Honors Physics (9^{th} Grade)

Summit High School
Summit, NJ

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Course Description

Physics is the science of matter and energy, space and time. As the most fundamental science, physics provides a supporting foundation for the other natural sciences, such as chemistry, biology, astronomy, and environmental science. Studying physics is key for understanding natural laws that govern the very big, the very small, and everything between. Students enrolled in this course will investigate motion, forces, momentum, energy, gravitation, electricity, magnetism, atomic structure, the nucleus, circuits, waves, sound, light and optics.   Frequent inquiry-based laboratory activities form a real-world anchor for abstract concepts.

Students in Honors Physics-9 will continuously apply high school level mathematics in problem solving and experimental investigations. Proficient fluency in fundamental algebra is required for success in this course. Useful geometric and trigonometric principles will be introduced and applied where necessary. Honors Physics-9 provides the best foundation for students who continue to AP Biology, AP Chemistry, and AP Physics in subsequent years.

Arrangement of units in academic calendar

Quarter 1	Quarter 2	Quarter 3	Quarter 4
Unit 1: Kinematics	Unit 3: Energy +		

Crosscutting Concepts (NGSS)

The following seven "crosscutting concepts" were identified by the Next Generation Science Standards. These core ideas bridge all academic disciplines of science and engineering and help students to develop a scientific approach to understanding.

1. **Patterns**. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

> *In grades 9-12, students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale; thus requiring improved investigations and experiments. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system.*

2. **Cause and effect: Mechanism and explanation**. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

> *In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.*

3. **Scale, proportion, and quantity**. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

> *In grades 9-12, students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).*

4. **Systems and system models**. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

> *In grades 9-12, students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system, and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They can also design systems to do specific tasks.*

5. **Energy and matter: Flows, cycles, and conservation**. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

> *In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.*

6. **Structure and function**. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

> *In grades 9-12, students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.*

7. **Stability and change**. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

> *In grades 9-12, students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.*

Scientific Practices and Methods

Scientific practices and the scientific method are an integrated instructional focus for all six content units of the course. During weekly laboratory investigations students will deepen their understanding of the scientific practices and methods.

NJ SCIENCE STANDARD 5.1 Scientific Processes All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results.
Big Ideas The scientific method is a powerful tool for conducting controlled systematic observations to inquire about natural phenomena. The scientific method is useful in coming to the understanding that the natural world can be explained and is predictable which enables problem solving. **Asking Questions and Defining Problems**. A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world(s) works and which can be empirically tested. (NGSS) **Developing and Using Models**. A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. (NGSS) **Planning and Carrying Out Investigations**. Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. (NGSS) **Analyzing and Interpreting Data**. Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis. (NGSS)

Using Mathematics and Computational Thinking. In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions. (NGSS)

Constructing Explanations and Designing Solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. (NGSS)

Engaging in Argument from Evidence. In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims. (NGSS)

Obtaining, Evaluating, and Communicating Information. Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity. Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to obtain information that is used to evaluate the merit and validity of claims, methods, and designs. (NGSS)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
● What makes science different from other ways of knowing? ● Does science ever prove anything? ● What is pseudoscience? ● Are all scientific theories true? ● Do the statistics tell the whole story? ● What is the proper way to treat data? ● What makes an experiment "scientific"? ● What is a scientific journal?	*Students will understand that…* ● Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. ● Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. ● It is important to know how to properly care for instrumentation. ● All experimentation begins with an understanding, evaluation and a plan for the practice of safe procedures. ● Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. ● Data and refined models are used to revise predictions and explanations. ● Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. ● Mathematical tools and technology are used to gather, analyze, and communicate results. ● Revisions of predictions and explanations are based on systematic observations, accurate

	measurements, and structured data/ evidence. Unexpected results can be important learning tools and have created some of the real breakthroughs in scientific understanding. ● Refinement of understandings, explanations, and models occurs as new evidence is incorporated. ● Empirical evidence is used to construct and defend arguments. ● Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. ● Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. ● Science involves using language, both oral and written, as a tool for making thinking public.

Areas of Focus: Proficiencies (Cumulative Progress Indicators)	Examples, Outcomes, Assessments
NGSS: **1. Asking questions and defining problems** ● Ask questions o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek additional information and relationships. o to determine relationships, including quantitative relationships, between independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. ● Evaluate a question to determine if it is testable and relevant. ● Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. ● Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. **2. Developing and Using Models** ● Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. ● Design a test of a model to ascertain its reliability. ● Develop, revise, and/or use a model based on evidence to illustrate and/or predict the	**Instructional Focus** ● Observational skills. ● Precision and accuracy of measurements. ● Organized data collection. ● Experimental design and the testing of hypotheses. ● Deductive and inductive reasoning. ● Communicating results. **Sample Assessments:** ● Written lab reports ● Analysis questions about scientific practices and the nature of science ● Reading, analyzing and critiquing scientific literature ● Relevant items on tests as well as the midterm and final exam ● Projects such as the Egg Drop and Rube-Goldberg machine **Instructional Strategies:** **Interdisciplinary Connections** ● Writing: technical writing for communicating scientific results ● Mathematics: Statistical analysis of data collected. ● History: Development of empirical science in the modern era. **Technology Integration** ● Use spreadsheet and other analysis tools to organize, analyze and display data and results. ● Distinguish between peer reviewed scientific findings and information *found* on the Internet. **Global Perspectives** ● International collaboration in science.

relationships between systems or between components of a system. ● Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. ● Develop a complex model that allows for manipulation and testing of a proposed process or system. ● Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. **3. Planning and Carrying Out Investigations** ● Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. ● 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. ● Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. ● Select appropriate tools to collect, record, analyze, and evaluate data. ● Make directional hypotheses that specify what happens to a dependent variable	● Science as a culturally unifying method in the modern world.

when an independent variable is manipulated. ● Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables. **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. ● Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. ● Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. ● Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. ● Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. ● Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. **5. Using Mathematics and Computational Thinking** ● Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. ● Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	

• Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, etc.). **6. Constructing Explanations and Designing Solutions** • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **7. Engaging in Argument from Evidence**	

● Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. ● Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ● Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions. ● Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. ● Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. ● Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). **8. Obtaining, Evaluating and Communicating Information** ● Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. ● Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.	

• Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. • Communicate scientific and/or 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 (i.e., orally, graphically, textually, mathematically). NJCCCS CPI #'s: **5.1.12.A.1** Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. **5.1.12.A.2** Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. **5.1.12.A.3** Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. **5.1.12.B.1** Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. **5.1.12.B.2** Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.	

5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. **5.1.12.B.4** Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. **5.1.12.C.1** Reflect on and revise understandings as new evidence emerges. **5.1.12.C.2** Use data representations and new models to revise predictions and explanations. **5.1.12.C.3** Consider alternative theories to interpret and evaluate evidence-based arguments. **5.1.12.D.1** Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. **5.1.12.D.2** Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. **5.1.12.D.3** Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.	

Unit 1
Motion in One and Two Dimensions

NJ Science Standard: 5.1 Scientific Processes All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results. **NJ Science Standard: 5.2 Physical Science** All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.
Big Ideas Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy. Motion is a relationship between position and time; motion can be measured and motion can be described with mathematical functions.

<table>
<tr><th>Essential Questions
What provocative questions will foster inquiry, understanding, and transfer of learning?</th><th>Enduring Understandings
What will students understand about the big ideas?</th></tr>
<tr><td>Who is really moving?
What needs to be known in order to properly describe motion?
When can you see acceleration?
How can a sailboat move into the wind?
How do trajectories change as we move through the universe?
How do you predict the trajectory of objects?</td><td>Students will understand that…
An object is in motion when its position is changing. The motion of an object can be described by the kinematic quantities of position, velocity and acceleration and mathematical functions, which relate these quantities.
An object’s position can be described by locating the object relative to other objects or a background. The description of an object’s motion from one observer’s view may be different from that reported from a different observer’s view.
Neglecting air resistance, objects in free fall accelerate at the same rate regardless of mass.
Perpendicular motion components can be treated independently, allowing for analysis of projectile motion.</td></tr>
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Areas of Focus: Proficiencies (Cumulative Progress Indicators)	Examples, Outcomes, Assessments

NGSS:
 	
(None specific to kinematics)
 	
NJCCCS:
 	
5.2.8.E.1 Calculate the speed of an object when given distance and time.
 	
5.2.12.E.1 Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values.
 	
5.2.6.E.1 Model and explain how the description of an object's motion from one observer's view may be different from a different observer's view.
 	
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Furthermore, students will:
 	
● Describe the distinction between distance and displacement
● Draw a clear distinction between the concepts of velocity and acceleration.
● Distinguish between average and instantaneous quantities.
● Distinguish between vector and scalar quantities and list examples of each.
● Measure the distance and time that various objects move in and outside the classroom
● Calculate the relationship between the position of moving objects and the elapsed in time.
● Calculate speed, velocity, and acceleration for objects moving
	Instructional Focus:
	● Science Practices and the Nature of Science
	● Kinematic definitions
	● Equations of motion for uniform velocity and acceleration
	● Algebraic problem solving including solving quadratics
	● Freefall motion: descriptions and calculations
	● Graphing of kinematic quantities and relationships between graphs
	● Practical applications of kinematics
	● Introduction to right angle trigonometry
	● Vectors and independence of perpendicular motion components
	● Motion viewed from different reference frames
	
	Sample Assessments:
	● Daily homework assignments from textbook or supplementary material
	● Short in-class quizzes
	● Unit tests including:
	  ● Relevant multiple choice items
	  ● Open-ended free response problems
	● Relevant items on Midterm/Final exam
	● Lab activity questions
	● Lab reports
	
	Labs and hands on activities:
	● Students time and plot motion of walking and running classmates
	● Graph Matching (sonic detectors and computers)
	● Graphing accelerated motion
	● Measuring g with a stopwatch

under uniform acceleration (including freefall) ● Graph distance vs. time and displacement vs. time for objects moving at constant velocity. ● Graph distance vs. time, velocity vs. time and acceleration vs. time for objects moving under uniform acceleration. ● Analyze motion graphs for objects moving under uniform acceleration, and describe the motion that is represented by the graph. ● Calculate velocities using slopes of position vs. time graphs and displacements using the area of a velocity vs. time graph. ● Describe the area under a velocity vs. time curve as displacement. ● Relate velocity and acceleration to natural motions such as simple harmonic motion of a mass-spring system and a pendulum ● Describe, calculate, and graph the motion of an object caused by the acceleration due to gravity of another object ● Utilize right angle trigonometry to solve vector problems ● Resolve motion into independent horizontal and vertical motions. ● Describe and calculate the trajectory, position, velocity, acceleration, and time in the air of a vertical projectile near the surface of the Earth. ● Describe and calculate the trajectory, position, velocity, acceleration, and time in the air of a horizontal projectile near the surface of the Earth. ● Describe and calculate the trajectory characteristics (maximum height, range, time of flight) for general projectile cases.	● Diluted gravity: ball rolling down incline or car along track (photo gates or sonic detectors and computers) ● Spaced washers (inverse square relationship) ● Horizontally launched projectiles ● Projectiles inquiry lab ● Projectiles: monkey and hunter **Instructional Strategies:** **Interdisciplinary Connections** Astronomy: Variation of 'g' on different planets Math: Slopes of lines, averages, scatter plotting, quadratic formula. History: Revolutionary experimental scientific methods of Galileo History: Knowledge of velocity, distance and time allowed the ancient Greeks to accurately estimate the circumference of the Earth **Technology Integration** Use motion sensors, photo gates, and video cameras to record motion data. Use computers to store motion data, and calculate displacements, velocities, and accelerations. **Global Perspectives** Explore travel distances and velocities of various international modes of transportation. Explore the concept of planetary travel to the Moon, Mars, and beyond **21st Century Skills:** **Critical Thinking and Problem Solving** Students analyze complex kinematic systems and solve for various quantities (e.g. finding the intersection of position of time for two objects)

• Describe, calculate and measure the motion of an object in different reference frames and relate those reference frames to one another.	**<u>21st Century Themes:</u>** **S.T.E.A.M.** • Students use slow motion video capabilities of phones to analyze linear and projectile motion

Unit 2
Newtonian Dynamics

NJ Science Standard: 5.1 Scientific Processes All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results. **NJ Science Standard: 5.2 Physical Science** All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.
Big Ideas Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy. Motion is a relationship between position and time; motion can be measured and motion can be described with mathematical functions. Matter is atomic; it has inertia; and it is fundamentally related to the phenomenon of gravitation. The universe has four fundamental forces; Newton’s laws of motion predict how forces affect the behavior of objects on the macroscopic scale.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the Big Ideas?*
● How can one explain and predict interactions between objects and within systems of objects? ● What are the principle in Physics that support the use of seatbelts and airbags? ● How is it possible to juggle on an airplane moving at 500mph? ● What do you need to know to properly describe current motion and predict changes in that motion? ● What factors affect the amount of friction or air drag between objects? ● What do Conservation Laws have to do with Newton's Laws? ● What does a spaceship move in the vacuum of space? ● How did Newton put a man on the moon? ● How do car crash investigators reconstruct the elements of an accident? ● How is momentum conserved when an object accelerates toward the Earth?	*Students will understand that…* ● Forces have magnitude and direction. Forces vectors can be added. The net force on an object is the sum of all the forces acting on the object. ● A free body diagram is a useful starting place for analyzing static and dynamic physical situations. ● An object at rest will remain at rest unless acted on by an unbalanced force; an object in motion at constant velocity will continue at the same velocity unless acted on by an unbalanced force. ● During interactions every action force is countered by an equal and opposite reaction force. ● The motion of an object changes only when a net force is applied. The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship ($a=F_{net}/m$) is independent of the nature of the force. ● Mass and weight are different quantities: mass is a measurement of inertia while weight is the gravitational force on an object. ● Friction and fluid drag forces tend to slow or prevent the motion of objects. ● Momentum is the product of an object's mass and velocity. During isolated interactions, the total momentum of a system is conserved. The Law of

	Conservation of Linear Momentum is derived from Newton's Laws of motion. ● The impulse acting on an object is equal to the change in its momentum. Cushioning minimizes the force acting on an object by increasing the time interval of a momentum change. ● An inward "centripetal force" is required to keep bodies in circular motion because their direction is always changing.

Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Examples, Outcomes, Assessments**
NGSS: **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. **HS-PS2-2** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. **HS-PS2-3** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. NJCCCS CPI #: **5.2.12.D.4** Energy may be transferred from one object to another during collisions.	**Instructional Focus:** ● Science Practices and the Nature of Science ● Mass vs. weight ● Free body diagrams ● Newton's Laws of Motion ● Solving simple and complex dynamic problems ● Analyzing interactions in terms of momentum ● Centripetal acceleration and force **Sample Assessments:** ● Daily homework assignments from textbook or supplementary material ● Short in-class quizzes ● Unit tests including: ● Relevant multiple choice items ● Open-ended free response problems ● Relevant items on Midterm/Final exam ● Lab activity questions ● Lab reports **Labs and hands-on activities:**

5.2.4.E.4 Earth pulls down on all objects with a force called gravity. Weight is a measure of how strongly an object is pulled down toward the ground by gravity. With a few exceptions, objects fall to the ground no matter where they are on Earth. **5.2.6.E.3** Friction is a force that acts to slow or stop the motion of objects. **5.2.8.E.2** Forces have magnitude and direction. Forces can be added. The net force on an object is the sum of all the forces acting on the object. An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion at constant velocity will continue at the same velocity unless acted on by an unbalanced force. **5.2.12.E.2** Objects undergo different kinds of motion (translational, rotational, and vibrational). **5.2.12.E.4** The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship (a=Fnet/m) is independent of the nature of the force. Furthermore, students will: ● Describe the effect on motion of objects in terms of forces. ● Define mass in terms of inertia. ● Compare forces of different magnitudes and common vs. SI units for force. ● Measure weight and show that it is directly proportional to mass.	● Measuring mass by shaking various weights from side to side (inertial balances) ● Force equilibrium tables ● Friction explorations ● Atwood machine demonstration ● The Inclined Plane ● Connected bodies ● Egg Drop Project ● The Centerpoint (explosions) ● Perfectly inelastic collisions ● The Whirligig (circular motion) **Instructional Strategies:** **Interdisciplinary Connections** ● Mathematics: algebraic manipulation of single variable equations (average speed, wave equation); solution of systems of two equations using substitution or elimination ● History: put Isaac Newton's 1687 magnum opus, *The Principia*, into its historical context; frame Copernicus, Brahe, Kepler, and Newton in their historical context ● Biology: Discuss the maximum boundaries of acceleration on the human body, particularly in roller coasters, airplanes, and spaceships. ● Sports: describe collisions in various sports (football, billiards, auto racing) in terms of momentum **Technology Integration** ● Collect force data using computer based lab devices ● Using infrared based timing devices to measure velocity ● Research applications of Newton's laws on the internet

• Calculate the net force resulting from force combinations. • Draw free body diagrams for objects in static and dynamic situations. • Compare the motion of an object acted on by balanced forces with the motion of an object acted on by unbalanced forces in a given specific scenario. • Describe motion and changes in motion in terms of Newton's Three Laws. • Create simple models to demonstrate the benefits of seatbelts and headrests in terms of the First Law. • Measure and describe the relationship between the force acting on an object and the resulting acceleration. • Demonstrate and explain the frictional force acting on an object with the use of a physical model. • Identify and measure the effects, if any, that weight, roughness, surface area, and speed have on friction forces. • Solve complex dynamics problems: inclined planes, connected bodies, and situations with friction. • Identify action-reaction pairs. • Observe various types of collisions and explosions, explain results in terms of energy and momentum conservation. • Relate impulse with change in momentum. • Solve 2-D momentum conservation problems by solving a system of equations. • Verify the centripetal force rule experimentally. • Apply Newton's Laws to uniform circular motion cases.	**Global Perspectives** • The laws of mechanics—equivalent throughout the universe—transcend geographical and cultural borders. • Inertia and relative motion as a reference frame phenomena--metaphor for Point of View. • Historical background of Newton's life and work **<u>21st Century Skills:</u>** **Critical Thinking and Problem Solving** • Students analyze complex dynamics systems and solve for various quantities (e.g. predicting the velocity of an object given forces acting and mass) • Students design an egg drop apparatus using pre-defined materials **<u>21st Century Themes:</u>** **S.T.E.A.M.** • Students use the accelerometer capabilities of their smart phones to measure angles and dynamic quantities

Unit 3
Energy and Gravitation

NJ Science Standard: 5.1 Scientific Processes
All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results. **NJ Science Standard 5.2 Physical Science:** All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.
Big Ideas
Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy. Energy cannot be created or destroyed but can be transferred from one form to another. Understanding of energy conservation and the laws of thermodynamics will enable students to make informed decisions and judgments relevant to important social and scientific issues. Electromagnetic and gravitational fields can be used to predict interactions between matter and energy.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
● How is energy transferred and conserved? ● Why does energy seem to be lost in some events and created in others? ● When mechanical energy is “lost”, where does it go? ● Why are the concepts of work and energy necessary and useful to physicists? ● Do energy transformations cause disasters? ● Is it possible to break even in an energy transformation? ● If energy can never be created or destroyed, why is there an “energy crisis”?	*Students will understand that…* ● Energy cannot be created or destroyed. ● Energy is constantly being transferred and transformed in the natural and man-made world. ● Thermodynamic processes tend to increase disorder. The amount of disorder is a measurable energetic quantity known as entropy. ● The potential energy of an object on Earth’s surface is increased when the object’s position is changed from one closer to Earth’s surface to one farther from Earth’s surface. ● Energy may be transferred from one object to another during collisions. ● The net work done on an object during a process is equal to its change in kinetic energy. This is a relationship that can be derived from Newton’s Laws of Motion. ● Collisions may be classified as elastic or inelastic according to their conservation or loss of mechanical energy. ● The force of gravitation between two bodies is directly proportional to their masses and inversely proportional to the square of the distance between them.

	● Kepler's Laws describe the orbits of bodies in space; Kepler's Laws can be derived from Newton's Laws of Motion.
Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Examples, Outcomes, Assessments**

NGSS:
 	
HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
 	
HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
 	
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
 	
HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
 	
HS-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.
	Instructional Focus:
	● Science Practices and the Nature of Science
	● Work and types of energy
	● Problem solving with energy methods in mechanical systems
	● Energy conservation
	● Energy considerations in collisions
	● 1^{st} and 2^{nd} Laws of Thermodynamics
	● Newton's Law of Gravitation
	● Kepler's Laws and connection to Newton's Law of Gravitation
	
	Sample Assessments:
	● Daily homework assignments from textbook or supplementary material
	● Short in-class quizzes
	● Unit tests including:
	  ● Relevant multiple choice items
	  ● Open-ended free response problems
	● Relevant items on Midterm/Final exam
	● Lab activity questions
	● Lab reports
	
	Labs and hands-on activities:
	● Sliding eraser
	● Rube Goldberg device project
	● Predict and measure the kinetic energy gain of a dropped object
	● Coefficient of restitution
	● Calorimetry and the 2^{nd} law of thermodynamics
	● Plot the path of a planet about the sun using real data and verify Kepler's Laws of planetary motion.

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. NJCCCS CPI #'s: **5.2.8.D.1** Relate the kinetic and potential energies of a roller coaster at various points on its path. **5.2.12.D.1** Model the relationship between the height of an object and its potential energy. **5.2.12.D.4** Measure quantitatively the energy transferred between objects during a collision. --- Furthermore, students will…. ● Define work, kinetic energy, and potential energy ● Review dynamics problems, including those with friction, using the work-kinetic energy theorem. ● Apply energy calculations to interaction problems and classify accordingly. ● Practice describing and calculating the continuous transfer of energy in a closed system. ● Draw parallels between local and universal energy transfers. ● Identify and describe Potential and Kinetic energy in a variety of natural and designed contexts ● Describe the process of energy transformation in a variety of natural and designed contexts ● Explain common natural and designed motions involving energy transformation.	● ● **Instructional Strategies:** **Interdisciplinary Connections** ● Biology: Biological basis of roller coaster design constraints – g forces. ● Math: Calculations of energies, velocities, forces at various points in a roller coaster. ● Social studies: How does the existence of high concentrations of potential energy (oil) affect global politics? **Technology Integration** ● Use computers to collect data on fast moving objects. ● Use computer simulations to observe and create unique energy transfer systems. **Global Perspectives** ● Compare and contrast classroom energy transformations with those within our solar system, our galaxy, and the universe. ● Investigate the geopolitical effects of energy policy. **21st Century Skills:** **Critical Thinking and Problem Solving** • Students analyze complex energy systems and solve for various quantities (e.g. predicting object velocities after various energy changes) • Students design a Rube Goldberg mechanism to carry out a specific task **21st Century Themes:** **S.T.E.A.M.**

• Explain and use the Law of Conservation of Energy • Describe and explain the meaning of energy • Construct a Rube-Goldberg device • Calculate the gravitational force between pairs of masses. • Use Kepler's Laws to predict the motion of planets and satellites	• Students use the slow motion capabilities of their smart phones to assist in measuring coefficients of restitution

Unit 4
Atomic Structure & Electrostatics

NJ Science Standard: 5.1 Scientific Processes All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results. **NJ Science Standard 5.2 Physical Science:** All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.
Big Ideas Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy. Matter is atomic; it has inertia; and it is fundamentally related to the phenomenon of gravitation. The universe has four fundamental forces; Newton's laws of motion predict how forces affect the behavior of objects on the macroscopic scale. Electromagnetic and gravitational fields can be used to predict interactions between matter and energy.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
● How can one explain the structure, properties, and interactions of matter? ● When is a scientific theory complete? ● How do we know that atoms exist? ● Why are only some substances radioactive? ● Are nuclear power plants a solution to the energy crisis? ● How do scientists “date” old objects? What are the limits of those techniques? ● Is radioactivity good or bad for the human race? ● Why must nuclear decay be understood as a statistical process? ● How long will the Sun last? ● What is the smallest particle? ● What is the most important of the four forces? ● What is a force field? Does matter ever touch? ● Do field lines really exist?	*Students will understand that….* ● Matter is made up of atoms. The different properties of matter are based on the organization of the subatomic particle within those atoms. ● Electrons, protons, and neutrons are parts of the atom and have measurable properties like mass and charge. In a neutral atom: the nucleus contains positively charged protons and is surrounded by an electron cloud with the same number of negatively charged electrons. ● A nucleus takes up an insignificant amount of the atoms volume but consists of nearly 100% of the mass. Nuclei of atoms are composed of protons and neutrons. The number of protons identifies the atom. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes. ● The electron cloud takes up nearly all of the atoms volume but has very little mass. It is the interaction of these electron clouds that is responsible for chemical reactions. ● Protons and electrons have equal but opposite charges. Neutral Atoms have equal numbers of neutrons and protons but can be negatively or positively charged by adding or removing electrons. Methods of charging include: friction, conduction, induction, and polarization

	● Forces that are only evident at nuclear distances hold the particles of the nucleus together and act to pull it apart. These forces can be harnessed to release enormous amounts of energy. ● Heavy nuclei can undergo fission, the process of nuclear splitting; light nuclei can undergo nuclear fusion. These processes have many important and controversial applications in the modern world. ● A radioactive material can naturally emit three different types of radiation: alpha, beta, and gamma. ● The rate of radioactive decay is characterized by half-life. Radioactive decay follows a characteristic exponential graph. ● Electrostatic forces are described by Coulomb's inverse square law and are responsible for keeping the electrons close to the nucleus. Electrostatic forces can be attractive or repulsive. ● Electric fields surround charged objects. Electric field lines give a visual description of the field.
Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Examples, Outcomes, Assessments**
NGSS: **HS-PS2-4** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. **HS-PS1-8** Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.	**Instructional Focus** ● Structure of the Atom and Nucleus ● Description of the development of modern atomic theory, including contributions of Thomson, Millikan, Rutherford ● Practical applications of nuclear phenomena ● Compare and contrast the four fundamental forces and describe their impact on everyday life. ● Electrostatic phenomena and ways to charge objects

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

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.

NJCCCS CPI #'s:

5.2.12.A.1 Use atomic models to predict the behaviors of atoms in interactions.

5.2.12.D.3 Describe the products and potential applications of fission and fusion reactions

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Furthermore, students will….

- Describe the properties of the atom and nucleus
- Trace the historical development of atomic theory
- Describe the important contributions of Millikan, Rutherford, and Thomson
- Calculate rates of radioactive decay
- Calculate net electrostatic forces on objects in configurations of two, three, and four charges
- Qualitatively describe and draw electric field lines for various simple configurations
- Calculate electric field strengths for configurations of two, three, and four charges
- Calculate the force and direction of a known charge in a known electric field

- Quantitative calculations of electrostatic forces and fields

<u>Sample Assessments:</u>
- Daily homework assignments from textbook or supplementary material
- Short in-class quizzes
- Unit tests including:
  - Relevant multiple choice items
  - Open-ended free response problems
- Relevant items on Midterm/Final exam
- Lab activity questions
- Lab reports

<u>Labs and hands-on activities:</u>
- Research nuclear applications
- <u>Static electricity explorations</u> (Van der Graaff, electroscopes, balloons, rods/fur, etc)
- <u>The Electrophorus</u>
- Electric field hockey (computer simulation)
- Electric field mapping (computer simulation)

Instructional Strategies:
Interdisciplinary Connections
- History: Integration of atomic theory timeline with historical events. Engineering: how nuclear devices work
- Environmental science: environmental pros and cons of nuclear energy
- Astronomy: the sun as a fusion engine
- History: development of nuclear power in the 20th century; effect of nuclear technology on world developments, such as the Cold War

	• Biology: the effects of nuclear radiation on tissue • Mathematics: real-world applications of an exponential functions **Technology Integration** • Use of a real Geiger counter for radioactive investigations. • Statistical analysis utilizing spreadsheet programming and visualization. • Computer simulations of nuclear reactors. • Use of computer simulations to model electric fields. **Global Perspectives** • International effort of developing atomic/nuclear theory • Variation in exploitation of nuclear power in different countries • Differing perspectives around the world (e.g. France vs. US) on nuclear power. • Radioactive natural resources and their relative geographic abundance around the world. • Human and geopolitical effects of nuclear weapons, as seen in Japan in 1945 and in the post-war world. **21st Century Skills:** **Critical Thinking and Problem Solving** • Students discuss and analyze modern issues surrounding nuclear applications **21st Century Themes:** **S.T.E.A.M.** • Students develop a project to visually describe the interrelated

	technological issues of nuclear applications

Unit 5
Circuits and Electromagnetism

NJ Science Standard: 5.1 Scientific Processes All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results. **NJ Science Standard 5.2 Physical Science:** All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.
Big Ideas Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy. Energy cannot be created or destroyed but can be transferred from one form to another. The universe has four fundamental forces; Newton's laws of motion predict how forces affect the behavior of objects on the macroscopic scale. Electromagnetic and gravitational fields can be used to predict interactions between matter and energy.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
● How do moving electric and magnetic fields cause change? ● How do ear bud speakers work? ● How are the relationships between electric and magnetic fields used to shape society? ● How have magnetic fields impacted human history and shed light on the natural history of the earth? ● How do animals use magnetic fields to navigate? ● How is electricity produced, and what is the difference between AC and DC? ● What is that big gray cylinder at the top of the telephone pole?	*Students will understand that…* ● Electric potential energy difference measures the potential energy per unit of charge. A potential difference across a closed conducting circuit will cause charge to flow, producing current. ● Electrical circuits require a complete loop through conducting materials in which an electrical current can pass. The amount of current is directly proportional to the potential difference but inversely proportional to the resistance of the circuit. ● All matter has internal resistance to the flow of charge. Resistance depends on the physical properties of matter, the shape and size of the object, and its temperature. ● Current flowing through an object (with resistance) results in the conversion of electrical energy into other forms of energy, such as light, heat, sound, or motion. ● The components of the circuit and their arrangement, such as in series or parallel determine the overall resistance of the circuit. ● Electricity flowing through an electrical circuit produces magnetic effects. Moving electric charges produce magnetic fields. ● Magnetic fields put forces on moving electric charges. ● Magnetic fields are shaped by the north and south magnetic poles of a magnetized object. ● Magnetic poles always occur in pairs and cannot be separated –

	unlike electric charge where positive and negative charges can be separated. ● Magnetic poles can attract and repel, as electric charges can; their magnitude obeys an inverse square law. ● The earth has a magnetic field that is detectable at the surface with a compass. ● The earth's magnetic field has north and south poles and lines of force that are used for navigation. ● Evidence from lava flows and ocean-floor rocks shows that Earth's magnetic field reverses (North – South) over geologic time. ● The directional relationship between currents, magnetic fields, and magnetic forces can be predicted by the right hand rule. ● Electric motors use magnetic forces to transfer electrical potential energy into kinetic energy. ● Generators use magnetic forces to transfer mechanical energy into electric potential energy.

Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Examples, Outcomes, Assessments**

NGSS:
 	
HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
 	
HS-PS3-5 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.
 	
NJCCCS CPI #'s:
 	
5.2.6.E.2 Describe the force between two magnets as the distance between them is changed.
 	
5.4.8.D.3 Explain why geomagnetic north and geographic north are at different locations.
 	
5.4.12.D.2 Calculate the average rate of seafloor spreading using archived geomagnetic-reversals data.
 	
5.2.4.D.1 Repair an electric circuit by completing a closed loop that includes wires, a battery (or batteries), and at least one other electrical component to produce observable change.
 	
5.2.6.D.1 Use simple circuits involving batteries and motors to compare and predict the current flow with different circuit arrangements
	<u>Instructional Focus:</u>
	● Basic definitions and units in circuits (voltage, current, power, volts, amps, watts)
	● Solving simple circuits: series, parallel and combination
	● Permanent magnetism
	● Magnetic fields from currents
	● Forces on moving charges in a magnetic field
	● Induction and motional emf
	● The operation of electromagnetic devices such as motors, generators, and transformers
	.
	
	<u>Sample Assessments:</u>
	● Daily homework assignments from textbook or supplementary material
	● Short in-class quizzes
	● Unit tests including:
	  ● Relevant multiple choice items
	  ● Open-ended free response problems
	● Relevant items on Midterm/Final exam
	● Lab activity questions
	● Lab reports
	
	<u>Labs</u>:
	  ● Measuring current and voltage
	  ● <u>Resistance and Ohm's Law</u>
	  ● <u>Voltage divider</u> (series circuit)
	  ● Parallel circuits
	  ● Model and describe magnetic field lines with a bar magnet and iron filings
	  ● Oersted effect or solenoids, electromagnets.

Furthermore, students will: ● Explain differences in resistance in terms of material, length, and cross-section. ● Calculate voltages and currents with Ohm's Law. ● Measure current and voltage with digital multimeters. ● Compare and contrast series, parallel, and combination circuits and explain why homes are wired in parallel. ● Fully analyze simple circuits for quantities of voltage, current, and power. ● Explain the purpose of a circuit breaker or fuse in a home. ● Build a simple electromagnetic, refining various designs, to pick up metal objects. ● Compare and contrast the production and usefulness of AC vs. DC power. ● Calculate motional emf, the force on charges moving through magnetic fields, and the forces on currents in magnetic fields. ● Use right hand rules to predict field lines and particle forces. ● Explain the operation of motors, generators, and transformers.	● Making electromagnets with nails and wire ● Making a simple motor ● Generators & Transformers **<u>Instructional Strategies:</u>** **Interdisciplinary Connections** ● Biology: biological basis of animal navigation by magnetic fields; electrical nature of nervous systems ● Astronomy: magnetic fields surrounding the sun and stars, such as neutron stars ● Math: calculations of a circuit's resistance, voltage and current; algebraic manipulations of simple one-variable, linear equations. ● History: investigate the use of magnetic fields in human navigation over the centuries. ● History: Galvani and "animal electricity" **Technology Integration** ● Use computers to simulate magnetic field lines and forces. ● Use large classroom audio/visual cathode ray tubes to demonstrate electron deflection by magnetic forces. **Global Perspectives** ● Explore global magnetic fields interacting with solar magnetic winds. ● Investigate the use of magnetic fields in human navigation over the centuries, and the mapping of local magnetic deviations. ● Find evidence of the earth's magnetic field reversing approximately every 10 million years.

	<u>21st Century Skills:</u> **Critical Thinking and Problem Solving** • Students analyze and design simple and intermediate resistive circuits **<u>21st Century Themes:</u>** **S.T.E.A.M.** • Students program Arduino based circuits to light up LED's, operate motors, and integrate touch and sound inputs

Unit 6
Waves and Optics

NJ Science Standard: 5.1 Scientific Processes All students will develop problem solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions and communicating results. **NJ Science Standard 5.2 Physical Science:** All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.
Big Ideas Our ability to understand the universe is made possible by knowing a finite set of laws that govern matter and energy. Energy cannot be created or destroyed but can be transferred from one form to another. Motion is a relationship between position and time; motion can be measured and motion can be described with mathematical functions. Waves transfer energy without transferring matter and serve as a powerful tool for explaining certain properties of sound and electromagnetic radiation.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
● What is a wave? ● How is transferring energy by waves different than transferring energy by matter? ● How do the properties of waves influence our perception of the world around us? ● What is sound? ● What is light? ● In what ways does light behave like a wave and in what ways is it like a particle? ● How are waves used to transfer energy and send and store information?	● Waves transfer energy without transferring matter. ● Waves can be described in terms of wavelength, frequency, amplitude, and energy. ● Waves tend to travel at constant speed through media of constant consistency; the speed of a wave depends only on the physical properties of the medium in which it propagates. ● Waves can exhibit reflection, refraction, diffraction, and interference. ● Sound waves are compression waves moving through media while varying the density of the media. ● Our perception of loudness is related to amplitude while our perception of pitch is related to frequency. The human auditory system is not a true interpreter of sound wave amplitude or frequency. ● Relative motion between receiver and source can cause perceptible apparent changes in wave properties, such as frequency. ● All electromagnetic waves travel at 300,000,000 m/s in a vacuum. A speed so fast as to seem instantaneous for most Earthly distances. ● Electromagnetic waves of different frequencies interact with matter differently. They have different effects on biological tissues,

	ranging from essential to dangerous. ● Visible light waves comprise a small part of the electromagnetic spectrum. Our perception of color is related to wavelength. ● Light rays tend to travel in straight lines but can change direction when reflecting from surfaces of refracting through transparent mediums, providing the possibility of real or virtual images. ● The refracted angle of an electromagnetic wave from one transparent medium into another can be predicted exactly with Snell's Law. ● Light exhibits wave-like properties and particle-like properties. ● Lenses and mirrors are found in many practical devices: eyeglasses, the human eye, microscopes, binoculars, cameras, telescopes, etc.

Areas of Focus: Proficiencies (Cumulative Progress Indicators)	Examples, Outcomes, Assessments
NGSS: **HS-PS4-1** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. **HS-PS4-2** Evaluate questions about the advantages of using a digital transmission and storage of information. **HS-PS4-3** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. **HS-PS4-4** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. **HS-PS4-5** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. NJCCCS CPI #: **5.2.2.C.2** An object can be seen when light strikes it and is reflected to	**Instructional Focus:** ● Wave phenomena of various mechanical and electromagnetic waves: diffraction, interference, reflection, and refraction. ● Hands-on activities with waves on a coiled spring, water waves, and sound waves ● Evidence for wave and particle properties of light ● Operation of the human ear and eye ● Practical optical instruments such as eyeglass lenses, telescopes, and microscopes **Sample Assessments:** ● Daily homework assignments from textbook or supplementary material ● Short in-class quizzes ● Unit tests including: ● Relevant multiple choice items ● Open-ended free response problems ● Relevant items on Midterm/Final exam ● Lab activity questions ● Lab reports **Labs and Hands-on Activities:** ● Pendulums and Simple Harmonic Motion ● Slinky Explorations ● Standing Waves ● Water wave table activities ● Resonance Tubes ● Plane Mirrors ● Refraction through water ● Converging Lenses **Instructional Strategies:**

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<td>a viewer's eye. If there is no light, objects cannot be seen.
5.2.4.C.4 Light travels in straight lines. When light travels from one substance to another (air and water), it changes direction.
5.2.6.C.1 Light travels in a straight line until it interacts with an object or material.
Light can be absorbed, redirected, bounced back, or allowed to pass through. The path of reflected or refracted light can be predicted.
5.2.6.C.2 Visible light from the Sun is made up of a mixture of all colors of light. To see an object, light emitted or reflected by that object must enter the eye.
5.2.4.E.1 Motion can be described as a change in position over a period of time.
<hr>
Furthermore, students will:

Observe that waves can affect objects across distances through a medium without the direct transfer of any matter.
Produce and observe pulse, periodic, longitudinal, transverse, and standing waves and measure their characteristics.
Compare and contrast mechanical waves with electromagnetic waves.
Categorize wave types as either longitudinal or transverse.
Cite evidence that mechanical waves require media while electromagnetic waves do not.
Measure wavelength, frequency, and amplitude of various types of waves and label those parts on a diagram.

</td>
<td>Interdisciplinary Connections

Mathematics: algebraic manipulation of single variable equations (average speed, wave equation)
History: development of information transmission at the speed of light (Marconi) as a historical turning point.
Biology: how eyes and ears function

Technology Integration

Use cell phone cameras to capture data about wave table shadows
Use computer based data collection software for sound and light demonstrations
Utilize lasers for refraction and reflection demonstrations.
Research the history of light theories on the internet.
Fiber optics technology
Solar cells

Global Perspectives

Speed of light as universal constant for electromagnetic radiation
2005 Indonesian tsunami and other tidal waves; ocean waves on shores around the world
Archimedes lens weapon (Mythbusters episode)
Color as a diversely perceived feature historically, culturally, and by different species.
Light as a cultural metaphorical construct

<u>21st Century Skills:</u>
Critical Thinking and Problem Solving

Students explore the possibilities of solar power and design a

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● Observe for various types of waves that wave velocity is only a function of the medium and explain why this fact is important for the enjoyment of music. ● Calculate wave speeds, wavelengths, or frequencies for problems or predictions. ● Qualitatively describe pitch and volume changes in terms of frequency and amplitude changes. ● Predict changes in apparent received pitch for various relative motion situations. ● Describe colors in terms of wavelength, and visible light's wavelength within the context of the larger EM spectrum. ● Explain reflection and refractions in terms of Huygens's principle and wave speeds. ● Verify Snell's Law for refracted angles for various optical media, such as glass, water, and oil. ● Calculate wavelength of monochromatic source(s) using a diffraction grating and equations. ● Predict and observe image characteristics using ray diagrams for light that has reflected from plane or spherical mirrors or refracted through transparent materials or lenses. ● Explain the optical function of common optical systems, such as microscopes, magnifying glasses, and the human eye based on fundamental physical concepts.	hypothetical solar power system for their school. **<u>21st Century Themes:</u>** **S.T.E.A.M.** ● Students create an art-based project using light and sound to explore color theory and sound effects.

Curricular Addendum

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Career-Ready Practices
CRP1: Act as a responsible and contributing citizen and employee.
CRP2: Apply appropriate academic and technical skills.
CRP3: Attend to personal health and financial well-being.
CRP4: Communicate clearly and effectively and with reason.
CRP5: Consider the environmental, social and economic impacts of decisions.
CRP6: Demonstrate creativity and innovation.
CRP7: Employ valid and reliable research strategies.
CRP8: Utilize critical thinking to make sense of problems and persevere in solving them.
CRP9: Model integrity, ethical leadership and effective management.
CRP10: Plan education and career paths aligned to personal goals.
CRP11:. Use technology to enhance productivity.
CRP12: Work productively in teams while using cultural global competence.

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Interdisciplinary Connections
- Close Reading of works of art, music lyrics, videos, and advertisements
- Use Standards for Mathematical Practice and Cross-Cutting Concepts in science to support debate/inquiry across thinking processes

Technology Integration
Ongoing:
- Listen to books on CDs, Playaways, videos, or podcasts if available.
- Use document camera or overhead projector for shared reading of texts.

Other:
- Use Microsoft Word, Inspiration, or SmartBoard Notebook software to write the words from their word sorts.
- Use available technology to create concept maps of unit learning.

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Instructional Strategies:
Supports for English Language Learners:

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects (realia)	Charts	In pairs or partners
Manipulatives	Graphic organizers	In triads or small groups
Pictures & photographs	Tables	In a whole group
Illustrations, diagrams, & drawings	Graphs	Using cooperative group structures
Magazines & newspapers	Timelines	With the Internet (websites) software programs
Physical activities	Number lines	In the home language
Videos & films		With mentors
Broadcasts		
Models & figures		

from https://wida.wisc.edu

Media Literacy Integration

- Use multiple forms of print media (including books, illustrations/photographs/artwork, video clips, commercials, podcasts, audiobooks, Playaways, newspapers, magazines) to practice reading and comprehension skills.

Global Perspectives

- [The Global Learning Resource Library](#)

Differentiation Strategies:

Accommodations	Interventions	Modifications
Allow for verbal responses	Multi-sensory techniques	Modified tasks/ expectations
Repeat/confirm directions	Increase task structure (e.g., directions, checks for understanding, feedback)	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding (e.g., writing, reading aloud, answering questions in class)	Individualized assessment tools based on student need
Audio Books	Utilize prereading strategies and activities: previews, anticipatory guides, and semantic mapping	Modified assessment grading