indicates an object is moving away from the observer. D. the observed redshift for most galaxies and the redshift vs. distance relationship is evidence that the universe is expanding.

Lab Physics **Unit 6: Geo- & Astrophysics** **6.2**
Essential Question: How did it all begin and where is it all going?
NJSLS-S Performance Expectations
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 in the form of radiation. **(shared with Chemistry)** [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over

centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-ESS1-1 [1] Use oral, written, and pictorial representation to develop a model to identify and describe the reaction that occurs in the Sun, including: A. hydrogen as the Sun's fuel; B. helium and energy as the products of fusion processes in the Sun; and C. that the lifespan of the Sun, like all stars, is based on the amount of starting material. D. the Sun's reaction can occur for 10 billion years. E. when reactants run out, the star burns out.
HS-ESS1-1 [2] Describe the process of radiation to transfer energy and how energy from the Sun's fusion reaction reaches Earth.

Lab Physics **Unit 6: Geo- & Astrophysics** **6.3**
Essential Question: How did it all begin and where is it all going?
NJSLS-S Performance Expectations
HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements. **(shared with Chemistry)** [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of different masses are not assessed.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-ESS1-3 [1]Use at least two different formats (written, oral, pictorial, or kinesthetic) to communicate scientific ideas about the way stars, over their life cycle, produce elements and cite the origin of information as appropriate.
HS-ESS1-3 [2]Identify and describe: A. the life cycle of stars and how it compares to the production of new elements. B. that when new elements are produced in fusion number of protons and neutrons are conserved (not the atoms of specific elements). C. the relationship between the mass of the star and the elements produced by fusion. D. the relationship between the stage of the star's development and the element created by its fusion reactions.

Lab Physics **Unit 6: Geo- & Astrophysics** **6.4**
Essential Question: How did it all begin and where is it all going?
NJSLS-S Performance Expectations
HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include

maps of Earth’s three-dimensional structure obtained from seismic waves, records of the rate of change of Earth’s magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth’s layers from high-pressure laboratory experiments.]

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-ESS2-3[1] Develop a model in which students identify and describe the components of Earth’s interior based on both seismic and magnetic evidence, including:
A. Earth’s interior in cross-section and radial layers (crust, mantle, liquid outer core, solid inner core) determined by density.
B. tectonic plate activity in the outer part of the geosphere.
C. radioactive decay and residual thermal energy from the formation of the Earth as a source of energy.
D. the transfer of thermal energy from the surface of the Earth to the surrounding environment.
E. the process of convection that causes hotter matter to rise and cooler matter to sink.

HS-ESS2-3[2] Describe relationships between different components in the model including:
A. energy from radioactive decay in Earth’s crust and mantle and residual thermal energy from the formation of Earth drives the movement of matter in the mantle.
B. thermal energy is released at the surface of the Earth as new crust is formed and cooled.
C. the flow of matter by convection in the solid mantle and the sinking of cold, dense crust back into the mantle exert forces on crustal plates that then move, producing tectonic activity.
D. matter can move between the crust and the mantle through subduction or plate separation.
E. there is a significant amount of thermal energy released by radioactive decay in Earth’s crust and mantle.

HS-ESS2-3[3] Use the developed model to describe the cycling of matter by thermal convection in Earth’s interior, including:
A. the flow of matter in the mantle that causes crustal plates to move.
B. the flow of matter in the outer liquid core causes Earth’s magnetic field.
C. evidence of changes in the direction of Earth’s magnetic fields includes surveys of historical pottery shards and seafloor exploration to find evidence.
D. the different layers of Earth's interior are separated by density.

Lab Physics
Unit 6: Geo- & Astrophysics
6.5

Essential Question: How did it all begin and where is it all going?

NJSLS-S Performance Expectations

HS-ESS2-1 Develop a model to illustrate how Earth’s internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

[Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).]

[Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth’s surface.]

Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-ESS2-1[1]Use evidence to develop a model in which they identify and describe the following components: A. descriptions and locations of specific continental features and specifics ocean-floor features B. a geographical scale, showing the relative sizes/extents of continental and/or ocean-floor features C. internal processes (such as volcanism and tectonic uplift) and surface processes (such as weathering and erosion) D. a temporal scale showing the relative times over which processes act to produce continental and/or ocean-floor features.
HS-ESS2-1[2]Use the model to describe the relationships between components, including: A. specific internal processes, mainly volcanism, mountain building or tectonic uplift, are identified as causal agents in building up Earth's surface over time. B. specific surface processes, mainly weathering and erosion, are identified as causal agents in wearing down Earth's surface over time. C. interactions and feedbacks between processes are identified (e.g., mountain-building changes weather patterns that then change the rate of erosion of mountains). D. the rate at which the features change is related to the time scale on which the processes operate. E. features that form or change slowly due to processes that act on long time scales (e.g., continental position due to plate drift). F. features that form or change rapidly due to processes that act on short time scales (e.g., volcanic eruptions).

Lab Physics **Unit 6: Geo- & Astrophysics** **6.6**
Essential Question: How did it all begin and where is it all going?
NJSLS-S Performance Expectations
HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. **(shared with Chemistry)** Clarification Statement: Emphasis is on mechanical (Physics) and chemical (Chemistry) investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes.
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-ESS2-5 [1] Analyze measurements or indications of the predicted effect of a property of water (transportation, deposition, and erosion) on Earth's materials or surface.
HS-ESS2-5 [2] Design an investigation into the mechanical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include: -stream transportation and deposition and the ability of water to prevent or facilitate movement of Earth materials. -erosion and the ability of water or prevent or facilitate movement of Earth materials.
HS-ESS2-5 [3] In the investigation include a means to indicate or measure the predicted effect of water on Earth's materials or surface processes. Include the role of flowing water to pick up, move and deposit sediment.

Lab Physics **Unit 6: Geo- & Astrophysics** **6.7**
Essential Question: How did it all begin and where is it all going?
NJSLS-S Performance Expectations

HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems. [Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gasses causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:
HS-ESS2-2[1]Make a claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems by: A. Organizing data that represent measurements of changes in the hydrosphere, cryosphere, atmosphere, biosphere, and geosphere in response to a change in Earth's surface. B. Describing what each given data set represents. C. Using tools, technologies, and/or models to analyze the data.
HS-ESS2-2[2]Identify and describe the relationships in datasets, including: A. The relationships between the changes in one system and changes in another (or within the same) Earth system. B. Possible feedback, including one example of feedback to the climate.
HS-ESS2-2[3]Analyze data to identify effects of human activity and specific technologies on Earth's system if present.
HS-ESS2-2[4]Use the analyzed data to describe a mechanism for the feedback between two of Earth's systems and whether or not the feedback is positive/destabilizing/increasing or negative/stabilizing/decreasing the original changes.

Lab Physics **Unit 6: Geo- & Astrophysics** **6.8**
Essential Question: How did it all begin and where is it all going?
NJSLS-S Performance Expectations
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. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]
Standards-Aligned Objectives. Instruction and assessment will align to the following objectives:

HS-ESS2-4[1] Analyze a model and identify the components of the model relevant for their mechanistic descriptions. Given models should include at least one factor that affects the output of energy, and at least one factor that affects the storage and redistribution of energy. Factors should be derived from the following list:
A. changes in Earth's orbit and the orientation of its axis
B. changes in the Sun's energy output
C. atmospheric composition (including amount of water vapor and CO_2)
D. glaciation
E. human activities
F. Earth's Energy Budget

HS-ESS2-4[2] Identify and describe the relationships between components of the model and organize the factors from the given model into three groups:
A. those that affect the input of energy,
B. the output of energy, and
C. the storage and redistribution of energy.

HS-ESS2-4[3] Describe the relationships between components of the model as either causal or correlational.

HS-ESS2-4[4] Use the given model to provide a mechanistic account of the relationship between energy transfer between Earth's systems and changes in climate, including:
A. the specific cause and effect relationships between the factors and the effect on energy flow into and out of the Earth's systems; and
B. the net effect of all of the competing factors in changing the climate.

UNIT 6: Lab Physics Science
Support Resources / NJSLS Companion Standards /
NJSLS Career Readiness and Preparation and Educational Technology

NJSLS Companion Standards		**HS-ESS1-2**	**HS-ESS1-1**	**HS-ESS1-3**	**HS-ESS2-2**	**HS-ESS2-4**	**HS-ESS2-5**	**HS-ESS2-1**	**HS-ESS2-3**
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	X	X						
RST.11-12.2	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.				X				
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes	X		X					
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						X		
SL.11-12.4	Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.			X					
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					X		X	X

MP.2	Reason abstractly and quantitatively.	X	X	X					
MP.4	Model with mathematics.		X						
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	X	X						
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.	X	X						
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	X	X						
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context	X	X						
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.	X	X						
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.	X	X						
NJSLS Career Readiness and Preparation and Educational Technology		**HS-ESS1-2**	**HS-ESS1-1**	**HS-ESS1-3**	**HS-ESS2-2**	**HS-ESS2-4**	**HS-ESS2-5**	**HS-ESS2-1**	**HS-ESS2-3**
CRP 4	Communicate clearly and effectively and with reason	X		X			X		
CRP 5	Consider the environmental, social and economic impacts of decisions.						X		
CRP 6	Demonstrate creativity and innovation						X		
CRP 7	Employ valid and reliable research strategies				X		X		
CRP 8	Utilize critical thinking to make sense of problems and persevere in solving them.				X		X		
9.2.12.C.3	Identify transferable career skills and design alternate career plans.				X		X		

UNIT 6 Lab Physics Science **NGSS Practices / Components**										
SCIENCE AND ENGINEERING PRACTICES Full **Description Available in NGSS Appendix F**			**HS-ESS1-2**	**HS-ESS1-1**	**HS-ESS1-3**	**HS-ESS2-2**	**HS-ESS2-4**	**HS-ESS2-5**	**HS-ESS2-1**	**HS-ESS2-3**
1	Asking questions (for science) and defining problems (for engineering)									
2	Developing and using models	Develop a model based on evidence to illustrate the relationships between systems or between components of a system.		X					X	X
3	Planning and carrying out investigations	Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations						X		

		on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.								
4	Analyzing and interpreting data	Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.				X				
5	Using mathematics and computational thinking									
6	Constructing explanations (for science) and designing solutions (for engineering)	Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	X							
7	Engaging in argument from evidence									
8	Obtaining, evaluating, and communicating information	Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).			X					
CROSSCUTTING CONCEPTS **Full Description Available in NGSS Appendix G**			**HS-ESS1-2**	**HS-ESS1-1**	**HS-ESS1-3**	**HS-ESS2-2**	**HS-ESS2-4**	**HS-ESS2-5**	**HS-ESS2-1**	**HS-ESS2-3**
1	Patterns									
2	Cause and effect									
3	Scale, proportion, and quantity	Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).		X						
4	Systems and system models									
5	Energy and matter	Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	X		X					
6	Structure and function									
7	Stability and change									
CONNECTIONS TO THE NATURE OF SCIENCE **Full Description Available in NGSS Appendix H**			**HS-ESS1-2**	**HS-ESS1-1**	**HS-ESS1-3**	**HS-ESS2-2**	**HS-ESS2-4**	**HS-ESS2-5**	**HS-ESS2-1**	**HS-ESS2-3**
1	Scientific Investigations Use a Variety of Methods									

2	Scientific Knowledge is Based on Empirical Evidence	Science knowledge is based on empirical evidence. (HS-ESS2-3) Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3) Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3) Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4)					X			X
3	Scientific Knowledge is Open to Revision in Light of New Evidence									
4	Scientific Models, Laws, Mechanisms & Theories Explain Natural Phenomena	A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	X							
5	Science is a Way of Knowing									
6	Scientific Knowledge Assumes an Order & Consistency in Natural Systems									
7	Science is a Human Endeavor									
8	Science Addresses Questions About the Natural and Material World									
CONNECTIONS TO ENGINEERING TECHNOLOGY AND APPLICATION OF SCIENCE. Full Description Available in NGSS Appendix J			**HS-ESS1-2**	**HS-ESS1-1**	**HS-ESS1-3**	**HS-ESS2-2**	**HS-ESS2-4**	**HS-ESS2-5**	**HS-ESS2-1**	**HS-ESS2-3**
1	Interdependence of Science, Engineering, and Technology	Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	X							X
2	Influence of Engineering, Technology, and Science on Society and the Natural World	Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.	X			X				

NJSLS Career Awareness, Exploration, Preparation, and Training, and Life Literacies and Key Skills	Unit

9.4.12.CI.1	Demonstrate the ability to reflect, analyze and use creative skills and ideas.	1-6
9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement and transition	2-4
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice.	1,2
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving.	1-6
9.4.12.CT.4	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).	4
9.4.12.TL.1	Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task	1-6
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.	4
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.	1-6
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.	1-6
9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.	1-6
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.	1-6
9.4.12.IML.9	Evaluate media sources for point of view, bias and motivations.	1-6
9.4.12.IML.10	Analyze the decisions creators make to reveal explicit and implicit messages within information and media.	1-6

(*) ID 9.2.12.CAP.11 duplicated in NJDOE NJSLS file page 1 and 2