SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

Physics

New Jersey Student Learning Standards SCIENCE

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

Unit 1: Overview
Unit 1: Forces and Motion
Content Area: Physics
Pacing: 25 Instructional days
Essential Question
How can one explain and predict interactions between objects and within systems of objects?
Student Learning Objectives (Performance Expectations)
HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship amongthe net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
HS-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.
Unit Summary
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.
Technical Terms
Newton's Second Law of Motion, macroscopic object, velocity, non-relativistic speed, net force, subatomic scales, conservation of momentum, collision, elasticity, vector drawings, causal relationships, correlational relationships, net force
Formative Assessment Measures

Part A: How do they know how long the yellow light should be on before it turns red? (traffic light)

Students who understand the concepts are able to:

Analyze data using tools, technologies, and/or models 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.

Analyze data using one-dimensional motion at nonrelativistic speeds 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.

Part B: How can a piece of space debris the size of a pencil eraser destroy the International Space Station?

Students who understand the concepts are able to:

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.

Use mathematical representations of the quantitative conservation of momentum and the qualitative meaning of this principle in systems of two macroscopic bodies moving in one dimension.

Describe the boundaries and initial conditions of a system of two macroscopic bodies moving in one dimension.

Part C: Red light cameras were placed in intersections to reduce the number of collisions caused by cars running red lights. Many people thought that they were unfair and demanded that they be removed. As an expert on the physics of moving bodies, you are challenged to engineer traffic signals to proactively reduce the number of people entering an intersection after the light turns red. The cost of the redesign must not exceed 10% of the current cost of current traffic signals or the energy needed to operate them.

Students who understand the concepts are able to:

Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Apply scientific ideas to solve a design problem for a device that minimizes the force on a macroscopic object during a collision, taking into account possible unanticipated effects.

Use qualitative evaluations and /or algebraic manipulations to design and refine a device that minimizes the force on a macroscopic object during a collision.

Interdisciplinary Connections

NJSLS- ELA	NJSLS- Mathematics
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. (HS-PS2-1) RST.11-12.1 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video,	Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) MP.2 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) MP.4

multimedia) in order to address a question or solve a problem. (HS-PS2-1) RST.11-12.7 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-3) RST.11-12.8 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) RST.11-12.9 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.(HS-PS2-3),(HS-ETS1-3) WHST.11-12.7 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1) WHST.11-12.9	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2) HSN.Q.A.1 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1),(HS-PS2-2) HSN.Q.A.2 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2) HSN.Q.A.3 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1) HSA.SSE.A.1 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. HSA.SSE.B.3 (HS-PS2-1) Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2) HSA.CED.A.1 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1),(HS-PS2-2) HSA.CED.A.2 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2) HSA.CED.A.4 Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1) HSF-IF.C.7 Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1) HSS-IS.A.1

21st Century Life and Careers	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5

Modifications

English Language Learners	Special Education	At-Risk	Gifted and Talented
Scaffolding Word walls Sentence/paragraph frames	Word walls Visual aides Graphic organizers	Teacher tutoring Peer tutoring Study guides	Curriculum compacting Challenge assignments Enrichment activities

Bilingual dictionaries/translation	Multimedia	Graphic organizers	Tiered activities
Think alouds	Leveled readers	Extended time	Independent research/inquiry
Read alouds	Assistive technology	Parent communication	Collaborative teamwork
Highlight key vocabulary	Notes/summaries	Modified assignments	Higher level questioning
Annotation guides	Extended time	Counseling	Critical/Analytical thinking tasks
Think-pair- share	Answer masking		Self-directed activities
Visual aides	Answer eliminator		
Modeling	Highlighter		
Cognates	Color contrast		

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PHYSICS

HS-PS2-1: Motion and Stability: Forces and Interactions

HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship amongthe net force on a macroscopic object, its mass, and its acceleration.

Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.

Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at nonrelativistic speeds.

Evidence Statements: HS-PS2-1

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Connections to Nature of Science** Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena Theories and laws provide explanations in science. Laws are statements or descriptions of the relationships among observable phenomena.	**PS2.A: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band: HS.PS3.C ; HS.ESS1.A ; HS.ESS1.C ; H.ESS2.C

Articulation of DCIs across grade-bands: MS.PS2.A ; MS.PS3.C

NJSLS- ELA: RST.11-12.1 , RST.11-12.7 , WHST.11-12.9

NJSLS- Math: MP.2 , MP.4 , HSN.Q.A.1 , HSN.Q.A.2 , HSN.Q.A.3 , HSA.SSE.A.1 , HSA.SSE.B.3 , HSA.CED.A.1 , HSA.CED.A.2 , HSA.CED.A.4 , HSF-IF.C.7 , HSS-IS.A.1

5E Model

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HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship amongthe net force on a macroscopic object, its mass, and its acceleration.	
Engage Anticipatory Set	The following PHET Colorado online simulations can be used to introduce students to the topic of force and motion. Forces and Motion Basics (HTML5) Force and Motion (Java) Ramp: Force and Motion
Exploration Student Inquiry	Applying Newton's Second Law Quantitatively In this lesson, students will solve a variety of problems with free body diagrams and Newton's Second Law. http://betterlesson.com/lesson/635014/applying-newton-s-second-law-quantitatively Combining Newton's Second Law and Kinematics In this lesson, students will solve a variety of problems with Newton's Second Law and the equations of motion. http://betterlesson.com/lesson/635295/combining-newton-s-second-law-and-kinematics PUM Lessons: Newton's Second Law- Qualitative Acceleration Newton's Second Law- Quantitative Part 1 Newton's Second Law- Quantitative Part 2
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS2.A: Forces and Motion Newton's second law accurately predicts changes in the motion of macroscopic objects.
Elaboration Extension Activity	An Introduction to Free Body Diagrams Students use the vector nature of forces to draw free body diagrams. http://betterlesson.com/lesson/630798/an-introduction-to-free-body-diagrams Newton's Second Law in 1-D Motion In this lesson, students will be able to identify Newton's Second Law and apply it to 1-dimensional motion. http://betterlesson.com/lesson/631023/newton-s-second-law-in-1-d Newton's Second Law in 2-D Motion

	Students will be able to apply Newton's Second Law to 2-dimensional motions. http://betterlesson.com/lesson/631088/newton-s-second-law-in-2-d	
Evaluation Assessment Tasks		Assessm In comp correla

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PHYSICS		
HS-PS2-2: Motion and Stability: Forces and Interactions		
HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.		
Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.		
Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.		
Evidence Statements: HS-PS2-2		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical representations of phenomena to describe explanations.	**PS2.A: Forces and Motion** Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. 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.	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.
Connections to other DCIs in this grade-band: HS.ESS1.A ; HS.ESS1.C		
Articulation of DCIs across grade-bands: MS.PS2.A ; MS.PS3.C		
NJSLS- ELA: N/A		
NJSLS- Math: MP.2 , MP.4 , HSN.Q.A.1 , HSN.Q.A.2 , HSN.Q.A.3 , HSA.CED.A.1 , HSA.CED.A.2 , HSA.CED.A.4		
5E Model		

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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.	
Engage Anticipatory Set	Hands On Activity: Bouncing Balls In this activity, students examine how different balls react when colliding with different surfaces. Also, they will have plenty of opportunity to learn how to calculate momentum and understand the principle of conservation of momentum. https://www.teachengineering.org/Activities/View/cub_energy_lesson03_activity3
Exploration Student Inquiry	Collision Lab : Introduction to One Dimension collisions https://phet.colorado.edu/en/contributions/view/3339 A Collisions Lab Students will be able to estimate the speed of an object by applying momentum conservation to collisions. http://betterlesson.com/lesson/636409/a-collision-lab Conservation of Momentum in Explosions The purpose of this experiment is to demonstrate conservation of momentum for two cars pushing away from each other. http://www-lhs.beth.k12.pa.us/faculty/Hoffman_M/Expt%2004%20Conservation%20of%20Momentum%20Explosions.pdf Demonstration Video https://www.youtube.com/watch?v=VZsTS1I5swI
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS2.A: Forces and Motion Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. 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.
Elaboration Extension Activity	Related Activities: http://www.physicsclassroom.com/NGSS-Corner/Force-and-Motion-DCIs-HS http://www.ck12.org/ngss/high-school-physical-sciences/motion-and-stability:-forces-and-interactions
Evaluation Assessment Tasks	Assessment Task A:

	Using the mathematical representations included in the above activities, students will support the claim that the momentum of the system is the same before and after the interaction between the objects in the system, so that momentum of the system is constant.

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PHYSICS		
HS-PS2-3: Motion and Stability: Forces and Interactions		
HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.		
Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.		
Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.		
Evidence Statements: HS-PS2-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**PS2.A: Forces and Motion** 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. ETS1.A: Defining and Delimiting an Engineering Problem 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. (secondary) ETS1.C: Optimizing the Design Solution 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. (secondary)	**Cause and Effect** Systems can be designed to cause a desired effect.
Connections to other DCIs in this grade-band: N/A		
Articulation of DCIs across grade-bands: MS.PS2.A ; MS.PS3.C		
NJSLS- ELA: WHST.11-12.7		
NJSLS- Math: N/A		

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5E Model	
HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.	
Engage Anticipatory Set	Mythbusters Car Crash Force https://www.youtube.com/watch?v=r8E5dUnLmh4 Test Dummy Hitting Deployed Airbag http://www.gettyimages.com/detail/video/crash-test-dummy-hitting-deployed-airbag-berlin-germany-stock-footage/103250356
Exploration Student Inquiry	Crafting a Prototype to Protect An Egg During Freefall Students will utilize their understanding of momentum and collisions to create a prototype that prevents an egg from shattering upon impact. http://betterlesson.com/lesson/637585/crafting-a-prototype-to-protect-an-egg-during-freefall Hands-on Activity: Design a Bicycle Helmet In this activity, students are introduced to the biomechanical characteristics of helmets, and are challenged to incorporate them into designs for helmets used for various applications. By doing this, they come to understand the role of enginering associated with safety products. The use of bicycle helmets helps to protect the brain and neck in the event of a crash. To do this effectively, helmets must have some sort of crushable material to absorb the collision forces and a strap system to make sure the protection stays in place. The exact design of a helmet depends on the needs and specifications of the user. https://www.teachengineering.org/Activities/view/bicycle_helmet_activity
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS2.A: Forces and Motion 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. ETS1.A: Defining and Delimiting an Engineering Problem 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. (secondary) ETS1.C: Optimizing the Design Solution

	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. (secondary)
Elaboration Extension Activity	Related Activities: http://www.ck12.org/ngss/high-school-physical-sciences/motion-and-stability:-forces-and-interactions http://www.physicsclassroom.com/NGSS-Corner/Force-and-Motion-DCIs-HS
Evaluation Assessment Tasks	Assessment Task A: In this above activities, teachers should evaluate students on their application of the engineering process which includes design, evaluation and refinement.

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PHYSICS		
HS-ETS1-2 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-2		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.C: Optimizing the Design Solution** 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.	
Connections to other DCIs in this grade-band: Physical Science: HS-PS1-6, HS-PS2-3		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B ; MS.ETS1.C		
NJSLS- ELA: N/A		
NJSLS- Math: MP.4		

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PHYSICS		
HS-ETS1-3 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** When evaluating 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.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
Connections to other DCIs in this grade-band: Earth and Space Science: HS-ESS3-2, HS-ESS3-4 Life Science: HS-LS2-7, HS-LS4-6		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B		
NJSLS- ELA: RST.11-12.7, RST.11-12.8, RST.11-12.9		
NJSLS- Math: MP.2, MP.4		

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Unit 2: Overview
Unit 2: Fundamental Forces
Content Area: Physics
Pacing: 20 Instructional days
Essential Question
How can one explain and predict interactions between objects and within systems of objects?
Student Learning Objectives (Performance Expectations)
HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
Unit Summary
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. 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.
Technical Terms
Newton's Law of Universal Gravitation, Coulomb's Law, gravitational force, electrostatic force, mechanics, natural phenomena, qualitative, velocity, acceleration
Formative Assessment Measures
Part A: Why are people on Earth stuck here while astronauts appear to be weightless? *How does the weight (force of gravity) of an astronaut of a specific mass (100 kg including gear) change at specific distances from Earth as the shuttle flies toward the moon?*
Students who understand the concepts are able to: Use mathematical representations of phenomena to describe or explain how gravitational force is proportional to mass and inversely proportional to distance squared. Demonstrate how Newton's Law of Universal Gravitation provides explanations for observed scientific phenomena. Observe patterns at different scales to provide evidence for gravitational forces between two objects in a system with two objects.
Part B: How far away can my finger be from my sister or brother if I want to zap them with static electricity?
Students who understand the concepts are able to:

Use mathematical representations of phenomena to describe or explain how electrostatic force is proportional to charge and inversely proportional to distance squared.
Use mathematical representations of Coulomb's Law to predict the electrostatic forces between two objects in systems with two objects.
Observe patterns at different scales to provide evidence for electrostatic forces between two objects in systems with two objects.

Interdisciplinary Connections

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

Core Instructional Materials	Can include: Textbooks Series, Lab Materials, etc.
21st Century Life and Careers	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5

Modifications

English Language Learners	Special Education	At-Risk	Gifted and Talented
Scaffolding	Word walls	Teacher tutoring	Curriculum compacting
Word walls	Visual aides	Peer tutoring	Challenge assignments
Sentence/paragraph frames	Graphic organizers	Study guides	Enrichment activities
Bilingual dictionaries/translation	Multimedia	Graphic organizers	Tiered activities
Think alouds	Leveled readers	Extended time	Independent research/inquiry
Read alouds	Assistive technology	Parent communication	Collaborative teamwork
Highlight key vocabulary	Notes/summaries	Modified assignments	Higher level questioning
Annotation guides	Extended time	Counseling	Critical/Analytical thinking tasks

Think-pair- share Visual aides Modeling Cognates	Answer masking Answer eliminator Highlighter Color contrast		Self-directed activities

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PHYSICS		
HS-PS2-4: Motion and Stability: Forces and Interactions		
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.		
Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.		
Assessment Boundary: Assessment is limited to systems with two objects.		
Evidence Statements: HS-PS2-4		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical representations of phenomena to describe explanations. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Theories and laws provide explanations in science. Laws are statements or descriptions of the relationships among observable phenomena.	**PS2.B: Types of Interactions** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. 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.	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
Connections to other DCIs in this grade-band: HS.PS3.A ; HS.ESS1.B		
Articulation of DCIs across grade-bands: MS.PS2.B ; MS.ESS1.B		
NJSLS- ELA: N/A		
NJSLS- Math: MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3, HSA.SSE.A.1, HSA.SSE.B.3		
5E Model		

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.	
Engage Anticipatory Set	The following PHET Colorado online simulations can be used to introduce Newton's Law of Gravitation and Coulomb's Law. https://phet.colorado.edu/en/simulation/gravity-force-lab
Exploration Student Inquiry	Gravitational Fields http://www.physicsclassroom.com/NGSS-Corner/Activity-Descriptions/Gravitational-Fields-Description If activity fails to open try using another browser Coulomb's Law Interactive http://www.physicsclassroom.com/NGSS-Corner/Activity-Descriptions/Coulombs-Law
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS2.B: Types of Interactions Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. 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.
Elaboration Extension Activity	Electrostatic and Coulomb's Law: Lab http://www.myips.org/cms/lib8/IN01906626/Centricity/Domain/8123/Coulombs%20Law%20E1.pdf Related Activities http://www.ck12.org/ngss/high-school-physical-sciences/motion-and-stability:-forces-and-interactions/
Evaluation Assessment Tasks	Assessment Task A: Using the two simulation activities above, teachers will evaluate the students' descriptions and predictions of electric or gravitational forces between objects.

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

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Unit 3: Overview	
Unit 3: Kepler's Laws	
Content Area: Physics	
Pacing: 15 Instructional days	
Essential Question	
How was it possible for NASA to intentionally fly into Comet Tempel 1?	
Student Learning Objectives (Performance Expectations)	
HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	
Unit Summary	
In this unit of study, 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.	
Technical Terms	
Kepler's Laws	
Formative Assessment Measures	
Part A: How was it possible for NASA to intentionally fly into Comet Tempel 1?	
Students who understand the concepts are able to: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. Use mathematical and computational representations of Newtonian gravitational laws governing orbital motion that apply to moons and human-made satellites. Use algebraic thinking to examine scientific data and predict the motion of orbiting objects in the solar system.	
Interdisciplinary Connections	
NJSLS- ELA	**NJSLS- Mathematics**
N/A	Reason abstractly and quantitatively.(HS-ESS1-4) MP.2 Model with mathematics.(HS-ESS1-4) MP.4 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.(HS-ESS1-4) HSN-Q.A.1

		Define appropriate quantities for the purpose of descriptive modeling.(HS-ESS1-4) HSN-Q.A.2 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.(HS-ESS1-4) HSN-Q.A.3 Interpret expressions that represent a quantity in terms of its context.(HS-ESS1-4) HSA-SSE.A.1 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.(HS-ESS1-4) HSA-CED.A.2 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.(HS-ESS1-4) HSA-CED.A.4	
Core Instructional Materials	Can include: Textbooks Series, Lab Materials, etc.		
21st Century Life and Careers	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12		
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Scaffolding Word walls Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Read alouds Highlight key vocabulary Annotation guides Think-pair- share Visual aides Modeling Cognates	Word walls Visual aides Graphic organizers Multimedia Leveled readers Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Graphic organizers Extended time Parent communication Modified assignments Counseling	Curriculum compacting Challenge assignments Enrichment activities Tiered activities Independent research/inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities

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PHYSICS		
HS-ESS1-4: Earth's Place in the Universe		
HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.		
Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.		
Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.		
Evidence Statements: HS-ESS1-4		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Using Mathematical and Computational Thinking Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical or computational representations of phenomena to describe explanations.	**ESS1.B: Earth and the Solar System** 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.	**Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Connections to Engineering,Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.
Connections to other DCIs in this grade-band: HS.PS2.B		
Articulation of DCIs across grade-bands: MS.PS2.A ; MS.PS2.B ; MS.ESS1.A ; MS.ESS1.B		
NJSLS- ELA: N/A		
NJSLS- Math: MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, HSA-SSE.A.1, HSA-CED.A.2, HSA-CED.A.4		
5E Model		
HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.		

Engage Anticipatory Set	Video: Gravity Visualized https://www.youtube.com/watch?v=MTY1Kje0yLg
Exploration Student Inquiry	Gravity, Orbits and Kepler's Law https://phet.colorado.edu/en/contributions/view/3874 Satellite Motion Lab In this activity, students will experiment with satellite motion using an interactive simulation, gaining an understanding of Kepler's Laws of Satellite Motion and Newton's Synthesis. https://phet.colorado.edu/en/contributions/view/3709 Going Full Circle on Gravity and Orbits- Day 1 In this lesson, students apply the circular motion equations to Newton's Universal Law of Gravity to derive circular orbit equations. http://betterlesson.com/lesson/637802/going-full-circle-on-gravity-and-orbits-day-1 Going Full Circle on Gravity and Orbits- Day 2 In this lesson, students determine that satellites in a certain orbit are geostationary based on observations and what they know about orbital periods. http://betterlesson.com/lesson/638515/going-full-circle-on-gravity-and-orbits-day-2
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): ESS1.B: Earth and the Solar System 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.
Elaboration Extension Activity	Tides Students will graph the tides in a region over a multi-day period to explain the factors which influence tides on the Earth and draw or identify the positions of the Earth, Moon, and Sun given specific tidal conditions. http://betterlesson.com/lesson/641869/tides
Evaluation Assessment Tasks	Assessment Task A: In the activities above, students will use mathematical representations to predict orbital changes in the solar system.

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SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

Unit 4: Overview
Unit 4: Energy
Content Area: Physics
Pacing: 25 Instructional days
Essential Question
How is energy transferred and conserved?
Student Learning Objectives (Performance Expectations)
HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
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-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
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.
HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
Unit Summary
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 sub core 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.
Technical Terms
Energy, conservation of energy , energy transfer, elastic potential energy, gravitational potential energy, kinetic energy, thermal energy, macroscopic scale, computational model, radiation, Rube Goldberg machines, quantitative property, quantifiable
Formative Assessment Measures
Part A: I have heard about it since kindergarten but what is energy?
Students who understand the concepts are able to: Develop and use models based on evidence to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects). Develop and use models based on evidence to illustrate that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Use mathematical expressions to quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compressions of a spring) and how kinetic energy depends on mass and speed. Use mathematical expressions and the concept of conservation of energy to predict and describe system behavior.
Part B: How can we use mathematics to prove what happens in an abiotic and biotic systems?
Students who understand the concepts are able to: Use basic algebraic expressions or computations to create a computational model to calculate the change in the energy of one component in a system (limited to two or three components) when the change in energy of the other component(s) and energy flows in and out of the system are known. Explain the meaning of mathematical expressions used to model the change in the energy of one component in a system (limited to two or three components) when the change in energy of the other component(s) and out of the system are known.
Part C: Superstorm Sandy devastated the New Jersey Shore and demonstrated to the public how vulnerable our infrastructure is. Using your understandings of energy, design a low technology system that would insure the availability of energy to residents if catastrophic damage to the grid occurs again.
Students who understand the concepts are able to: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Analyze a device to convert one form of energy into another form of energy by specifying criteria and constraints for successful solutions. Use mathematical models and/or computer simulations to predict the effects of a device that converts one form of energy into another form of energy.
Interdisciplinary Connections

NJSLS- ELA	**NJSLS- Mathematics**

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.(HS-PS1-3) RST.11-12.1 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.(HS-PS1-2) WHST.9-12.2 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.(HS-PS1-2),(HS-ETS1-3) WHST.9-12.5 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.(HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) WHST.9-12.7 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.(HS-PS1-3),(HS-ETS1-3),(HS-ETS1-1),(HS-ETS1-3) WHST.11-12.8 Draw evidence from informational texts to support analysis, reflection, and research.(HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) WHST.9-12.9 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) SL.11-12.5	Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) MP.2 Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) MP.4 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.(HS-PS1-2),(HS-PS1-3) HSN-Q.A.1

Core Instructional Materials	Can include: Textbooks Series, Lab Materials, etc.
21st Century Life and Careers	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5

Modifications

English Language Learners	Special Education	At-Risk	Gifted and Talented
Scaffolding	Word walls	Teacher tutoring	Curriculum compacting

Word walls	Visual aides	Peer tutoring	Challenge assignments
Sentence/paragraph frames	Graphic organizers	Study guides	Enrichment activities
Bilingual dictionaries/translation	Multimedia	Graphic organizers	Tiered activities
Think alouds	Leveled readers	Extended time	Independent research/inquiry
Read alouds	Assistive technology	Parent communication	Collaborative teamwork
Highlight key vocabulary	Notes/summaries	Modified assignments	Higher level questioning
Annotation guides	Extended time	Counseling	Critical/Analytical thinking tasks
Think-pair- share	Answer masking		Self-directed activities
Visual aides	Answer eliminator		
Modeling	Highlighter		
Cognates	Color contrast		

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

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BOE APPROVAL: August 2016

PHYSICS		
HS-PS3-2: Energy		
HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).		
Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.		
Assessment Boundary: N/A		
Evidence Statements: HS-PS3-2		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. 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.	**Energy and Matter** Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
Connections to other DCIs in this grade-band: HS.PS1.A ; HS.PS1.B ; HS.PS2.B		

Articulation of DCIs across grade-bands: MS.PS1.A ; MS.PS2.B ; MS.PS3.A ; MS.PS3.C	
NJSLS- ELA: SL.11-12.5	
NJSLS- Math: MP.2, MP.4	
5E Model	
HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).	
Engage Anticipatory Set	Video: Energy Lost When a Ball Bounces (Can be done as classroom demonstration) https://www.youtube.com/watch?v=ZSOxVwTv58Q
Exploration Student Inquiry	Skatepark Energy Students learn the concepts of kinetic and potential energy as they explore a skateboard simulation. http://betterlesson.com/lesson/638233/skate-park-energy Skatepark Energy Revisited Students determine how friction and the shape of the ramp impact the transformation of potential into kinetic energy. http://betterlesson.com/lesson/638235/skate-park-energy-revisited Venn Diagram of Kinetic and Potential Energies Students compare and contrast kinetic energy and potential energy by creating a Venn Diagram of the two types of energy.S http://betterlesson.com/lesson/638234/venn-diagram-of-kinetic-and-potential-energies Simple Pendulum Lab https://phet.colorado.edu/en/contributions/view/3591
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS3.A: Definitions of Energy Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. 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.
Elaboration Extension Activity	Swinging Pendulum https://www.teachengineering.org/Activities/view/cub_energy_lesson03_activity2 Related Activities http://www.ck12.org/ngss/high-school-physical-sciences/energy/
Evaluation Assessment Tasks	Assessment Task A: Energy Skate Park- Bar Graph Model http://betterlesson.com/lesson/resource/3218871/energy-skate-park?from=resource_image Assessment Task B: Kinetic and Potential Energy Venn Diagram http://betterlesson.com/lesson/638234/venn-diagram-of-kinetic-and-potential-energies

PHYSICS		
HS-PS3-1: Energy		
HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.		
Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.		
Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.		
Evidence Statements: HS-PS3-1		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and	**PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Systems and System Models** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Create a computational model or simulation of a phenomenon, designed device, process, or system.	**PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. 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. The availability of energy limits what can occur in any system.	Science assumes the universe is a vast single system in which basic laws are consistent.
Connections to other DCIs in this grade-band: HS.PS1.B ; HS.LS2.B ; HS.ESS2.A		
Articulation of DCIs across grade-bands: MS.PS3.A ; MS.PS3.B ;MS.ESS2.A		
NJSLS- ELA: SL.11-12.5		
NJSLS- Math: MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3		

5E Model

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.

Engage Anticipatory Set	Ballistic Pendulum Physics https://www.youtube.com/watch?v=I87Dr2lJEOk
Exploration Student Inquiry	The Springy Pen Lab Students will be able to prove conservation of energy in a pen's spring. http://betterlesson.com/lesson/634088/the-springy-pen-lab The Conservation of Energy Pendulum The purpose of this experiment is to measure the potential energy and the kinetic energy of a mechanical system and to quantitatively compare the two forms of mechanical energy to determine if the total mechanical energy is conserved. http://www.austincc.edu/mmcgraw/Labs_1401/8c-Con%20of%20Energy-Pendulum-RGC-1-15-09.pdf

	Ramp and Review In this hands-on activity—rolling a ball down an incline and having it collide into a cup—the concepts of mechanical energy, work and power, momentum, and friction are all demonstrated. During the activity, students take measurements and use equations that describe these energy of motion concepts to calculate unknown variables and review the relationships between these concepts. https://www.teachengineering.org/Activities/view/cub_energy_lesson05_activity2
Explanation Concepts and Practices	In these Teacher Student Topics t PS3.A: D Energy i system. system, PS3.B: C Conserv out of t Energy c Mathem charged of energ The ava
Elaboration Extension Activity	Energy and the Pogo Stick Students learn about the conservation of energy with the inclusion of elastic potential energy. They use pogo sticks to experience the elastic potential energy and its conversion to gravitational potential energy. https://www.teachengineering.org/Activities/view/van_hybrid_design_activity3
Evaluation Assessment Tasks	Students use the computational model to calculate the changes in the energy of one component of the system when changes in the energy of the other components and the energy flows are known. Assessment Task A: Springy Pen Lab Computational models

	Assessment Task B: The Conservation of Energy Pendulum Data analysis portion of lab report to create computational models Assessment Task C: Ramp and Review Worksheet http://content.teachengineering.org/content/cub_/activities/cub_energy/cub_energy_lesson05_activity2_worksheet.pdf

SUBJECT: SCIENCE/PHYSICS **Cliffside Park Public Schools** GRADE: 9-12

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PHYSICS		
HS-PS3-3: Energy		
HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.		
Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.		
Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.		
Evidence Statements: HS-PS3-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**PS3.A: Definitions of Energy** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. **ETS1.A: Defining and Delimiting an Engineering Problem** 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. (secondary)	**Energy and Matter** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. **Connections to Engineering,Technology, and Applications of Science** **Influence of Science, Engineering and Technology on Society and the Natural World** Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
Connections to other DCIs in this grade-band: HS.ESS3.A		
Articulation of DCIs across grade-bands: MS.PS3.A ; MS.PS3.B ; MS.ESS2.A		

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

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NJSLS- ELA: WHST.9-12.7	
NJSLS- Math: MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3	
5E Model	
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.	
Engage Anticipatory Set	Roller Coaster Physics https://www.youtube.com/watch?v=-dpBVtAbKJU Kingda Ka- Front Row https://www.youtube.com/watch?v=HN8nv4tVFuA
Exploration Student Inquiry	Roller Coaster Design: Day 1 Students design their own roller coasters, calculate potential energy and apply conservation of energy to calculate the velocities at key points of the ride. http://betterlesson.com/lesson/638238/roller-coaster-design-day-1 Roller Coaster Design: Day 2 Students design their own roller coasters and calculate important aspects of the ride like velocities, work and power of the motor, and braking force. http://betterlesson.com/lesson/639206/roller-coaster-design-day-2 Rube Goldberg Contraptions https://www.teachingchannel.org/videos/rube-goldberg-contraptions Introduction Video: https://www.youtube.com/watch?v=ieQSiDnOhzY
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS3.A: Definitions of Energy At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. PS3.D: Energy in Chemical Processes Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

	ETS1.A: Defining and Delimiting an Engineering Problem- 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. (secondary)
Elaboration Extension Activity	Related Activities: http://www.ck12.org/ngss/high-school-physical-sciences/energy/
Evaluation Assessment Tasks	Assessment Task A: Roller Coaster When creating their models, students should describe and quantify (when appropriate) prioritized criteria and constraints for the design of the device, along with the tradeoffs implicit in these design solutions. 3D Model Rubric Rube Goldberg Contraption Evaluate student design using the 3D model rubric.

PHYSICS		
HS-ETS1-1 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-1		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.	**ETS1.A: Defining and Delimiting Engineering Problems** 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. Humanity faces major global challenges today, such as the need for supplies of clean water and food or for	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	
Connections to other DCIs in this grade-band: Physical Science: HS-PS2-3, HS-PS3-3		
Articulation of DCIs across grade-bands: MS.ETS1.A		
NJSLS- ELA: RST.11-12.7, RST.11-12.8, RST.11-12.9		
NJSLS- Math: MP.2, MP.4		

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PHYSICS		
HS-ETS1-2 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-2		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.C: Optimizing the Design Solution** 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.	
Connections to other DCIs in this grade-band: Physical Science: HS-PS1-6, HS-PS2-3		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B ; MS.ETS1.C		
NJSLS- ELA: N/A		
NJSLS- Math: MP.4		

PHYSICS		
HS-ETS1-3 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** When evaluating 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.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
Connections to other DCIs in this grade-band: Earth and Space Science: HS-ESS3-2, HS-ESS3-4 Life Science: HS-LS2-7, HS-LS4-6		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B		
NJSLS- ELA: RST.11-12.7, RST.11-12.8, RST.11-12.9		
NJSLS- Math: MP.2, MP.4		

PHYSICS		
HS-ETS1-4 Engineering Design		
HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-4		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**ETS1.B: Developing Possible Solutions** 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.	**Systems and Systems Models** Systems and System Models Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales.
Connections to other DCIs in this grade-band: Earth and Space Science: HS-ESS3-2, HS-ESS3-4 Life Science: HS-LS2-7, HS-LS4-6		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B ; MS.ETS1.C		
NJSLS- ELA: N/A		
NJSLS- Math: MP.2, MP.4		

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

Unit 5: Overview
Unit 5: Physics of the Geosphere
Content Area: Physics
Pacing: 15 Instructional days
Essential Question
How much force and energy is needed to move a continent?
Student Learning Objectives (Performance Expectations)
HS-ESS2-1: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
HS-ESS2-3: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
HS-ESS1-5: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
Unit Summary
In this unit of study, students construct explanations for the scales of time over which Earth processes operate. An important aspect of Earth and space sciences involves making inferences about events in Earth's history based on a data record that is increasingly incomplete the farther one goes back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record. Students develop models and explanations for the ways that feedback among different Earth systems controls the appearance of the Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down land through weathering and erosion. Students demonstrate proficiency in developing and using models, constructing explanations, and engaging in argument from evidence. The crosscutting concepts of stability and change, energy and matter, and patterns are called out as organizing elements of this unit.
Technical Terms
Thermal convection, plate tectonics, geoscience, geosphere, seismic waves , radioactive decay, exponential decay, electromagnetic radiation
Formative Assessment Measures
Part A: How long does it take to make a mountain?
Students who understand the concepts are able to:

Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. Develop a model to illustrate how the appearance of land features and seafloor features are a result of both constructive forces and destructive mechanisms.
Quantify and model rates of change of Earth's internal and surface processes over very short and very long periods of time.
Part B: How much force is needed to move a continent? What can possibly provide the energy for that much force?
Students who understand the concepts are able to: Develop an evidence-based model of Earth's interior to describe the cycling of matter by thermal convection. Develop a one-dimensional model, based on evidence, of Earth with radial layers determined by density to describe the cycling of matter by thermal convection. Develop a three-dimensional model of Earth's interior, based on evidence, to show mantle convection and the resulting plate tectonics. Develop a model of Earth's interior, based on evidence, to show that energy drives the cycling of matter by thermal convection.
Part C: Are all rocks the same age?
Students who understand the concepts are able to: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. Evaluate evidence of plate interactions to explain the ages of crustal rocks
Part D: How do changes in the geosphere effect the atmosphere?
Students who understand the concepts are able to: Analyze geoscience data using tools, technologies, and/or models (e.g., computational, mathematical) to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

Interdisciplinary Connections	
NJSLS- ELA	**NJSLS- Mathematics**
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. (HS-ESS1-5), (HS-ESS2-2),(HS-ESS2-3) RST.11-12.1 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2) RST.11-12.2	Reason abstractly and quantitatively. (HS-ESS1-5), (HS-ESS2-1),(HS-ESS2-2),(HSESS2-3) MP.2 Model with mathematics. (HS-ESS2-1),(HS-ESS2-3) MP.4 Use units as a way to understand problems and to guide the solution of multi step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-5), (HSESS2-1),(HS-ESS2-2),(HS-ESS2-3) HSN-Q.A.1

Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-5) RST.11-12.8 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-5) WHST.9-12.2 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5) WHST.9-12.7 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-1),(HS-ESS2-3) SL.11-12.5	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1- 5), (HS-ESS2-1),(HS-ESS2-3) HSN-Q.A.2 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-5) ,(HS-ESS2-1),(HS-ESS2-2),(HS-ESS2-3) HSNQ.A.3

Core Instructional Materials	Can include: Textbooks Series, Lab Materials, etc.
21st Century Life and Careers	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5

Modifications

English Language Learners	Special Education	At-Risk	Gifted and Talented
Scaffolding	Word walls	Teacher tutoring	Curriculum compacting
Word walls	Visual aides	Peer tutoring	Challenge assignments
Sentence/paragraph frames	Graphic organizers	Study guides	Enrichment activities
Bilingual dictionaries/translation	Multimedia	Graphic organizers	Tiered activities
Think alouds	Leveled readers	Extended time	Independent research/inquiry
Read alouds	Assistive technology	Parent communication	Collaborative teamwork
Highlight key vocabulary	Notes/summaries	Modified assignments	Higher level questioning
Annotation guides	Extended time	Counseling	Critical/Analytical thinking tasks
Think-pair- share	Answer masking		Self-directed activities
Visual aides	Answer eliminator		
Modeling	Highlighter		

Cognates	Color contrast		

SUBJECT: SCIENCE/PHYSICS # Cliffside Park Public Schools **GRADE: 9-12**

BOE APPROVAL: August 2016

PHYSICS		
HS-ESS2-1: Earth's Systems		
HS-ESS2-1: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.		
Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and seafloor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).		
Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.		
Evidence Statements: HS-ESS2-1		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE)	**Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
Connections to other DCIs in this grade-band: HS.PS2.B		
Articulation of DCIs across grade-bands: MS.PS2.B ; MS.LS2.B ; MS.ESS1.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D		
NJSLS- ELA: SL.11-12.5		
NJSLS- Math: MP.2. MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3		
5E Model		
HS-ESS2-1: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.		
Engage	Sea Floor Spreading and Plate Tectonics	

Anticipatory Set	https://www.youtube.com/watch?v=ZzvDlP6xd9o The Grand Canyon- How It Was Formed https://www.youtube.com/watch?v=ktf73HNZZGY Volcanoes 101 http://video.nationalgeographic.com/video/101-videos/volcanoes-101
Exploration Student Inquiry	Sea-Floor Spreading and Subduction Model In this lesson, students will build a model of the outer 300 km (180 miles) of the Earth that can be used to develop a better understanding of the principal features of plate tectonics, including sea-floor spreading, the pattern of magnetic stripes frozen into the sea floor, transform faulting, thrust faulting, subduction, and volcanism. http://pubs.usgs.gov/of/1999/ofr-99-0132/
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): ESS2.A: Earth Materials and Systems Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. ESS2.B: Plate Tectonics and Large-Scale System Interactions Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE)
Elaboration Extension Activity	Related Activities http://www.symbaloo.com/mix/hs-ess2-1?searched=true
Evaluation Assessment Tasks	Assessment Task A: Sea Floor Spreading Model Students use the model to illustrate the relationship between: The formation of continental and ocean floor features Earth's internal and surface processes operating on different temporal or spatial scales.

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PHYSICS		
HS-ESS2-3: Earth's Systems		
HS-ESS2-3: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.		
Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.		
Assessment Boundary: N/A		
Evidence Statements: HS-ESS2-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Develop a model based on evidence to illustrate the relationships between systems or between components of a system. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based on empirical evidence. Science disciplines share common rules of evidence used to evaluate explanations about natural systems.	**ESS2.A: Earth Materials and Systems** Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. **PS4.A: Wave Properties**	**Energy and Matter** Energy drives the cycling of matter within and between systems. **Connections to Engineering,Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

Science includes the process of coordinating patterns of evidence with current theory.	Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)	
Connections to other DCIs in this grade-band: HS.PS2.B ; HS.PS3.B ; HS.PS3.D		
Articulation of DCIs across grade-bands: MS.PS1.A ; MS.PS1.B ; MS.PS2.B ; MS.PS3.A ; MS.PS3.B ; MS.ESS2.A ; MS.ESS2.B		
NJSLS- ELA: RST.11-12.1, SL.11-12.5		
NJSLS- Math: MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3		

5E Model	
HS-ESS2-3: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.	
Engage Anticipatory Set	Hot Planet Reviews the evidence that Earth was once molten and where heat comes from today. http://www.ck12.org/earth-science/Earths-Layers/rwa/Hot-Planet/
Exploration Student Inquiry	Convection in the Earth http://astroventure.arc.nasa.gov/teachers/pdf/AV-Geolesson-4.pdf In this multi-day lesson, students will explore conditions that change the density of a substance, resulting in movement. They observe convection & use this information to infer how movement occurs inside the Earth. Mathematical & graphic models will be developed.
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): ESS2.A: Earth Materials and Systems- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. ESS2.B: Plate Tectonics and Large-Scale System Interactions- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

	PS4.A: Wave Properties Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)
Elaboration Extension Activity	Modeling the Earth--Motion Mock-Ups http://www.thetech.org/sites/default/files/pdfs/Design-Challenge-Learning-Lessons/Seismic_Lesson1_ELA_final.pdf The purpose of this activity is to get students to teach each other about: the mechanics of plate tectonics, faults and plate boundaries, how fault slippage causes earthquakes and how seismic waves travel. Students will read about and model one of these topics. They will then present their findings to the class.
Evaluation Assessment Tasks	Assessment Task A: Student Model Students use the model to describe the cycling of matter by thermal convection in Earth's interior, including: 1. The flow of matter in the mantle that causes crustal plates to move; 2. The flow of matter in the liquid outer core that generates the Earth's magnetic field, including evidence of polar reversals 3. The radial layers determined by density in the interior of Earth 4. The addition of a significant amount of thermal energy released by radioactive decay in Earth's crust and mantle.

PHYSICS		
HS-ESS1-5: Earth's Place in the Universe		
HS-ESS1-5: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.		
Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core (a result of past plate interactions).		
Assessment Boundary: N/A		
Evidence Statements: HS-ESS1-5		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and	**ESS1.C: The History of Planet Earth** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. **ESS2.B: Plate Tectonics and Large-Scale System Interactions**	**Patterns** Empirical evidence is needed to identify patterns.

critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.	Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary) **PS1.C: Nuclear Processes** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)	
Connections to other DCIs in this grade-band: HS.PS3.B ; HS.ESS2.A		
Articulation of DCIs across grade-bands: MS.ESS1.C ; MS.ESS2.A ; MS.ESS2.B		
NJSLS- ELA: RST.11-12.1, RST.11-12.8, WHST.9-12.2		
NJSLS- Math: MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3		

5E Model	
HS-ESS1-5: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.	
Engage Anticipatory Set	Oceanic Crust: Definition, Composition & Facts http://study.com/academy/lesson/oceanic-crust-definition-composition-facts.html Plate Tectonics Documentary https://www.youtube.com/watch?v=1-HwPR_4mP4
Exploration Student Inquiry	Features of Rock Layers http://betterlesson.com/lesson/635125/features-of-rock-layers In this lesson, students will identify intrusions, extrusions, folding, faulting, and contact metamorphism in rock layers and determine the relative age of various rock layers using cross-cutting relationships Plate Tectonics: Simulation & Lesson Students will investigate the different convergent and divergent boundaries. https://phet.colorado.edu/en/contributions/view/3770
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):

	ESS1.C: The History of Planet Earth Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. ESS2.B: Plate Tectonics and Large-Scale System Interactions Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary) PS1.C: Nuclear Processes Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)	
Elaboration Extension Activity		Radioac https://
Evaluation Assessment Tasks	Assessment Task: A 1. Students describe how the following patterns observed from the evidence support the explanation about the ages of crustal rocks: The pattern of the continental crust being older than the oceanic crust, the pattern that the oldest continental rocks are located at the center of continents, with the ages decreasing from their centers to their margin and the pattern that the ages of oceanic crust are greatest nearest the continents and decrease in age with proximity to the mid-ocean ridges. 2. Students synthesize the relevant evidence to describe the relationship between the motion of continental plates and the patterns in the ages of crustal rocks, including that: At boundaries where plates are moving apart, such as mid-ocean ridges, material from the interior of the Earth must be emerging and forming new rocks with the youngest ages, the regions furthest from the plate boundaries (continental centers) will have the oldest rocks because new crust is added to the edge of continents at places where plates are coming together, such as subduction zones and the oldest crustal rocks are found on the continents because oceanic crust is constantly being destroyed at places where plates are coming together, such as subduction zones.	

PHYSICS
HS-ESS2-2: Earth's Systems
HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of

ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.		
Assessment Boundary: N/A		
Evidence Statements: HS-ESS2-2		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.D: Weather and Climate** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. **Connections to Engineering,Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
Connections to other DCIs in this grade-band: HS.PS3.B ; HS.PS4.B ; HS.LS2.B ; HS.LS2.C ; HS.LS4.D ; HS.ESS3.C ; HS.ESS3.D		
Articulation of DCIs across grade-bands: MS.PS3.D ; MS.PS4.B ; MS.LS2.B ; MS.LS2.C ; MS.LS4.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D ; MS.ESS3.C ; MS.ESS3.D		
NJSLS- ELA: RST.11-12.1, RST.11-12.2		
NJSLS- Math: MP.2, HSN.Q.A.1, HSN.Q.A.3		

5E Model	
HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	
Engage Anticipatory Set	Earth System: El Nino http://www.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.eselnino/earth-system-el-nintildeo/
Exploration Student Inquiry	Earth's Radiation Budget http://missionscience.nasa.gov/ems/13_radiationbudget.html Investigating the Greenhouse Effect

	Investigate how atmospheric changes affect global temperature, examine how clouds contribute to the greenhouse effect, and predict how changing greenhouse gas levels affect global temperature. https://phet.colorado.edu/en/contributions/view/3092;jsessionid=624761EF03DA4E1D5801F7686C66450D Analyzing Geoscience Data: Prezi https://prezi.com/ifdbpkhz8oi_/115-analyze-geoscience-data/ This presentation includes: A brief description of what a feedback cycle is in general. A description of why scientists believe that arctic ice is part of a feedback cycle with ice melting even faster than just warmer air temperatures would produce. Mentions two pieces of data that support the claim that the arctic ice feedback cycle exists.
Explanation Concepts and Practices	Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): ESS2.A: Earth Materials and Systems Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. ESS2.D: Weather and Climate The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. ESS2.D: Weather and Climate The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.
Elaboration Extension Activity	Related Activities http://www.earthsciweek.org/ngss-performance-expectations/hs-ess2-2
Evaluation Assessment Tasks	Assessment Task A: Geoscience Data Analysis Students will use the geoscience data presented in the activities above to: Describe a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative Describe a particular unanticipated or unintended effect of a selected technology in Earth's systems if present

SUBJECT: SCIENCE/PHYSICS **Cliffside Park Public Schools** **GRADE: 9-12**

BOE APPROVAL: August 2016

Unit 6: Overview

Unit 6: Wave Properties

Content Area: Physics

Pacing: 20 Instructional days

Essential Question

How are waves used to transfer energy and send and store information?

Student Learning Objectives (Performance Expectations)

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

Unit Summary

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.

Technical Terms

Frequency, wavelength, crests, troughs, speed, amplitude, nodes, antinodes, seismic waves, mechanical waves, Electromagnetic Radiation Unit (ERU), P-Waves, S-Waves, longitudinal waves , transverse waves , surface waves, energy transmission, reflection, infraction, absorption, diffraction resonance, tsunami, plate tectonics

Formative Assessment Measures

Part A: Why do physicists make the best surfers? How do we know what the inside of the Earth looks like?

Students who understand the concepts are able to:

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

Use algebraic relationships to quantitatively describe relationships among the frequency, wavelength, and speed of waves traveling in various media.

Interdisciplinary Connections

NJSLS- ELA	NJSLS- Mathematics
Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-1) RST.11-12.7	Reason abstractly and quantitatively. (HS-PS4-1) MP.2 Model with mathematics. (HS-PS4-1) MP.4 Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1) HSA-SSE.A.1

		Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS4-1) HSASSE.B.3 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS4-1) HSA.CED.A.4	
Core Instructional Materials	Can include: Textbooks Series, Lab Materials, etc.		
21st Century Life and Careers	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12		
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Scaffolding Word walls Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Read alouds Highlight key vocabulary Annotation guides Think-pair- share Visual aides Modeling Cognates	Word walls Visual aides Graphic organizers Multimedia Leveled readers Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Graphic organizers Extended time Parent communication Modified assignments Counseling	Curriculum compacting Challenge assignments Enrichment activities Tiered activities Independent research/inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities

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PHYSICS		
HS-PS4-1: Waves and their Applications in Technologies for Information Transfer		
HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.		
Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.		
Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.		
Evidence Statements: HS-PS4-1		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**PS4.A: Wave Properties** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
Connections to other DCIs in this grade-band: HS.ESS2.A		
Articulation of DCIs across grade-bands: MS.PS4.A ; MS.PS4.B		
NJSLS- ELA: RST.11-12.7		
NJSLS- Math: MP.2 , MP.4 , HSA-SSE.A.1 , HSA-SSE.B.3 , HSA.CED.A.4		
5E Model		
HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.		
	GCSE Science Revision - Types of Waves	

Engage Anticipatory Set	https://www.youtube.com/watch?v=w2s2fZr8sqQ Radio Waves & Electromagnetic Fields Students will investigate how radio broadcasting and radio receivers work. https://phet.colorado.edu/services/download-servlet?filename=%2Factivities%2F3084%2FHW11_SIM.pdf
Exploration Student Inquiry	Making Waves and Determining Mathematical Relationships Students make waves and find an important relationship between variables. http://betterlesson.com/lesson/639696/making-waves-and-determining-mathematical-relationships Wave Lab Stations Day 1 Students participate in lab stations about the wave phenomena. http://betterlesson.com/lesson/639703/wave-lab-stations-day-1 Wave Lab Stations Day 2 Students will be able to identify the wave phenomena occurring at each station in the lab. http://betterlesson.com/lesson/639704/wave-lab-stations-day-2
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS4.A: Wave Properties The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.
Elaboration Extension Activity	Measuring the Speed of Sound What is the speed of sound in our classroom? Today, students find out! http://betterlesson.com/lesson/640789/measuring-the-speed-of-sound
Evaluation Assessment Tasks	Assessment Task A: Making Waves Activity Students will use mathematical relationships to support their claims regarding the relationships between frequency, speed and wavelength. Using the mathematical relationship, students assess claims about any of the three quantities when the other two quantities are known for waves traveling in various specified media. Students use the mathematical relationships to distinguish between cause and correlation with respect to the supported claims.

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Unit 7: Overview
Unit 7: Electromagnetic Radiation
Content Area: Physics
Pacing: 30 Instructional days
Essential Question
Why has digital technology replaced analog technology?
Student Learning Objectives (Performance Expectations)
HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
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-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-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.
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.
Unit Summary
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.
Technical Terms
Wave model, particle model, qualitative criteria quantitative criteria, photoelectric, digitized information, diffraction, Michelson-Morley experiment, polarization, Doppler shift, wave interference, geometric optics, ray diagrams, photoelectric effect, Piezoelectric effect, spectra
Formative Assessment Measures

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Part A: How can electromagnetic radiation be both a wave and a particle at the same time?	
Students who understand the concepts are able to: 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. Evaluate experimental evidence 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. Use models (e.g., physical, mathematical, computer models) to simulate electromagnetic radiation systems and interactions—including energy, matter,and information flows—within and between systems at different scales.	
Part B: Should we encourage the board of education to install solar panels?	
Students who understand the concepts are able to: Evaluate the validity and reliability of multiple claims in published materials about the effects that different frequencies of electromagnetic radiation have when absorbed by matter. Evaluate the validity and reliability of claims that photons associated with different frequencies of light have different energies and that the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Give qualitative descriptions of how photons associated with different frequencies of light have different energies and how the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Suggest and predict cause-and-effect relationships for electromagnetic radiation systems when matter absorbs different frequencies of light by examining what is known about smaller scale mechanisms within the system.	
Part C: How does the International Space Station power all of its equipment? How do astronauts communicate with people on the ground?	
Students who understand the concepts are able to: Communicate qualitative 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. Communicate technical information or ideas about technological devices that use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy in multiple formats (including orally, graphically, textually, and mathematically). Analyze technological devices that use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy by specifying criteria and constraints for successful solutions. Evaluate a solution offered by technological devices that use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy based on scientific knowledge,student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	
Interdisciplinary Connections	
NJSLS- ELA	**NJSLS- Mathematics**
Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-3), (HS-PS4-4),(HS-PS4-2) RST.9-10.8	Reason abstractly and quantitatively. (HS-PS4-3), (HS-ETS1-1), (HS-ETS1-3) MP.2 Model with mathematics. (HS-ETS1-1),(HS-ETS1-3) MP.4

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. (HS-PS4-3), (HS-PS4-4),(HS-PS4-2) RST.11-12.1 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS4-4),(HS-ETS1-1),(HS-ETS1-3) RST.11-12.7 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-3), (HS-ETS1-1), (HS-ETS1- 3),(HS-PS4-2) RST.11-12.8 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1), (HS-ETS1- 3) RST.11-12.9 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. (HS-PS4-5) WHST.11- 12.2 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HSPS4-4) WHST.11-12.8	Interpret expressions that represent a quantity in terms of its context. (HS-PS4-3) HSA-SSE.A.1 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS4-3) HSASSE.B.3 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS4-3) HAS.CED.A.4

Core Instructional Materials	Can include: Textbooks Series, Lab Materials, etc.
21st Century Life and Careers	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5

Modifications

English Language Learners	Special Education	At-Risk	Gifted and Talented
Scaffolding	Word walls	Teacher tutoring	Curriculum compacting
Word walls	Visual aides	Peer tutoring	Challenge assignments
Sentence/paragraph frames	Graphic organizers	Study guides	Enrichment activities

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Bilingual dictionaries/translation	Multimedia	Graphic organizers	Tiered activities
Think alouds	Leveled readers	Extended time	Independent research/inquiry
Read alouds	Assistive technology	Parent communication	Collaborative teamwork
Highlight key vocabulary	Notes/summaries	Modified assignments	Higher level questioning
Annotation guides	Extended time	Counseling	Critical/Analytical thinking tasks
Think-pair- share	Answer masking		Self-directed activities
Visual aides	Answer eliminator		
Modeling	Highlighter		
Cognates	Color contrast		

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PHYSICS		
HS-PS4-3: Waves and their Applications in Technologies for Information Transfer		
HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.		
Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.		
Assessment Boundary: Assessment does not include using quantum theory.		
Evidence Statements: HS-PS4-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**PS4.A: Wave Properties** [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) **PS4.B: Electromagnetic Radiation** Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	**Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Connections to other DCIs in this grade-band: HS.PS3.D ; HS.ESS1.A ; HS.ESS2.D		
Articulation of DCIs across grade-bands: MS.PS4.B		

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NJSLS- ELA: RST.9-10.8, RST.11-12.1, RST.11-12.8	
NJSLS- Math: MP.2, HSA-SSE.A.1, HSA-SSE.B.3, HSA.CED.A.4	
5E Model	
HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	
Engage Anticipatory Set	Do Cellphones Cause Brain Tumors? https://www.youtube.com/watch?v=wU5XkhUGzBs
Exploration Student Inquiry	Electromagnetic Investigations- Day 1 It's important to balance theory with observations and to provide evidence for any claim. Students will apply this thinking to four big ideas in electromagnetics. http://betterlesson.com/lesson/636830/electromagnetic-investigations-day-1 Electromagnetic Investigations- Day 2 It is important to balance theory with observation - particularly, as is the case with electromagnetics, when the theory is not intuitive. http://betterlesson.com/lesson/636213/electromagnetic-investigations-day-2 Electromagnetic Investigations- Day 3 It's important to balance theory with observations and to provide evidence for any claim. Students will apply this thinking to four big ideas in electromagnetics. http://betterlesson.com/lesson/637306/electromagnetic-investigations-day-3
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS4.A: Wave Properties [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) PS4.B: Electromagnetic Radiation

	Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
Elaboration Extension Activity	A Closer Look at Photoelectric Effect Data from different metals show similarities and differences in the photoelectric effect, highlighting fundamental physics phenomena. http://betterlesson.com/lesson/638454/a-closer-look-at-photoelectricity
Evaluation Assessment Tasks	Assessment Task A: Electromagnetic Investigations Following this three day investigation, students should: Evaluate the given evidence for interference behavior of electromagnetic radiation to determine how it supports the argument that electromagnetic radiation can be described by a wave model. Evaluate the phenomena of the photoelectric effect to determine how it supports the argument that electromagnetic radiation can be described by a particle model. Evaluate the given claims and reasoning for modeling electromagnetic radiation as both a wave and a particle, considering the transfer of energy and information within and between systems, and why for some aspects the wave model is more useful and for other aspects the particle model is more useful to describe the transfer of energy and information.

PHYSICS		
HS-PS4-4: Waves and their Applications in Technologies for Information Transfer		
HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.		
Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.		
Assessment Boundary: Assessment is limited to qualitative descriptions.		
Evidence Statements: HS-PS4-4		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**PS4.B: Electromagnetic Radiation** 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.	**Cause and Effect** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
Connections to other DCIs in this grade-band: HS.PS1.C ; HS.PS3.A ; HS.PS3.D ; HS.LS1.C		
Articulation of DCIs across grade-bands: MS.PS3.D ; MS.PS4.B ; MS.LS1.C ; MS.ESS2.D		
NJSLS- ELA: RST.9-10.8, RST.11-12.1, RST.11-12.7, RST.11-12.8, WHST.11-12.8		
NJSLS- Math: N/A		
5E Model		
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.		
Engage Anticipatory Set	Effects of Electromagnetic Radiation on Human Health	

	Electromagnetic Radiation (EMR) from Cell Phones, Computers, Tablets, Wi-Fi Routers and other personal electronic devices are harmful for human health in many ways. See this video and learn more on how the Radiation from these devices are harmful. https://www.youtube.com/watch?v=lJwnK52a3W0 The Most Radioactive Places on Earth Who on Earth is exposed to the most ionizing radiation? https://www.youtube.com/watch?v=TRL7o2kPqw0 What is Radiation? To properly assess health risks, it is important to understand the transfer of electromagnetic energy. https://betterlesson.com/lesson/636197/what-is-radiation
Exploration Student Inquiry	Creating a Radiation Journal Radiation is a word used and misused frequently - students must come to grips with what we truly mean when we use it. http://betterlesson.com/lesson/636199/creating-a-radiation-journal Radiation Journal Time Electromagnetic phenomenon are complex; exploring them takes time and reflection. http://betterlesson.com/lesson/636829/radiation-journal-time
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS4.B: Electromagnetic Radiation 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.
Elaboration Extension Activity	Why Materials Block Your Phone Signal Electromagnetic radiation interacts with matter in three ways: absorbed, reflected or transmitted. https://betterlesson.com/lesson/645259/what-materials-block-your-phone-s-signal
Evaluation Assessment Tasks	Assessment Task: Evaluating Claims In the exploration activities above, students will evaluate claims on electromagnetic radiation. In their evaluation, students should: Describe the cause and effect reasonings in each claim, including the extrapolation to larger scales from cause and effect relationships of mechanisms at small scales.

PHYSICS		
HS-ETS1-1 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-1		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** 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. Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
Connections to other DCIs in this grade-band: Physical Science: HS-PS2-3, HS-PS3-3		
Articulation of DCIs across grade-bands: MS.ETS1.A		
NJSLS- ELA: RST.11-12.7, RST.11-12.8, RST.11-12.9		
NJSLS- Math: MP.2, MP.4		

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

PHYSICS

HS-PS4-5: Waves and their Applications in Technologies for Information Transfer

HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.

Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.

Evidence Statements: HS-PS4-5

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**PS3.D: Energy in Chemical Processes** Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary) **PS4.A: Wave Properties** 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. **PS4.B: Electromagnetic Radiation** Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **PS4.C: Information Technologies and Instrumentation** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday 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.	**Cause and Effect** Systems can be designed to cause a desired effect. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** Science and engineering complement each other in the cycle known as research and development (R&D). **Influence of Engineering, Technology, and Science on Society and the Natural World** Modern civilization depends on major technological systems.

Connections to other DCIs in this grade-band: HS.PS3.A

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

Articulation of DCIs across grade-bands: MS.PS4.A ; MS.PS4.B ; MS.PS4.C	
NJSLS- ELA: WHST.9-12.2	
NJSLS- Math: N/A	
5E Model	
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.	
Engage Anticipatory Set	How Photovoltaic Solar Cells Work https://www.youtube.com/watch?v=x2zjdtxrisc Photoelectric Effect Demonstration https://www.youtube.com/watch?v=1d7EE1grbA0
Exploration Student Inquiry	Simplified MRI While x-rays are used to image bones, magnetic resonance imaging (MRI) is used to examine tissues within the body by detecting where hydrogen atoms (H atoms) are and their environment (e.g. is the H atom part of water (H2O) or is it part of a long hydrocarbon chain as in a fat molecule). Simulation: https://phet.colorado.edu/en/simulation/legacy/mri https://phet.colorado.edu/en/contributions/view/3003 Microwave Simulation Microwave ovens use microwaves to increase the energy of water molecules. Simulation: https://phet.colorado.edu/en/simulation/legacy/microwaves https://phet.colorado.edu/en/contributions/view/3085
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS3.D: Energy in Chemical Processes Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary) PS4.A: Wave Properties 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. PS4.B: Electromagnetic Radiation

	Photoelectric materials emit electrons when they absorb light of a high-enough frequency. PS4.C: Information Technologies and Instrumentation Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday 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.
Elaboration Extension Activity	Solar Energy Science Projects The final activity investigates the transformation of light to electrical energy. And how different wavelengths and intensity can affect the transformation to electricity. http://www.nrel.gov/education/pdfs/educational_resources/high_school/solar_projects_hs.pdf
Evaluation Assessment Tasks	Assessment Task A: Communicate Technical Information When discussing technological devices in the above exploration activities students should: Use at least two different formats to communicate technical information and ideas, including fully describing at least two devices and the physical principles upon which the devices depend. Identify the wave behavior utilized by the device for the absorption of protons and production of electrons for devices that rely on the photoelectric effect and qualitatively describe how the basic physic principles were utilized in the design. Discuss the real-world problem each device solves or needs it addresses and how civilization now depends on the device. Identify and communicate the cause and effect relationships that are used to produce the functionality of the device.

SUBJECT: SCIENCE/PHYSICS # Cliffside Park Public Schools **GRADE: 9-12**

BOE APPROVAL: August 2016

PHYSICS		
HS-PS4-2: Waves and their Applications in Technologies for Information Transfer		
HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.		
Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.		
Assessment Boundary: N/A		
Evidence Statements: HS-PS4-2		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.	**PS4.A: Wave Properties** 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.	**Stability and Change** Systems can be designed for greater or lesser stability. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
Connections to other DCIs in this grade-band: N/A		
Articulation of DCIs across grade-bands: MS.PS4.A ; MS.PS4.B ; MS.PS4.C		
NJSLS- ELA: RST.9-10.8, RST.11-12.1, RST.11-12.8		
NJSLS- Math: N/A		

5E Model	
HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.	
Engage Anticipatory Set	Electronic Device http://www.ck12.org/physical-science/Electronic-Device-in-Physical-Science/lecture/CPU-How-It-Works/?referrer=concept_details Physical Storage vs Digital Storage

	https://mozy.com/blog/infographics/physical-storage-vs-digital-storage/ Self-Driving Car Test https://www.youtube.com/watch?v=cdgQpa1pUUE
Exploration Student Inquiry	Tattoos You Can Use Tiny electronic devices called "electronic tattoos" aren't real tattoos either, but someday you may wear them on your skin. In this activity, students will view a video and then evaluate discussion questions. http://www.ck12.org/physical-science/Electronic-Device-in-Physical-Science/rwa/Tattoos-You-Can-Use/?referrer=concept_details
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS4.A: Wave Properties 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.
Elaboration Extension Activity	How to Build a Robot Start building a robot that can follow lines or walls and avoid obstacles! http://www.allaboutcircuits.com/projects/build-your-own-robot-design-and-schematic/
Evaluation Assessment Tasks	Assessment Task A: Tattoos You Can Use- Evaluation Students evaluate the given questions in terms of whether or not answers to the questions would provide means to empirically determine whether given features are advantages or disadvantages.

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

PHYSICS		
HS-ETS1-3 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** When evaluating 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.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
Connections to other DCIs in this grade-band: Earth and Space Science: HS-ESS3-2, HS-ESS3-4 Life Science: HS-LS2-7, HS-LS4-6		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B		
NJSLS- ELA: RST.11-12.7, RST.11-12.8, RST.11-12.9		
NJSLS- Math: MP.2, MP.4		

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

Unit 8: Overview
Unit 8: Electricity and Magnetism
Content Area: Physics
Pacing: 15 Instructional days
Essential Question
How can one explain and predict the interactions between objects and within a system of objects?
Student Learning Objectives (Performance Expectations)
HS-PS2-5: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
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.
Unit Summary
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.
Technical Terms
Magnetism, electric currents, electric energy, magnetic fields
Formative Assessment Measures
Part A: What are the relationships between electric currents and magnetic fields?
Students who understand the concepts are able to: Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence that an electric current can produce a magnetic field. Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence that a changing magnetic field can produce an electric current. In experimental design, decide on the types, amounts, and accuracy of data needed to produce reliable measurements, consider limitations on the precision of the data, and refine the design accordingly. Collect empirical evidence to support the claim that an electric current can produce a magnetic field. Collect empirical evidence to support the claim that a changing magnetic field can produce an electric current.

<table>
<tr><td colspan="4">Part B: How can I exert a force on an object when I can’t touch it?</td></tr>
<tr><td colspan="4"><u>Students who understand the concepts are able to:</u>
Develop and use an evidence-based 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.
Suggest and predict cause-and-effect relationships for two objects interacting through electric or magnetic fields.</td></tr>
<tr><th colspan="4">Interdisciplinary Connections</th></tr>
<tr><th colspan="2">NJSLS- ELA</th><th colspan="2">NJSLS- Mathematics</th></tr>
<tr><td colspan="2">Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
(HS-PS2-5),(HSPS3-5) WHST.9-12.7
Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
(HS-PS2-5),(HS-PS3-5) WHST.11-12.8
Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-5), (HS-PS3-5) WHST.9-12.9
Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-5) SL.11-12.5</td><td colspan="2">Reason abstractly and quantitatively. (HS-PS3-5) MP.2
Model with mathematics. (HS-PS3-5MP.4)
Use units as a way to understand problems and to guide the solution of multi step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-5) HSN.Q.A.1
Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-5) HSN.Q.A.2
Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-5) HSN.Q.A.3</td></tr>
<tr><td>Core Instructional Materials</td><td colspan="3">Can include: Textbooks Series, Lab Materials, etc.</td></tr>
<tr><td>21st Century Life and Careers</td><td colspan="3">CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11, CRP 12</td></tr>
<tr><td>Technology Standards</td><td colspan="3">8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.A.4, 8.1.12.A.5, 8.1.12.E.1, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5</td></tr>
<tr><th colspan="4">Modifications</th></tr>
<tr><th>English Language Learners</th><th>Special Education</th><th>At-Risk</th><th>Gifted and Talented</th></tr>
<tr><td>Scaffolding
Word walls
Sentence/paragraph frames</td><td>Word walls
Visual aides
Graphic organizers</td><td>Teacher tutoring
Peer tutoring
Study guides</td><td>Curriculum compacting
Challenge assignments
Enrichment activities</td></tr>
</table>

Bilingual dictionaries/translation Think alouds Read alouds Highlight key vocabulary Annotation guides Think-pair- share Visual aides Modeling Cognates	Multimedia Leveled readers Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Graphic organizers Extended time Parent communication Modified assignments Counseling	Tiered activities Independent research/inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities

PHYSICS		
HS-PS2-5: Motion and Stability: Forces and Interactions		
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.		
Clarification Statement: N/A		
Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.		
Evidence Statements: HS-PS2-5		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data	**PS2.B: Types of Interactions** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. 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.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS3.A: Definitions of Energy** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary)	

Connections to other DCIs in this grade-band: HS.PS3.A ; HS.PS4.B ; HS.ESS2.A

Articulation of DCIs across grade-bands: MS.PS1.A ; MS.PS2.B ; MS.ESS1.B

NJSLS- ELA: WHST.11-12.7, WHST.11-12.8, WHST.11-12.9

NJSLS- Math: HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3

5E Model

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.

Engage Anticipatory Set	Understanding Electromagnetic Induction https://www.youtube.com/watch?v=tC6E9J925pY DC Motor: How it Works https://www.youtube.com/watch?v=LAtPHANEfQo
Exploration **Student Inquiry**	Faraday Law and Electromagnet Lab Using this simulation, students will predict how the current will change when the conditions are varied. They will then design an experiment to determine how the size and direction of the induced current will change when the conditions are varied. Collect data, make observations and record your information in a table. https://phet.colorado.edu/en/contributions/view/2827 Magnetic Field Investigation In this lab you will investigate the properties of magnetic fields around a bar magnet. Lab Worksheet: https://phet.colorado.edu/services/download-servlet?filename=%2Factivities%2F3903%2FPhET_NGSS+Fields+2+Student+Sheet+-+Understand+and+Draw.pdf Simulation: https://phet.colorado.edu/en/simulation/electric-hockey Magnetism and Electricity Lab In this activity, students will be charged with building a better electromagnet. http://hendrix2.uoregon.edu/~dlivelyb/phys101/lab7_s07.pdf

Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS2.B: Types of Interactions Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. 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. PS3.A: Definitions of Energy "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary)
Elaboration Extension Activity	Explaining Electrical Conductivity in Neurons Neurons are specialized to conduct electrical impulses using varied ion concentrations. https://www.youtube.com/watch?v=bS_N-nMiqnM How transformers work
Evaluation Assessment Tasks	Assessment Task A: Faraday Law and Electromagnet Lab Students will be assessed on their experimental design. Assessment Task B: Magnetism and Electricity Lab Students will be assessed on the effectiveness of the electromagnet that they improve.

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: August 2016

PHYSICS		
HS-PS3-5: Energy		
HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.		
Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.		
Assessment Boundary: Assessment is limited to systems containing two objects.		
Evidence Statements: HS-PS3-5		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS3.C: Relationship Between Energy and Forces** When two objects interacting through a field change relative position, the energy stored in the field is changed.	**Cause and Effect** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
Connections to other DCIs in this grade-band: HS.PS2.B		
Articulation of DCIs across grade-bands: MS.PS2.B ; MS.PS3.C		
NJSLS- ELA: WHST.9-12.7, WHST.11-12.8, WHST.9-12.9, SL.11-12.5		
NJSLS- Math: MP.2, MP.4		

5E Model	
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.	
Engage Anticipatory Set	Force on a Charged Particle Moving in A Magnetic Field https://www.youtube.com/watch?v=Gdh2srqH57M&list=PL66BFE4ED235C44D7 What Will Happen When the Earth's Magnetic Field Reverse

	http://www.smithsonianmag.com/science-nature/what-will-happen-when-earths-magnetic-field-begins-reverse-180951166/?no-ist
Exploration Student Inquiry	Electric Field Lab The objective of this lab is to explore electric field based on different charge configurations. https://phet.colorado.edu/en/contributions/view/3992 Electric Field Hockey Determine the variables that affect how charged bodies interact and predict how charged bodies will interact. https://phet.colorado.edu/en/contributions/view/2853
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): PS3.C: Relationship Between Energy and Forces When two objects interacting through a field change relative position, the energy stored in the field is changed.
Elaboration Extension Activity	Drifting Into Current Students discover the definitions of current and drift speed in a reading exploration activity. http://betterlesson.com/lesson/641911/drifting-into-current http://www.smithsonianmag.com/science-nature/what-will-happen-when-earths-magnetic-field-begins-reverse-180951166/?no-ist
Evaluation Assessment Tasks	Assessment Task A: Electric Field Lab https://phet.colorado.edu/en/contributions/view/3992 Student should use their models (drawings/diagrams) to: Determine whether the energy stored in the field increased, decreased or remained the same when the objects interacted Support the claim that the change in the energy stored in the field is consistent with the change in energy of the objects Describe the cause and effect relationships on a qualitative level between forces produced by electric or magnetic fields and the change of energy of the objects in the system.