Washington Township School District

> ***The mission of the Washington Township Public Schools*** *is to provide a safe, positive, and progressive educational environment that provides opportunity for all students to attain the knowledge and skills specified in the NJ Learning Standards at all grade levels, so as to ensure their full participation in an ever-changing world as responsible, self-directed and civic-minded citizens.*

Course Title:	**College Preparatory Physics**

Grade Level(s):	**11-12**

Duration:	*Full Year:*	**x**	*Semester:*		*Marking Period:*	
Course Description:	**The College Prep Physics course is designed to strengthen student problem solving and logical reasoning skills, while providing a basic and thorough background in classical physics. Major topics include: Forces and motion; the conservation principles, harmonics, wave mechanics, electromagnetism, and optics. The year begins with a discussion of classical mechanics – focusing heavily on Newton's Laws and their effect on motion. Students will then explore the fundamental forces of gravitation and electromagnetism, including their use in the modern world. The conservation principles of energy and momentum will be introduced, followed by a discussion of wave mechanics, concentrating on the behavior of waves. The course ends with a discussion of the electromagnetic spectrum and its importance in the communications industry.**					
Grading Procedures:	**Tests – 45%** **Lab Work – 20%** **Quizzes – 10%** **Independent Work – 10%** **Projects – 10%**					
Primary Resources:	**NJ Model Physics Curriculum** **Next Generation Science Standards** **New Jersey Student Learning Standards (NJSLS)** **Walker, J. (2014). *Physics*. Boston, MA: Pearson.**					

Washington Township Principles for Effective Teaching and Learning

- Implementing a standards-based curriculum
- Facilitating a learner-centered environment
- Using academic target language and providing comprehensible instruction
- Adapting and using age-appropriate authentic materials
- Providing performance-based assessment experiences
- Infusing 21st century skills for College and Career Readiness in a global society

Designed by:	AF Carpinelli, MS

Under the Direction	Dr. Patricia Hughes

Written: ______________________________

Revised: ______________________________

BOE Approval: __________________________

Unit Title: Forces and Motion

Unit Description: In this unit, students will explore the motion of objects under the influence of forces. They will explore the relationships between distance, time, and velocity in accelerated and non-accelerated systems and conduct experiments to verify those relationships. One- and Two-dimensional systems will be examined. Students will also become familiar with Newton's Laws of Motion and their effect on motion.

From the NJ Model Physics Curriculum: In this unit of study, students are expected to *plan and conduct investigations*, *analyze data and using math to support claims*, and *apply scientific ideas to solve design problems* students in order to develop an understanding of ideas related to why some objects keep moving and some objects fall to the ground. Students will also build an understanding of forces and Newton's second law. Finally, they will develop an understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are also able to apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of *patterns*, *cause and effect*, and *systems and systems models* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in *planning and conducting investigations*, *analyzing data and using math to support claims*, and *applying scientific ideas to solve design problems* and to use these practices to demonstrate understanding of the core ideas.

Unit Duration: 8-10 weeks

Desired Results

Standard(s): 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-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Indicators:

HS-PS2.A: Given a graph of position or velocity as a function of time, recognize in what time intervals the position, velocity and acceleration of an object are positive, negative, or zero and sketch a graph of each quantity as a function of time

HS-PS2.A: Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation

HS-PS2.A: Understand and apply the relationship between the net force exerted on an object, its inertial mass, and its acceleration to a variety of situations

HS-ETS1.A: Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them

HS-ETS1.B: When evaluative solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts

HS-ETS1.C: Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of criteria over others (trade-offs) may be needed.

Understandings: *Students will understand that…* 1. The motion of an object can be represented by a graph, the shape of which determines the type of motion the object is undergoing 2. Motion at a constant velocity causes distance to increase at a constant rate 3. Motion at constant, non-zero acceleration casues distance to change at a non-constant rate but causes velocity to change at a constant rate. 4. Scalar quantities (like distance, time, and speed) include only magnitude, whereas vector quantities (like velocity, acceleration, and force) include both magnitude and direction 5. Objects in freefall are accelerating at -9.8 m/s^2 at all times, whether rising or falling. 6. Two dimensional motion must be resolved into horizontal and vertical planes and dealt with separately 7. Unbalanced forces cause acceleration. 8. A system can be broken down into respective parts and described by those parts. 9. A design may go through many trials before it is perfected for use. 10. New inventions face public scrutiny before they are accepted by society and can cause societal change as they are utilized.	**Essential Questions:** 1. What do the slopes of distance-time and velocity-time graphs indicate? 2. What does accelerated motion look like on a distance-time graph? On a velocity-time graph? 3. What is the relationship between distance and time when moving at constant velocity? 4. What is the relationship between distance and time when moving with constant acceleration? 5. What is the relationship between velocity and time when moving with constant acceleration? 6. What is the acceleration of a freely falling object? 7. How does the velocity of an object thrown into the air change as it moves up and down? 8. What quantity links the horizontal and vertical planes for a moving object? 9. How is the horizontal motion of a object moving two-dimensionally different from its vertical motion? 10. How does increasing the launch angle affect the time, altitude, and range of a projectile? 11. What are Newton's Three Laws of Motion? 12. What is an unbalanced force and how does it affect motion? 13. What is an action-reaction pair? 14. How does mass affect force and acceleration? 15. How does a free body diagram represent motion? 16. What are some common forces and how are they represented in a free body diagram? 17. How does the engineering process relate to the design of a final product? 18. How do new inventions change society?
Assessment Evidence	

Performance Tasks:
Students will:
1. Mathematically and graphically represent the motion of an object undergoing acceleration
2. Solve a complex equation based on a real world motion sitation
3. Create a narrative to describe one of Newton's Laws of Motion
	Other Evidence:
	• Quizzes
	  ○ Speed
	  ○ Acceleration
	  ○ Freefall
	  ○ 2-D Kinematics
	  ○ Newton's Laws
	  ○ Free Body Diagrams
	  ○ Friction

4. Diagram a system under the influence of multiple forces and determine the motion of the object based on that diagram	• Lab Work (includes reports and assessments) ○ Distance-Displacement ○ Acceleration ○ Freefall ○ Horizontal Release Projectiles ○ Newton's 2nd Law ○ Friction ○ Vector Addition and Resolution • Independent Work ○ Selected text problems ch 2 – 5 ○ Teacher made problem review sheets ○ Computer simulations ▪ Moving Man ▪ Projectile Motion ▪ Forces and Motion ▪ Atwood's Machine • Project ○ Oral Presentation on Invention Design, Modification, and Implementation • Tests ○ Kinematics ○ Dynamics

Benchmarks:

Freefall and Newton's 2nd Law Labs or similar lab experiences

Learning Plan

Learning Activities:

The concepts in this unit are presented in Walker's Physics (2014) chapters 2 – 5.
For each major topic/lesson, specific activities are listed. Sources of activities can be found at the end of this section.

Kinematics

I. 1-Dimensional Kinematics
   a. Non-accelerated Motion
      i. Topics include: kinematics vocabulary, Displacement-time graphs, vector vs scalar quantities, v=x/t
      ii. Suggested activities include: Distance-Displacement Lab; Vernier Graph Matching Activity; Moving Man Simulation; Read ch 2 and solve selected problems
   b. Accelerated Motion

i. Topics include: Velocity-Time Graphs, Acceleration Formulae, Distance/Velocity/Time relationships; Law of Falling Bodies
ii. Suggested activities include: Acceleration Lab; Vernier Freefall Lab; Graph Matching Simulation; Read ch 3 and solve selected problems; Beetle Drop Video

II. 2-Dimensional Kinematics
   a. Topics include: Horizontal Release Projectiles, Vector Resolution; Angled Release Projectiles
   b. Suggested Activities Include: Horizontal Release Projectile Lab; Projectile Motion Simulation; Horizontal Release Demonstration; Monkey-Hunter Demonstration; Read ch 4 and solve selected problems

<u>Dynamics</u>

I. Newton's Laws
   a. Topics include: conceptual discussion of Newton's Laws; Vector Addition; Mass vs Weight; Force/Mass/Acceleration Relationships
   b. Suggested Activities include: Vernier Newton's 2nd Law Lab; Vector Resolution and Addition Lab; Forces and Motion Computer Simulation; Read ch 5 and solve selected problems

II. Applications of Newton's 2nd Law
   a. Topics Include: Atwood's Machine; Free Body Diagrams; Friction; Apparent Weight
   b. Suggested Activities: Friction Lab; Atwood's Machine Computer Simulation; Free Body Diagram Online Review; Elevator Ride Computer Simulation; Read ch 4 and solve selected problems

<u>Project</u>

Students will research an invention of the past 250 years (*or as determined by the instructor*). Students will develop an oral presentation highlighting the development, usage, public perceptions, and future of their chosen invention.

Resources:

- Walker, James. (2014). <u>Physics</u>. Boston, MA. Pearson.
- PhET Interactive Simulations. (n.d.). Retrieved July 05, 2017, from https://phet.colorado.edu/
- The Physics Classroom. (n.d.). Retrieved July 05, 2017, from http://www.thephysicsclassroom.com/
- Gastineau, J. E., Appel, K., Baaken, C., Sorensen, R., Vernier, D., & Anderson, J. A. (2015). *Physics with Vernier: physics experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.

- B. (2011, January 25). VW Beetle Dropped from Helicopter Vs Porsche in 1 Mile Race Against Gravity! - Top Gear - BBC Two. Retrieved July 05, 2017, from https://www.youtube.com/watch?v=SiAbcw5s9_8

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): **Forces and Motion: Newton’s second law accurately predicts changes in the motion of macroscopic objects. (NGSS HS PS2.A)** *This Goal and Scale specifically addresses one-dimensional motion.*	
4.0	**Students will be able to:** • **Extrapolate the relationships between distance, time, and velocity in accelerated and non-accelerated systems based on their collected lab data**
3.0	**Students will be able to:** • **Design and interpret distance-time and velocity-time graphs from lab generated data** • **Trace the motion (changes in velocity, position, and acceleration) for a falling/rising object** • **Use kinematics principles to solve multi-step motion problems** • **Compare and contrast accelerated and non-accelerated motion in terms of changes in position and velocity over time**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: kinematics, distance, displacement, speed, velocity, vector, scalar, constant velocity, average velocity, instantaneous velocity, acceleration, freefall, law of falling bodies, terminal velocity, air resistance** • **Identify motion trends from a distance-time and a velocity-time graph** • **Solve simple (one-step) kinematics problems for one-dimensional motion** • **Determine the average velocity, distance, time, final/initial velocity, or acceleration of a moving object using kinematics principles** • **Experimentally, determine *g* using computer based lab equipment** • **Experimentally, determine the difference between distance and displacement**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Forces and Motion: Newton’s second law accurately predicts changes in the motion of macroscopic objects. (NGSS HS PS2.A) *This Goal and Scale specifically addresses two dimensional (projectile) motion.*	
4.0	**Students will be able to:** • **Predict the landing point of a projectile based on experimental data with minimal input from the instructor** • **Mathematically determine the altitude, time of flight, and range for an angled release projectile**
3.0	**Students will be able to:** • **Compare and contrast the two types of motion seen in projectiles** • **Mathematically determine the range, altitude, and initial velocity of a horizontal release projectile**

	• Describe the differences in path, altitude, time of flight, and range for projectiles launched at high and low angles • Predict how changes in horizontal or vertical velocity will affect the altitude, time of flight, and range for a projectile
2.0	**Students will be able to:** • Define the following terms in relation to physics: projectile, trajectory, parabola, range, altitude • Resolve a vector into its horizontal and vertical components • State the link (time) between the two planes of motion for a projectile
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Forces and Motion: Newton's second law accurately predicts changes in the motion of macroscopic objects. (NGSS HS PS2.A)	
4.0	**Students will be able to:** • Predict the motion of an object based on a self-created free body diagram correctly showing all the forces acting on the object
3.0	**Students will be able to:** • Diagram a system of forces acting on an object • Determine the relationships between force and mass and between mass and acceleration based on experimentally derived data • Determine the tension in a cable using free body diagrams • Apply Newton's Laws to written situations
2.0	**Students will be able to:** • Define the following terms in relation to physics: force, mass, inertia, unbalanced force, action-reaction pair, friction, coefficient of friction, free body diagram, apparent weight, tension, normal force, sum of forces • State Newton's three laws of motion • Differentiate between a balanced and an unbalanced force • Use the Pythagorean Theorem to determine the resultant of two force vectors • Calculate the weight for an object • Determine the force of friction for a surface
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s):
Engineering Design: Optimizing the Design Solution (ETS1.C) Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. **Engineering Design: Developing Possible Solutions (ETS1.B)** Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is

	most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.
4.0	**Students will be able to:** • **Predict how the selected invention will continue to influence society**
3.0	**Students will be able to:** • **Prepare an oral presentation to highlight the development, production and impact of the selected invention** • **Analyze the effect that the selected invention has had on other inventions and society/history as a whole**
2.0	**Students will be able to:** • **State the requirements of the project** • **Identify an invention that has influenced society in the 21st century** • **Research the developmental stages and production of the selected invention**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, The Physics Classroom, Dynamic Study Modules and Tutorial problems available via MyLab&Mastering) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:
Common Core State Standards Connections: ELA/Literacy

- 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.
- 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.
- WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
- HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
- 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.
- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

<u>Science & Engineering Practices</u>:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

<u>Cross-Cutting Connections:</u>
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

<u>Connections to Nature of Science:</u>
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Circular Motion & Fundamental Forces

Unit Description: In this unit, students will examine specific types of forces – centripetal, gravitational, and electromagnetic. Students will be introduced to motion in a circle and how it relates to planetary dynamics. Kepler's Laws will be discussed and applied to the solar system and satellite motion. Gravitation and the electromagnetic forces will be compared and contrasted.

From the NJ Model Physics Curriculum: In this unit of study, students plan and conduct investigations and apply scientific ideas to make sense of Newton's law of gravitation and Coulomb's Law. They apply these laws to describe and predict the gravitational and electrostatic forces between objects. Students *use mathematical and computational thinking* to examine the processes governing the workings of the solar system and universe. The crosscutting concepts of *scale, proportion, and quantity* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in *using mathematical and computational thinking* and to use this practice to demonstrate understanding of core ideas.The crosscutting concept of *patterns* is called out as an organizing concept for this disciplinary core idea. Students are expected to demonstrate proficiency in *planning and conducting investigations* and *applying scientific ideas* to demonstrate an understanding of core ideas.

Unit Duration: 5 - 6 weeks

Desired Results

Standard(s): 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-PS2-4: 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-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system
HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Indicators:

HS-PS2.A: Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation

HS-PS2.A: Understand and apply the relationship between the net force exerted on an object, its inertial mass, and its acceleration to a variety of situations
HS-PS2.B: Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects
HS-PS2.B: Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
HS-ESS1.B: Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system
HS-ETS1.A: Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them

HS-ETS1.B: When evaluative solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts
HS-ETS1.C: Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of criteria over others (trade-offs) may be needed.

Understandings:
Students will understand that…
1. Objects moving in a circular path are accelerating regardless of speed.
2. Centripetal forces act toward the center of a circle.
3. Increassing an object's velocity will exponentially increase its centripetal force.
4. Highways are designed with certain criteria (ie banking, radius of curvature, friction, speed limits) so that they can be safely travelled.
5. Non-uniform circular motion (vertical circles) result in changes in tension and apparent weight between the top and bottom of the circle.
6. The force of gravity between two objects is directly proportional to the masses of the objects and inversely proportional to the square of the distance separating them.
7. Universal gravitation can be used to determine orbital velocity, acceleration due to gravity, and temporal period of an orbiting body.
8. The fundmental forces include gravity, electromagnetism, and the nuclear forces.
9. Coulomb's Law describes the force between charged particles.
10. Universal Gravitation and Coulomb's Law are both inverse square relationships.
11. The shape of the orbits of the planets is an ellipse with the sun at one focus.
12. Planets are moving fastest when nearest the sun and slowest when far from the sun.
13. A planet's temporal period (year) is proportional to its distance from the sun.

Essential Questions:

1. How can an object moving at constant speed be accelerating?
2. In what direction does centripetal force act?
3. What is the relationship between velocity and centripetal force?
4. How does friction affect centripetal force?
5. What is the purpose of banking a highway?
6. How and why does an object's apparent weight change as it moves in a vertical circle?
7. On what does the force of gravity depend?
8. What did the Cavendish experiment discover about universal gravitation?
9. How does changing the distance between objects affect the force of gravity between them?
10. How is gravity related to centripetal force?
11. How does the orbital velocity of a satellite change as its position (altitude) changes?
12. What characteristics of a planet affect its acceleration due to gravity?
13. How is universal gravitation similar to electromagnetism? How is it different?
14. How is Coulomb's Law similar to the equation for Universal Gravitation? How is it different?
15. What are the fundamental forces? Why are they considered "fundamental"?
16. What is an inverse square relationship? Cite examples of inverse square relationships.
17. What are Kepler's Laws of Planetary Motion?
18. What is the shape of the orbits of the planets in the solar system?
19. How does a planet's speed change during its trip around the sun?
20. What is the relationship between a planet's distance to the sun and its temporal period?

Assessment Evidence

Performance Tasks:
Students will:

Other Evidence:
- Quizzes
  - Uniform Circular Motion

1. Mathematically and graphically represent the motion of an object undergoing centripetal acceleration 2. Solve a complex equation based on a real world motion sitation 3. Describe the use of circular motion in civil engineering 4. Compare and contrast Newton's Universal Gravitation and Coulomb's Law of Electromagnetism 5. Use Universal Gravitation to determine orbital characteristics 6. Use Kepler's Laws to describe the characteristics of the solar system	○ Universal Gravitation ○ Coulomb's Law ○ Kepler's Laws • Lab Work (includes reports and assessments) ○ Centripetal Force ○ The Vertical Circle ○ Center of Mass ○ Kepler's Laws • Independent Work ○ Selected text problems ch 9 19 ○ Teacher made problem review sheets ○ Computer simulations ▪ Centripetal Acceleration ▪ Race Track ▪ Gravity and Solar System Dynamics ▪ Gravity and Orbits ▪ Coulomb's Law • Test ○ One test at end of unit

Benchmarks:

Unit test

Learning Plan

Learning Activities:

The concepts in this unit are presented in Walker's Physics (2014) chapters 9 & 19.
For each major topic/lesson, specific activities are listed. Sources of activities can be found at the end of this section.

Circular Motion

I. Uniform Circular Motion
   a. Topics include: circular motion vocabulary, centripetal acceleration and force, highway engineering, banking angles
   b. Suggested activities include: Centripetal Force Lab; Centripetal Acceleration and Race Track Simulations; Read ch 9 and solve selected problems

II. Non-Uniform Circular Motion
   a. Topics include: Vertical Circles; Critical Speed
   b. Suggested Activities Include: Vertical Circle Lab; Water Pail Demonstration; Read ch 9 and solve selected problems

Fundamental Forces

I. Gravitation and Coulomb's Law
   a. Topics include: conceptual discussion of fundamental forces; Gravity and Orbital Properties; Coulomb's Law
   b. Suggested Activities include: Gravity and Orbits and Coulomb's Law Computer Simulations; Read ch 9 & 19 and solve selected problems

II. Kepler's Laws and Planetary Motion
   a. Topics Include: conceptual discussion of Kepler's Laws; Solar System Properties
   b. Suggested Activities: Kepler's Law Lab; Kepler's Law Simulation; Gravity and Solar System Dynamics Computer Simulation; Read ch 9 and solve selected problems

Resources:

- Walker, James. (2014). Physics. Boston, MA. Pearson.

- PhET Interactive Simulations. (n.d.). Retrieved July 05, 2017, from https://phet.colorado.edu/

- The Physics Classroom. (n.d.). Retrieved July 05, 2017, from http://www.thephysicsclassroom.com/

- Gastineau, J. E., Appel, K., Baaken, C., Sorensen, R., Vernier, D., & Anderson, J. A. (2015). *Physics with Vernier: physics experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.

- (n.d.). Retrieved July 07, 2017, from http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf%3A%3A800%3A%3A600%3A%3A%2Fsites%2Fdl%2Ffree%2F0072482621%2F78778%2FKepler_Nav.swf%3A%3AKeplers Second Law Interactive

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): **Forces and Motion: Newton's second law accurately predicts changes in the motion of macroscopic objects. (NGSS HS PS2.A)** **Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (NGSS HS-ETS1-3)**	
4.0	**Students will be able to:** • **Extrapolate the relationships between radius, velocity, mass, and force for an object moving in a circular path**
3.0	**Students will be able to:** • **Draw and label a circle diagram showing the orientation of all forces on an object moving in a circular path** • **Decide whether a curve meets safety standards for travel at given speeds or conditions (friction)** • **Solve multi-step problems for circular motion** • **Determine the apparent weight of an object moving in a vertical loop**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: centripetal motion, centripetal acceleration, centripetal force, uniform circular motion, non-uniform circular motion, critical speed** • **Identify the orientation (direction) of the centripetal force** • **Solve simple (one-step) problems for circular motion** • **Identify the positions in a vertical circle where tension (apparent weight) are the highest and lowest** • **State the relationship between velocity and centripetal acceleration and between radius and centripetal acceleration**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. **NGSS HS-PS2-4**	
4.0	**Students will be able to:** • **Adapt Newton's Law of Gravitation to solve for other astrophysics quantities like acceleration due to gravity, orbital velocity, escape velocity, and temporal period of a satellite**

3.0	**Students will be able to:** • **Compare and contrast Newton's Law of Gravitation and Coulomb's Law in terms of formula, quantities, orientation (attractive/repulsive), and strength** • **Determine the relationship between planetary mass/radius and acceleration due to gravity** • **Solve multi-step force problems** • **Predict the changes in force based on changes in distance, charge, or mass**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: Gravity; inverse square law; fundamental force; attractive force; repulsive force; Universal Gravitation Constant; electromagnetic force; nuclear force; Coulomb's Law; Coulomb's Constant; contact force; field force; orbital velocity; temporal period; escape velocity** • **Name and define the fundamental forces** • **Solve one-step force problems** • **Identify a force as attractive or repulsive**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): Use mathematical or computational representations to predict the motion of orbiting objects in the solar system **NGSS HS-ESS1-4**	
4.0	**Students will be able to:** • **Investigate whether the orbits of the planets follow Kepler's Laws of Planetary Motion**
3.0	**Students will be able to:** • **Predict the speed of a planet in general terms based on its position in its orbit around the sun** • **Trace the development of Kepler's Laws of Planetary Motion** • **Compare and constrast eccentric and circular orbits**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: Kepler's Laws of Planetary Motion; ellipse; focus; aphelion; perihelion; eccentricity** • **Find the distance to the sun for a planet based on its year** • **Describe the shape of the orbits of the planets**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, The Physics Classroom, Dynamic Study Modules and Tutorial problems available via MyLab&Mastering) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here.

		Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections
Indicators: **Common Core State Standards Connections: ELA/Literacy** • 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. • 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. • WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research. **Common Core State Standards Connections: Mathematics** • MP.2: Reason abstractly and quantitatively. • MP.4: Model with mathematics. • 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. • HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling. • HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. • HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context. • 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. • HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems. • 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.

- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Integration of 21st Century Skills

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Electromagnetism

Unit Description: This unit will deal with electromagnetic fields and electric circuits. Concepts will include field strength and orientation, motion regarding fields, and field diagrams. Students will experiment with electromagnets and with simple electric circuits. Earth's magnetic field will also introduced. A project regarding the use of electromagnets will be included.

From the NJ Model Physics Curriculum: In this unit of study, students' understanding of how forces at a distance can be explained by fields, why some materials are attracted to each other while other are not, how magnets or electric currents cause magnetic fields, and how charges or changing magnetic fields cause electric fields. The crosscutting concept of *cause and effect* is called out as an organizing concept. Students are expected to demonstrate proficiency *in planning and conducting investigations and developing and using models*

Unit Duration: 3-4 weeks

Desired Results

Standard(s):

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.

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.

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

Indicators:

HS-PS2.B: Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or Electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

HS-PS3.A: "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.

HS-ETS1.A: Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them

HS-ETS1.B: When evaluative solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts

HS-ETS1.C: Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of criteria over others (trade-offs) may be needed.

Understandings: *Students will understand that…* 1. Field forces are forces that exist in a region of space and do not require contact between objects to cause accelerations. 2. Charged particles cause fields. 3. Charged particles moving through fields will accelerate based on the strength of the field. 4. Multiple fields can overlap causing interference. 5. Fields can be represented by field lines. 6. Magnets cause magnetic fields. 7. Due to the molten iron core, Earth produces a strong magnetic field. 8. Changes in Earth's magnetic field are recorded in the rock record of the Atlantic Ocean. 9. The orientation of the magnetic field can be found using the Right Hand Rule. 10. A magnetic field can be produced by an electric current. 11. Electric currents move through closed circuits. 12. Ohm's Law states that the current through a circuit is proportional to its potential difference (voltage). 13. There are two basic types of circuits – series and parallel. 14. Resistors are parts of circuits that impede the flow of current and can be used to perform work. 15. Resistors in series all carry different voltages but have the same current. 16. Resistors in parallel all carry different currents but have the same voltage.	**Essential Questions:** 1. What is a field force? 2. How are fields represented? 3. What causes a field? 4. How do particles respond to fields? 5. What happens when field interact? 6. What is a magnet? 7. How/why is Earth like a giant magnet? 8. How is paleomagnetism used to determine rates of seafloor spreading? 9. What is the direction of the magnetic field compared to the orientation of the magnet? 10. How is the Right Hand Rule used? 11. What is an electromagnet? 12. How is an electromagnet produced and used? 13. What is electric current? 14. What relationship is shown in Ohm's Law? 15. How are parallel and series circuits different?
Assessment Evidence	

Performance Tasks:
Students will:
1. Map an electromagnetic field
2. Develop a strategy to separate steel from aluminum for industrial recycling use electromagnets
3. Compare and contrast series and parallel circuits
	Other Evidence:
	• Quizzes
	  ○ Electric Fields
	  ○ Magnetism
	  ○ Circuits
	• Lab Work (includes reports and assessments)
	  ○ Earth's Magnetic Field
	  ○ Paleomagnetism
	  ○ Electromagnets
	  ○ Circuits

	• Independent Work
	  ○ Selected text problems ch 20 – 22
	  ○ Article Reading and Response Questions: "Magnetic Pole Reversal Ahead?"
	  ○ Teacher made problem review sheets
	  ○ Computer simulations
	    ▪ Charges and Fields
	    ▪ Electromagnet Game
	    ▪ DC Circuit Construction
	
	• Project
	  ○ Presentation and Report on Reclamation Challenge
	• Tests
	  ○ One test at end of unit

Benchmarks:

Mid-term Scheduled at the end of this unit

Learning Plan

Learning Activities:

The concepts in this unit are presented in Walker's Physics (2014) chapters 20-22.
For each major topic/lesson, specific activities are listed. Sources of activities can be found at the end of this section.

Electromagnetic Fields

I. Electric Fields
   a. Topics include: E-M vocabulary; E-M formulae; Field Lines; Field Interactions
   b. Suggested activities include: Charges and Fields Computer Simulation; van de Graff Generator demonstration (if available); Read ch 20 and solve selected problems

II. Magnetic Fields
   a. Topics include: Right Hand Rule; Magnets; Earth's Magnetic Field; Electromagnets
   b. Suggested Activities Include: Vernier Magnetic Field Lab(s); Vernier Paleomagnetism Lab; Article Reading and Response Questions; Read ch 22 and solve selected problems

Circuits

I. Ohm's Law
   a. Topics include: conceptual discussion of Ohm's law; Current/Voltage Relationships
   b. Suggested Activities include: Read ch 21 and solve selected problems

II. Series and Parallel Circuits
   a. Topics Include: Resistor Addition; Comparison of Circuits; Circuit Analysis

b. Suggested Activities: Vernier Circuitry Lab; DC Circuit Construction Computer Simulation; Read ch 21 and solve selected problems

Project

Students will be presented with the "industrial" task of separating scrap steel and iron (paper clips and iron filings) from aluminum and plastic (pellets and beads). The steel and iron will be reclaimed for industrial purposes and the aluminum and plastic will be recycled. Students will work in teams to brainstorm how the task can be completed and will be instructed on the design and building of an electromagnet. A "competition" will be held. Teams will need to meet a threshold of separation as part of the grading criteria. The team with the highest amount reclaimed will win the "contract" (bonus points). To finalize the project, students will submit a written report showing their design and cost analysis as well as an analysis of their success or failure.

Resources:

- Walker, James. (2014). Physics. Boston, MA. Pearson.
- PhET Interactive Simulations. (n.d.). Retrieved July 05, 2017, from https://phet.colorado.edu/
- The Physics Classroom. (n.d.). Retrieved July 05, 2017, from http://www.thephysicsclassroom.com/
- Gastineau, J. E., Appel, K., Baaken, C., Sorensen, R., Vernier, D., & Anderson, J. A. (2015). *Physics with Vernier: physics experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.
- Electromagnet Game. (n.d.). Retrieved July 08, 2017, from http://www.harcourtschool.com/activity/electromagnets/
- Clean Up This Mess - Unit. (n.d.). Retrieved July 08, 2017, from https://www.teachengineering.org/curricularunits/view/van_cleanupmess_unit
- Tarduno, J., & Hare, V. (2017, February 10). Magnetic pole reversal ahead? Retrieved July 08, 2017, from http://earthsky.org/earth/magnetic-pole-reversal-ahead

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): ***This goal refers to Electromagnetic Fields and their use.*** **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.** **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.** **HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.**	
4.0	**Students will be able to:** • **Design and build an electromagnet capable of separating and lifting steel and iron from aluminium and plastic and justify the design to their peers**
3.0	**Students will be able to:** • **Analyze a real world industrial problem and offer a solution** • **Predict the orientation of a magnetic field** • **Solve multi-step field problems** • **Trace the development of Earth's magnetic field** • **Create a simple electromagnet and circuit**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: electric field; magnetic field; field lines; interference; dipole; electromagnet; current** • **Solve simple (one-step) problems for electric fields** • **Diagram the field surround a charge or magnet** • **Describe the Earth's magnetic field** • **Measure the strength of a field**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*
Standard(s): ***This goal refers to the design of a circuit.*** **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.** **HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.**

4.0	**Students will be able to:** • **Design and analyze a complex (combination) circuit in terms of resistance, power, current, and voltage**
3.0	**Students will be able to:** • **Experimentally determine the relationship between current and voltage (Ohm's Law)** • **Compare and contrast series and parallel circuits** • **Solve a combination circuit for total resistance, total power, and total current** • **Determine the voltage and current on individual resistors in a combination circuit**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: Ohm's Law; Voltage; circuit; battery; resistance; resistor; series circuit; parallel circuit; complex circuit; power** • **Solve simple circuit problems** • **Use Ohm's Law to determine voltage, resistance, or current** • **Identify basic circuit symbols** • **Add resistors in series and parallel**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, The Physics Classroom, Dynamic Study Modules and Tutorial problems available via MyLab&Mastering) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections
Indicators: **Common Core State Standards Connections: ELA/Literacy** • 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. • 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. • WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
- HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
- 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.
- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

<u>Science & Engineering Practices</u>:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

<u>Cross-Cutting Connections:</u>
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

<u>Connections to Nature of Science:</u>
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: The Conservation Principles
Unit Description: This unit will focus on conservation of energy and conservation of momentum. Students will be introduced to the basic types of work and energy (potential and kinetic) and will then apply those to conservation of energy. Momentum and collisions will then be discussed. Experiments will focus on verifying the conservation of both principles. Students will the design and construct a working scale sized roller coaster to ***From the NJ Model Physics Curriculum:*** In this unit of study, students *develop and use models, plan and carry out investigations, use computational thinking and design solutions* as they make sense of the disciplinary core idea*.* The disciplinary core idea of *Energy* is broken down into subcore ideas: *definitions of energy*, *conservation of energy* and *energy transfer*, and *the relationship between energy and forces*. Energy is understood as a quantitative property of a system that depends on the motion and interactions of matter, and the total change of energy in any system is equal to the total energy transferred into and out of the system. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy. The crosscutting concepts of *cause and effect, systems and systems models, energy and matter, and the influence of science, engineering, and technology on society and the natural world* are further developed in the performance expectations. Students are expected to demonstrate proficiency in *developing and using models, planning and carry out investigations, using computational thinking and designing solutions*, and they are expected to use these practices to demonstrate understanding of core ideas.
Unit Duration: 5-6 weeks
Desired Results
Standard(s): **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 motion of particles (objects) and energy associated with the relative position 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-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 science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision**
Indicators: **HS-PS3.A:** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. **HS-PS3.A:** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **HS-PS3.A:** These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In

some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

HS-PS3.B: Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.

HS-PS3.B: Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

HS-PS3.B: Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

HS-PS3.B: The availability of energy limits what can occur in any system.

HS-PS2.A: Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.

HS-PS2.A: If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

HS-ETS1.A: Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them

HS-ETS1.B: When evaluative solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts

HS-ETS1.C: Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of criteria over others (trade-offs) may be needed.

Understandings:

Students will understand that…

1. Work is a scalar quantity that is the product of force and displacement.
2. Not all forces cause work to be done.
3. Energy is the ability to do work.
4. Potential energy is due to position.
5. There are three types of potential energy – gravitational; elastic; and electric.
6. As height above a surface changes; potential energy will change.
7. Kinetic energy is due to motion.
8. As velocity increases, kinetic energy increases at an exponential rate.
9. Changes in kinetic energy cause work and vice versa.
10. A change in potential energy causes an equivalent change in kinetic energy, unless work done by the system.
11. Momentum is a measure of an object's inertia.
12. An impulse force will change a change in an object's momentum.
13. Momentum is conserved in a closed system.

Essential Questions:

1. What is work?
2. Under what conditions is work not done by an applied force?
3. What is energy?
4. What are the different types of energy?
5. How is potential energy related to position?
6. Why does an object have multiple potential energies?
7. How is an object's velocity related to its kinetic energy?
8. What is the work-kinetic energy theorem?
9. As an object falls (or rises) how does its total energy change? How does its potential energy change? Its kinetic energy?
10. What is meant by "conservation of energy"?
11. How does work affect conservation of energy?
12. What is momentum?
13. What is an impulse?
14. How are impulse and momentum related to Newton's 2nd Law?
15. What happens to the momentum of an object in a collision?

14. Inelastic collisions cause objects to stick together. 15. Elastic collision cause objects to bounce apart. 16. In a perfectly elastic collision, energy will be conserved along with momentum. 17. Different types of collisions yield different changes in speed, causing differing outcomes to those involved in the collision.	16. What are the three different types of collisions? 17. How is an inelastic collision different from an elastic collision? 18. What makes a perfectly elastic collsion "perfectly" elastic? 19. What is meant by "conservation of momentum"?

Assessment Evidence

Performance Tasks:

Students will:

1. Experimentally verify the Law of Conservation of Energy
2. Solve conservation of energy problems involving height changes, velocity changes, and work
3. Design and present a working model roller coaster with multiple features that highlight changes in potential and kinetic energy
4. Experimentally verify the Law of Conservation of Momentum
5. Solve collision problems to show that the type of collision affects the outcome (ie – rearend collision versus head-on).

Other Evidence:

- Quizzes
  - Work and Energy
  - Conservation
  - Momentum and Impulse
  - Collisions
- Lab Work (includes reports and assessments)
  - Work and Kinetic Energy
  - Conservation of Energy
  - Momentum and Impulse
  - Collisions
- Independent Work
  - Selected text problems ch 6 & 7
  - Teacher made problem review sheets
  - Computer simulations
    - Energy Skate Park
    - Collisions
    - Design a Roller Coaster
- Project
  - Presentation of Roller Coaster
- Tests
  - Energy
  - Momentum

Benchmarks:

Conservation of Energy Lab or similar lab experience

Learning Plan

Learning Activities:

The concepts in this unit are presented in Walker's Physics (2014) chapters 6 & 7.
For each major topic/lesson, specific activities are listed. Sources of activities can be found at the end of this section.

Energy

I. Types of Work and Energy
   a. Topics include: Work-Energy vocabulary; Work Qualitative and Quantitative Analysis; Energy Comparisons; Energy Relationship; Work-Kinetic Energy Theorem
   b. Suggested activities include: Vernier Work-Energy Lab; Read ch 6 and solve selected problems

II. Conservation of Energy
   a. Topics include: Conservation of Energy Problem Solving Techniques; Energy Relationships; Conservation of Energy without Work; Conservation of Energy with Work
   b. Suggested Activities Include: Vernier Conservation of Energy Lab; Energy Skate Park Simulation; Read ch 6 and solve selected problems

Momentum

I. Conservation of Momentum
   a. Topics include: conceptual discussion of momentum and impulse; momentum/impulse Relationships; conservation of linear momentum
   b. Suggested Activities include: Vernier Momentum and Impulse Lab; Read ch 7 and solve selected problems

II. Collisions
   a. Topics Include: Inelastic and Elastic Collisions
   b. Suggested Activities: Collision Lab; Collisions Computer Simulation; Read ch 7 and solve selected problems

Project

Students will be tasked with designing and building a theme roller coaster for "Physics World Amusement Park". They will be directed to watch a video (https://www.youtube.com/watch?v=H3UQiuDej38) and read an article (https://www.scientificamerican.com/article/shriek-science-simple-physics-powers-extreme-roller-coasters/) describing the physics behind roller coasters. They and their teams will then select a theme and design a roller coaster to highlight the concepts of conservation of energy. Students will use the following tutorial to assist in the design: https://www.learner.org/exhibits/parkphysics/coaster.html. Coasters will be built and presented in class.

Resources:

- Walker, James. (2014). Physics. Boston, MA. Pearson.
- PhET Interactive Simulations. (n.d.). Retrieved July 05, 2017, from https://phet.colorado.edu/
- The Physics Classroom. (n.d.). Retrieved July 05, 2017, from http://www.thephysicsclassroom.com/

- Gastineau, J. E., Appel, K., Baaken, C., Sorensen, R., Vernier, D., & Anderson, J. A. (2015). *Physics with Vernier: physics experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.
- Forcces Behind the Fun. (n.d.). Retrieved July 12, 2017, from https://www.learner.org/exhibits/parkphysics/coaster.html
- (2014, February 23). Retrieved July 12, 2017, from https://youtu.be/H3UQiuDej38
- Hackett, J. (2015, October 14). Shriek Science: Simple Physics Powers Extreme Roller Coasters. *Scientific American*. Retrieved July 12, 2017, from https://www.scientificamerican.com/article/shriek-science-simple-physics-powers-extreme-roller-coasters/

Unit Learning Goal and Scale

(Level 2.0 reflects a minimal level of proficiency)

Standard(s):

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 motion of particles (objects) and energy associated with the relative position 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

4.0	**Students will be able to:** • **Design and build a roller coaster with multiple features (hills, loops, turns, etc) and ascertain the energy transformations that occur during its running**
3.0	**Students will be able to:** • **Describe under what conditions an applied force would/would not perform work** • **Solve multi-step conservation of energy problems involving multiple types of energy and/or work** • **Predict the change in kinetic energy based on the change in velocity for an object** • **Use experimental data to verify the law of conservation of energy** • **Use experimental data to verify the work-kinetic energy theorem**

	• **Develop a strategy for determining the amount of work done by comparing changes in kinetic and potential energy**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: work; energy; power; potential energy; gravitational potential energy; elastic potential energy; electric potential energy; kinetic energy; work-kinetic energy theorem; conservation of energy** • **Solve simple (one-step) work-energy problems** • **Describe in general terms the loss/gain of potential energy or kinetic energy in a specific situation** • **Distinguish between positive and negative gravitational potential energy** • **State the relationship between position and potential energy** • **State the law of conservation of energy** • **Match an energy formula to the type of energy**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): **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 science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision**	
4.0	**Students will be able to:** • **Predict the severity of collisions based on the type of collision involved and offer a rationale for their prediction**
3.0	**Students will be able to:** • **Experimentally verify the conservation of momentum** • **Differentiate between the three types of collisions** • **Use a force-time graph to determine velocity change** • **Predict the motion of an object based on conservation of momentum principles**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: momentum; impulse force; conservation of momentum; elastic collision; inelastic collision; perfectly elastic collision** • **Solve simple momentum problems** • **Relate the change in momentum to an impulse force** • **State the law of conservation of momentum** • **Compare initial and final momenta for a system**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, The Physics Classroom, Dynamic Study Modules and Tutorial problems available via MyLab&Mastering) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include:
	  • Variation of time: adapting the time allotted for learning, task completion, or testing
	  • Variation of input: adapting the way instruction is delivered
	  • Variation of output: adapting how a student can respond to instruction
	  • Variation of size: adapting the number of items the student is expected to complete
	  • Modifying the content, process or product
	
	Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here.
	Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and

	participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections
Indicators: **Common Core State Standards Connections: ELA/Literacy** • 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. • 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. • WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research. **Common Core State Standards Connections: Mathematics** • MP.2: Reason abstractly and quantitatively. • MP.4: Model with mathematics. • 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. • HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling. • HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. • HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context. • 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. • HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems. • 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. • HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

- HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Oscillation and Wave Properties

Unit Description: This unit will focus on simple harmonic motion and wave mechanics. Students will explore Hooke's Law and mass-spring systems, as well as pendula, in lab experiments. The concept of wave motion will be introduced and verified in lab experiments. Types of waves and wave behavior will be explored, focusing primarily on standing waves and sound waves. Students will experimentally determine the speed of sound and examine the effect of the height of an air column on sound frequency. Sound intensity (decibels) and relative motion (Doppler Effect) will be examined.

From the NJ Model Physics Curriculum: In this unit of study, students apply their understanding of how wave properties can be used to transfer information across long distances, store information, and investigate nature on many scales. The crosscutting concept of *cause and effect* is highlighted as an organizing concept for these disciplinary core ideas. Students are expected to demonstrate proficiency in *using mathematical thinking*, and to use this practice to demonstrate understanding of the core idea.

Unit Duration: 5-6 weeks

Desired Results

Standard(s):

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-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 motion of particles (objects) and energy associated with the relative position of particles (objects).

HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy

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

HS-PS-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.

Indicators:

HS-PS2.A: Newton's second law accurately predicts changes in the motion of macroscopic objects.

HS-PS3.A: Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
HS-PS3.A: At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
HS-PS3.A: These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.
HS-PS3.B: Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
HS-PS3.B: Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
HS-PS3.B: Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
HS-PS4.A: The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

Understandings: *Students will understand that…*	**Essential Questions:**
1. Simple Harmonic Motion occurs when a restoring force causes repetitive motion. 2. The force required to stretch or compress an elastic material is a product of the elasticity of the material (k) and the displacement caused by the stretch/compression. 3. An oscillating object will have its highest velocity at the equilibrium position and its highest force/acceleration at the extremes. 4. The period of a mass-spring oscillator is dependant on the mass on the spring and the spring's elasticity. 5. The period of a simple pendulum is only affected by its length, assuming gravity to be a constant. 6. The frequency and wavelength of a wave are inversely related to each other. 7. Light is an example of a transverse wave, which travel perpendicular to the direction of propagation. 8. Sound is an example of a longitudinal wave, which travels parallel to the direction of travel. 9. Constructive and destructive interference occur when waves interact. 10. When waves encounter boundaries, their behavior is determined by the type of boundary. 11. Standing waves are produced in media vibrating at specific frequencies. 12. The speed of sound varies due to temperature and the elasticity of the material the waves travel through. 13. Humans hear a limited range of sounds. 14. When the relative distance between a wave source and observer change, the apparent frequency of the waves change. 15. Sound intensity is directly related to the power of the sound wave and inversely proportional to the area through which the sound moves. 16. The decibel scale is a logarithmic scale developed to rate human experience of sound intensity.	1. What are some examples of objects undergoing simple harmonic motion? 2. What affects the stretch or compression of a spring? 3. Identify the oscillation points when an oscillator will have the max/min velocity, force, acceleration, potential energy, and kinetic energy. 4. What affects the period of a mass-spring oscillator? 5. What affects the period of a pendulum? 6. How can a pendulum be used to determine altitude? 7. How are wavelength and frequency related? 8. Compare and contrast the two basic types of waves. 9. What causese interference patterns in waves? 10. What are the two basic types of interference? 11. How will a wave behave at a fixed boundary? At a flexible boundary? 12. What is the interference pattern produced by the fundamental frequency of a standing wave in a string? 13. Diagram and label a standing wave of *n* harmonic. 14. How are standing waves produced in columns of air? 15. How does the height of an air column affect the frequency of the standing wave it produces? 16. How does the speed of sound change as the air temperature changes? 17. What happens to the wavelength and frequency of a sound wave as it enters a new medium? 18. How are sounds affected by relative motion? 19. What happens to observed sounds as the distance between source and observer shrinks? When it increases? 20. What can cause a powerful wave to appear low in magnitude? 21. How are sounds on the decibel scale related to human comfort? 22. How does sound intensity change as you increase decibel level?

Assessment Evidence

Performance Tasks:	Other Evidence:

Students will:
1. Experimentally determime the period of a mass-spring oscillator.
2. Experimentally determine the factors affecting the period of a simple pendulum.
3. Diagram the max/min positions and kinematics of an oscillator.
4. Draw and label the nodes, antinodes, and wavelength of a standing wave of a given frequency.
5. Experimentally determine the speed of sound.
6. Experimentally determine the relationship between wavelength and frequency.
7. Describe the usage of waves in the fields of music, astronomy, and geology.
	• Quizzes
	  ○ Hooke's Law and Elastic Energy
	  ○ Period of Oscillation
	  ○ Wave Properties
	  ○ Sound and its Applications
	• Lab Work (includes reports and assessments)
	  ○ Hooke's Law
	  ○ The Pendulum
	  ○ Sound Waves
	  ○ Speed of Sound
	  ○ Mathematics of Music
	• Independent Work
	  ○ Selected text problems ch 13 & 14
	  ○ Teacher made problem review sheets
	  ○ Computer simulations
	    ▪ Hooke's Law and Mass-Spring Oscillators
	    ▪ Waves on a String
	    ▪ Standing Waves
	    ▪ Virtual Earthquake
	    ▪ Doppler Effect
	• Tests
	  ○ Harmonic Motion
	  ○ Waves and Sound

Benchmarks:

Pendulum Lab or similar lab experience

Learning Plan

Learning Activities:

The concepts in this unit are presented in Walker's Physics *(2014) chapters 13 & 14.*
For each major topic/lesson, specific activities are listed. Sources of activities can be found at the end of this section.

Harmonic Motion

I. Topics include: Simple Harmonic Motion vocabulary; Hooke's Law; Elastic Potential Energy; Mass-Spring Oscillators; The Pendulum
II. Suggested activities include: Vernier Elastic Energy Lab; The Pendlum Lab; Mass-Spring Oscillators Computer Simulation; Pendulum Video; Read ch 13 and solve selected problems

Waves and Sound

I. Wave Properties
   a. Topics include: Wave "Anatomy"; Types of Waves; Interference; Wavelength/Frequency Relationships; Standing Waves
   b. Suggested Activities include: Vernier Sound Waves Lab; Vernier Mathemtics of Music Lab; Wave Demonstration (Ripple Tank); Wave Video clips; Standing Waves Computer Simulation; Virtual Earthquake Computer Simulation; Waves on a String Computer Simulation; Read ch 14 and solve selected problems
II. Sound
   a. Topics Include: Speed of Sound; The Doppler Effect; Sound Intensity; Human Experience of Sound
   b. Suggested Activities: Vernier Speed of Sound Lab; Doppler Effect Computer Simulation; Resonance Video; Read ch 14 and solve selected problems

Resources:

- Walker, James. (2014). Physics. Boston, MA. Pearson.
- PhET Interactive Simulations. (n.d.). Retrieved July 05, 2017, from https://phet.colorado.edu/
- The Physics Classroom. (n.d.). Retrieved July 05, 2017, from http://www.thephysicsclassroom.com/
- Gastineau, J. E., Appel, K., Baaken, C., Sorensen, R., Vernier, D., & Anderson, J. A. (2015). *Physics with Vernier: physics experiments using Vernier sensors*. Beaverton, OR: Vernier Software & Technology.

- Doppler Shift Interactive. (n.d.). Retrieved July 14, 2017, from http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf%3A%3A800%3A%3A600%3A%3A%2Fsites%2Fdl%2Ffree%2F0072482621%2F78778%2FDoppler_Nav.swf%3A%3ADoppler Shift Interactive

- Dann, J. (2010, August 12). Standing Waves Part I: Demonstration. Retrieved July 14, 2017, from https://youtu.be/-gr7KmTOrx0

- Goodman, J. (2014, September 07). Pendulum Wave Demonstration. Retrieved July 14, 2017, from https://youtu.be/YhMiuzyU1ag

- Novak, G., & Mayo, D. (n.d.). Virtual Earthuake . Retrieved July 14, 2017, from http://www.sciencecourseware.com/eec/Earthquake/

- Wine glass resonance in slow motion. (2009, March 06). Retrieved July 17, 2017, from https://youtu.be/BE827gwnnk4

Unit Learning Goal and Scale

(Level 2.0 reflects a minimal level of proficiency)

Standard(s):

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-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 motion of particles (objects) and energy associated with the relative position 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.

4.0	**Students will be able to:** • **Experimentally analyze a pendulum and determine the factors affecting its period/frequency** • **Explain how a pendulum can used to determine the altitude of a point**
3.0	**Students will be able to:** • **Predict the points of max/min velocity, acceleration, force, potential and kinetic energies for an oscillating object** • **Predict the affect of increasing the mass on or elasticity of a spring on the frequency of the oscillation** • **Solve multi-step harmonic motion problems**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: Simple Harmonic Motion; oscillation; Hooke's Law; spring constant; elastic potential energy; mass-spring oscillator; pendulum; period; frequency** • **Solve simple (one-step) harmonic motion problems**

	• **State the conditions for simple harmonic motion** • **State the relationship between force applied and displacement of a spring** • **Convert frequency into period and vice versa**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): ***This focuses on general wave properties.*** **HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**	
4.0	**Students will be able to:** • **Adapt an air column to produce changes in frequency of a standing wave** • **Experimentally determine the relationship between wavelength and frequency**
3.0	**Students will be able to:** • **Predict changes in wavelength based on changes in frequency** • **Solve multi-step wave problems** • **Deduce the relationship between nodes, antinodes, and wavelength for standing waves of multiple harmonics** • **Form conclusions about the production of music from different instruments based on types of standing waves** • **Predict the epicenter of an earthquake based on seismic waves** • **Classify waves based on their behavior** • **Compare and contrast transverse and longitudinal waves** • **Investigate the usage of waves in other areas of science**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: wave; crest; trough; wavelength; amplitude; constructive interference; destructive interference; longitudinal wave; transverse wave; standing wave; node; antinode; harmonic; fundmental frequency** • **Solve simple (one-step) wave problems** • **Diagram the "anatomy" of a wave** • **State the relationship between wavelength and frequency** • **Describe the behavior of waves at boundaries** • **Describe the effects of constructive and destructive interference on waves**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*
Standard(s): *This focuses specifically on sound waves.* **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-PS-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.	
4.0	**Students will be able to:** • **Predict air temperature by experimentally determining the speed of a sound wave** • **Generalize the behavior of sound as a wave**
3.0	**Students will be able to:** • **Predict changes in the speed of sound based on changes in temperature** • **Solve multi-step sound problems** • **Determine the frequency of a sound wave in various media** • **Predict the change in frequency of a sound wave during relative motion** • **Predict levels of sound intensity at various distances from a source** • **Classify sound intensities (in W/m^2) as decibel ratings and state whether they would be harmful to humans**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: sound; ultrasonic; subsonic; supersonic; Doppler Effect; intensity; decibel scale** • **Solve simple (one-step) sound problems** • **Recognize human detectable sound waves** • **State the relationship between temperature and the speed of sound** • **Identify the changes in sound frequency caused by motion** • **Use the decibel scale to describe sound intensity** • **Convert between intensity and the decibel scale** • **Describe (in general terms) the changes in sound intensity as distance increases**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, The Physics Classroom, Dynamic Study Modules and Tutorial problems available via MyLab&Mastering) • Utilize peer tutors during class to work with struggling learners

English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections

Indicators:
Common Core State Standards Connections: ELA/Literacy

- 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.
- 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.
- WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
- HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
- 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.
- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Indicators:
The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

<u>Science & Engineering Practices</u>:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Unit Title: Light and the Electromagnetic Spectrum

Unit Description: This unit will focus on the nature and behavior of light and the electromagnetic spectrum (EMS). Students will be introduced to the parts of the EMS. Light's behavior at boundaries will be a major focus. Labs will highlight reflection and refraction. Optical systems will be discussed and analyzed mathematically and graphically through ray diagrams. Transmission of data via fiber optics and radio waves will be discussed. A project at the end of the unit will wrap up topics covered throughout the year.

From the NJ Model Physics Curriculum: In this unit of study, students are able to apply their understanding of wave properties to make sense of how electromagnetic radiation can be used to transfer information across long distances, store information, and be used to investigate nature on many scales. Models of electromagnetic radiation as both a wave of changing electrical and magnetic fields or as particles are developed and used. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of *systems and system models*; *stability and change*; *interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world* are highlighted as organizing concepts. Students are expected to demonstrate proficiency in *asking questions, engaging in argument from evidence, and obtaining, evaluating, and communicating information*, and they are expected to use these practices to demonstrate understanding of the core ideas.

Unit Duration: 3-4 weeks

Desired Results

Standard(s):

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-PS3-3: 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.

Indicators:

HS-PS4.A: The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

HS-PS4.A: Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

HS-PS4.B: Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.

HS-PS4.B: When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

HS-PS4.C: Multiple technologies based on the understanding of waves and their interactions with matter are part of every day experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Understandings:

Students will understand that…

1. The speed of light in a vacuum is a constant.
2. The Doppler Effect can also be applied to light and was instrumental in discovering the expansion of the universe.
3. Light can behave as both a particle and as a wave.
4. Light waves are produced by oscillating E-M fields.
5. The EMS is the range of frequencies for electromagnetic waves.
6. The energy of an E-M wave is directly related to its frequency.
7. Humans see a relatively small portion of the EMS; other organisms see different parts of the EMS.
8. E-M waves of high frequency tend to be damaging to human tissues.
9. Different types of E-M waves have different properties.
10. Light rays at boundaries can be reflected (bounced back) or refracted (bent).
11. For a smooth flat surface, the angle of reflection is equal to the angle of incidence.
12. Curved mirrors distort the size and orientation of images.
13. Real images are produced where light rays actually come into focus; virtual images are produced where light only appears to come into focus.
14. The speed of light changes as it moves into different materials based on the density of the material.
15. A light ray will be bent towards the normal when traveling from a low density material to a high density material; it will be bent away in the opposite circumstance.
16. When light travels from a high density material to a low density material, it can be bent so much that it appears to reflect back into the original material – called total internal reflection.
17. Total internal reflection is responsible for mirages and is the basis for fiber optic cable.

Essential Questions:

1. What is the speed of light?
2. How was the expansion of the universe determined?
3. How does light act like a particle?
4. In what way is light like a wave?
5. What is the Electromagnetic Spectrum?
6. How is the EMS arranged?
7. What is the relationship between frequency and energy?
8. What is true about the “high end” of the EMS in relation to human?
9. How is the “low end” of the EMS used by humans?
10. How does light behave at a boundary?
11. Describe the path of a light ray that encounters a plane (flat) mirror.
12. Compare and contrast concave and convex mirrors.
13. How do concave and convex mirrors form images?
14. What type(s) of magnification are seen with concave mirrors? With convex?
15. What are some examples of concave and convex mirrors?
16. Explain the difference(s) between real and virtual images.
17. What happens to a light ray’s speed as it enters a more dense material?
18. How does a light ray behave when it enters a more dense material? A less dense material?
19. What is total internal reflection? What causes it and how is it used in communications?
20. Compare and contrast convex and concave lenses.
21. What are some common lense systems used in science?
22. How are ray tracings used to determine the location, type, size and orientation of images?

18. Fiber optic cable can send information hundreds of miles as reflected light pulses. 19. Lenses cause light to be bent and focused at different points. 20. Systems of lenses and/or mirrors, like microscopes and telescopes, use refraction and reflection to magnify objects. 21. Ray tracing is a tool to locate and describe images produced by mirrors and lenses.	

Assessment Evidence

Performance Tasks:

Students will:

1. Describe light as both a wave and a particle.
2. Label parts of the EMS, including high/low wavelength, frequency, and energy.
3. Determine the image location, type, size, and orientation for mirrors and lenses mathematically and via ray tracing.
4. Experimentally verify Snell's Law.
5. Explain the cause and usage of total internal reflection.

Other Evidence:

- Quizzes
  - The Nature of Light and the EMS
  - Mirrors
  - Snell's Law
  - Lenses
- Lab Work (includes reports and assessments)
  - The Doppler Effect and the Expanding Universe
  - Law of Reflection
  - Snell's Law
  - Lenses
- Independent Work
  - Selected text problems ch 15 - 17
  - Teacher made problem review sheets
  - Computer simulations
    - Electromagnetic Spectrum Interactive
    - Bending Light
    - Lenses and Mirrors
- Tests
  - One test at end of unit
- Project
  - Website on Engineering Disaster

Benchmarks:

Final Exam at end of unit

Learning Plan

Learning Activities:

The concepts in this unit are presented in Walker's Physics (2014) chapters 15 – 17.
For each major topic/lesson, specific activities are listed. Sources of activities can be found at the end of this section.

Light and the Electromagnetic Spectrum

I. Topics include: Nature of Light; Speed of Light; the Electromagnetic Spectrum
II. Suggested activities include: Doppler Effect and the Expanding Universe Activity; The Electromagnetic Spectrum Computer Activity; Read ch 15 and solve selected problems

Reflection of Light

I. Plane Mirrors
   a. Topics include: Types of Reflection; Law of Reflection
   b. Suggested Activities include: Reflection Lab; Read ch 16 and solve selected problems
II. Spherical Mirrors
   a. Topics Include: Types of Spherical Mirrors; The Mirror Equation; Ray Tracing for Mirrors
   b. Suggested Activities: Lenses and Mirrors Computer Simulation; Mirror Ray Tracing Demostration (using Optics Bench Kit); Read ch 16 and solve selected problems

Refraction of Light

I. Snell's Law
   a. Topics Include: Index of Refraction; Snell's Law; Total Internal Reflection; Apparent Depth
   b. Suggested activities include: Snell's Law Lab; Bending Light Computer Simulation; Total Internal Reflection Video; Fiber Optic Cable Video; Snell's Law Demo (using Optics Bench Kit); Read ch 17 and solve selected problems
II. Lenses
   a. Topics Include: Types of Lenses; The Lense Equation; Ray Tracing for Lenses
   b. Suggested activities include: Lenses Lab; Lense Demo (using Optics Bench Kit); Lenses and Mirrors Computer Simulation; Read ch 17 and solve selected problems

Resources:

- Walker, James. (2014). Physics. Boston, MA. Pearson.
- PhET Interactive Simulations. (n.d.). Retrieved July 05, 2017, from https://phet.colorado.edu/
- The Physics Classroom. (n.d.). Retrieved July 05, 2017, from http://www.thephysicsclassroom.com/
- Total Internal Reflection. (2012, January 13). Retrieved July 17, 2017, from https://youtu.be/NAaHPRsveJk
- Fiber optic cables: How they work. (2011, June 20). Retrieved July 17, 2017, from https://youtu.be/0MwMkBET_5I

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): *This section deals with the nature of light and the EMS.* **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-PS3-3: 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.**	
4.0	**Students will be able to:** • **Develop an argument that the universe is expanding based on the Doppler Effect in light**
3.0	**Students will be able to:** • **Predict the relative "danger" that parts of the EMS pose to humans based on their wavelength/frequency** • **Categorize parts of the EMS in terms of applications to human technology and communication**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: wavicle; Electromagnetic Spectrum; Planck's Law** • **Identify light as both a wave and a particle** • **List the parts of the Electromagnetic Spectrum** • **Identify the high energy and low energy parts of the EMS** • **Identify the speed of light in a vacuum** • **State the relationship between frequency and energy**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*
Standard(s): *This section deals with reflection and refraction of light.* **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-PS3-3: 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.	
4.0	**Students will be able to:** • **Investigate multiple lense/mirror combinations in use in various areas of science (microscopes, telescopes, etc)**
3.0	**Students will be able to:** • **Predict the nature of images (location, type, orientation, and size) produced by various types of lenses or mirrors** • **Classify various types of lenses or mirrors** • **Predict the bending of light in general terms (toward/away from the normal) based on Snell's Law** • **Explain the conditions for total internal reflection and how it is used in telecommunications**
2.0	**Students will be able to:** • **Define the following terms in relation to physics: reflection; plane mirror; spherical mirror; law of reflection; refraction; index of refraction; Snell's Law; total internal refection; magnification; real image; virtual image; converging lense/mirror; diverging lense/mirror; radius of curvature; focal length; ray diagram** • **Determine the index of refraction for a material** • **List the angle of reflection for an incident ray** • **State the relationship between density and the speed of light in a material** • **Classify the focal length of lenses and mirrors as positive or negative based on the type of lense/mirror** • **Use the lens equation to locate an image** • **Categorize images as real or virtual based on the lens equation** • **Describe spherical mirrors** • **Describe the use of ray tracing to location and identify images.**
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Provide opportunities for the advanced learner to act as a peer tutor during class time that involves student choice of activities. • Facilitate access to extensive enrichment activities using online learning management system • Provide challenge problems for advanced learners to solve
Struggling Learners	• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

	• Facilitate access to extensive review and remediation activities through the learning management system and/or online text content (for example, use of Khan Academy, The Physics Classroom, Dynamic Study Modules and Tutorial problems available via MyLab&Mastering) • Utilize peer tutors during class to work with struggling learners
English Language Learners	• http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf • Coordinate with ELL advisors to modify activities where appropriate • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Resource Guide to Section 504 to assist in the development of appropriate plans.

Interdisciplinary Connections

Indicators:
Common Core State Standards Connections: ELA/Literacy

- 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.
- 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.

- WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core State Standards Connections: Mathematics

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- 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.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context.
- 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.
- HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
- 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.
- HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
- HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots).

Indicators:

The standards listed above and the performance tasks and activities that support them are infused with 21st Century Skills. The Level 3 skills listed in each of the Goals & Scales sections involve critical and creative thinking, communication and collaboration. The methods by which students attain these skills require that students practice multi-step problem solving, using technology to research and solve problems, and communicate results with their instructors and peers. The learning activities listed provide a mix of traditional classroom work and interactive, online experiences.

Science & Engineering Practices:
Asking questions and defining problems
Using Mathematics and Computational Thinking
Analyzing and Interpreting Data
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Cross-Cutting Connections:
Influence of Science, Engineering, and Technology on Society and the Natural World
Cause and Effect

Connections to Nature of Science:
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena