SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Physics

New Jersey
Student Learning Standards
SCIENCE

All standards are NJSLS-S

BOE adopted 5/2017

Unit 1: Overview
Unit 1: Kinematics
Content Area: Physics
Pacing: 25 Instructional days
Essential Questions
1. How vectors are used to analyze motion? 2. What is the difference between speed and velocity? 3. What are the relationships between position, velocity, and acceleration?
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 among the net force on a macroscopic object, its mass, and its acceleration.
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.
Unit Summary
By the end of this unit, students will: · understand the general relationships among position, velocity, and acceleration for the motion of a particle along a straight line. · understand the special case of motion with constant acceleration. · understand the relationship among words, equations and graphs for motion in one dimension. By the end of this unit, students will be able to: · solve problems specifically by first writing out all variables present, determining the appropriate equation to use, solving the equation for the variable needed, inserting numbers into the equation, and finally performing calculations with a scientific calculator. · apply the qualitative definition of acceleration (speeding up, or slowing down, and/or changing direction) to determine if an object is accelerating. · Students will be able to determine velocity by taking the slope of a position-time graph, and determine acceleration from the slope of a velocity-time graph, as well as the displacement by calculating the area under the curve. Students will correlate negative and positive slopes with positive and negative velocities and accelerations.
Technical Terms
Newton's Laws of Motion, vectors and scalars, acceleration, distance vs. displacement, speed vs. velocity, acceleration, non-relativistic speed, vector drawings,

causal relationships, correlational relationships, kinematics equations #1, #2, and #3.
Formative & Summative Assessment Measures
During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and a response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below. Average Speed Quiz Equation 1 Quiz Equation 2 Quiz Equation 3 Quiz Mixed Equations Quiz Kinematics Test Other assessments on the NJCTL website are optional and can be used as needed.

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, 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,	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 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

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	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

Core Instructional Materials	Can include: NJCTL Presentations/Classwork, Lab Materials, etc.
Career ready Practices	CRP 1, CRP 2, CRP 5, CRP 6, CRP 7, CRP 9, CRP 11
Technology Standards	8.1.12.A.1, 8.1.12.A.2, 8.1.12.A.3, 8.1.12.E.1

Modifications

English Language Learners	Special Education	At-Risk	Gifted and Talented
Word walls Formula Displays Bilingual translation Highlight key vocabulary Annotation guides Visual aides Modeling Spanish Articles: NEWSELA *All presentations and problems available entirely in Spanish.	Word walls Visual aides Multimedia Leveled readers: NEWSELA Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Heterogeneous Groups Graphic organizers Extended time Parent communication Modified assignments	Curriculum compacting Challenge assignments Tiered activities Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks

SUBJECT: SCIENCE/PHYSICS

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GRADE: 9-12

BOE APPROVAL: 8/2018

PHYSICS		
HS-PS2-1: Motion Properties of an Object		
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 in motion, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.		
Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.		
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	
HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	
Engage Anticipatory Set	Hands On Activity: Speed Demonstration The demonstration will allow students to discover the concept and mathematical interpretation of speed. Students will be given 5 to 10 minutes to work in groups of five to find which of three pull back cars travel the fastest. However, the students cannot race more than one car at a time. After 5 to 10 minutes, the teacher will begin asking equation questions. The equation questions slowly introduce students to the mathematical interpretation of speed. See video for further explanation: https://youtu.be/B7zdabE4rbA Free Fall Demonstration: The demonstration will allow students to discover the conceptual and mathematical interpretations of freefall. Students will be given 5 to 10 minutes to work in groups of five to find the final speed of a baseball before it hits the ground. The students will be given a baseball and a timer. After 5 to 10 minutes, the teacher will begin asking equation questions. The equation questions slowly introduce students to an algebraic derivation of the first kinematics equation. The following video provides additional explanation: https://youtu.be/6TWYVZn_ogM
Exploration Student Inquiry	Kinematics: Students will analyze one dimensional motion without considering the forces acting on the object. Applying Newton's Second Law Quantitatively

	Students will solve a variety of problems involving motional properties of an object to introduce Newton's Laws of Motion. Combining Newton's Second Law and Kinematics Students will solve a variety of problems with equations of motion to introduce Newton's Laws of Motion. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Daily lesson breakdown, unit plans, and pacing guides available.
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. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/
Elaboration Extension Activity	NJCTL Lessons: Virtual simulations, PHET Labs, and Lab activities are provided. https://njctl.org/courses/science/algebra-based-physics/ NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	Assessment Task: Students will be able to represent the unknown variables associated with the motion of objects using algebraic equations and then calculate these unknown variables using the three kinematics equations.

Unit 2: Overview
Unit 2: Dynamics
Content Area: Physics
Pacing: 26 Instructional days
Essential Questions
1. How can an object be made to accelerate? 2. How do forces interact? 3. How do objects respond to multiple forces acting on them?
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 among the net force on a macroscopic object, its mass, and its acceleration.
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.
Unit Summary
By the end of this unit, students will know: • How to apply the concept of inertia to determine the motion of an object experiencing a net force and zero net force. • How to algebraically manipulate and utilize the following equations: $\Sigma F = ma$ $f_k = \mu_k F_N$ $f_s < \mu_s F_N$ $w = mg$ • How to solve problems specifically by first sketching the setup, drawing a free body diagram, determining the forces present, aligning coordinate axes, solving the equation for the variable needed, inserting numbers into the equation, and finally performing calculations with a scientific calculator. • How to determine the weight of objects in settings with vertical accelerations and determine the difference between true weight and apparent weight (normal force). • How apply Newton's Third Law (for every action force, there is an equal and opposite reaction force) to determine action/reaction pairs. • How to identify when friction must be considered in a problem and when it can be ignored, determine the type of friction present, and the point at which the static friction is overcome to result in kinetic friction. • How to identify all the different types of force present in a problem. They will draw the relative magnitudes and directions of the forces on a free body diagram and note the direction of acceleration

• How to, after drawing a free body diagram, students will apply Newton's Second Law to a problem, determining the net force acting on an object. They will solve for net forces and forces specific to the problem. • How to identify the following forces and illustrate their relative magnitudes and directions when problem solving: o Applied Force o Normal Force o Weight (Gravitational Force) o Apparent Weight o Tension o Friction (Kinetic and Static) • How to solve Atwood machine type problems. By the end of this unit, students will be able to: • Describe inertia using Newton's First Law. • Relate force, mass and acceleration using Newton's Second Law. • Solve problems using Newton's Second Law. • Describe inertial reference frames. • Differentiate between weight and mass. • Describe weight as a force in terms of mass and gravitational acceleration. • Describe the normal force and understand the conditions in which it exists. • Identify a reaction force if given an action force. • Determine whether a frictional force is kinetic (moving) or static (not moving). • Solve problems involving static and kinetic friction. • Identify and solve for tension force. • Draw free body diagrams. • Solve problems involving multiple forces and accelerations
Technical Terms
Newton's Laws of Motion, inertia, mass, acceleration, force, weight vs. mass, tension, friction, Free Body Diagram, normal force, static friction vs. kinetic friction,
Formative & Summative Assessment Measures
During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and a response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below. • Newton's Second Law Quiz • Weight and Mass Quiz • Friction Quiz (Either one/or both, at discretion of teacher.) • Dynamics Test Other assessments on the NJCTL website are optional and can be used as needed.

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, 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	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 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
Core Instructional Materials	Can include: NJCTL Presentations/Classwork, Lab Materials, etc.

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Career ready Practices	CRP 2, CRP 4, CRP 5, CRP 6, CRP 7, CRP 8 , CRP 11, CRP 12		
Technology Standards	8.1.12.A.1, 8.1.12.A.3, 8.1.12.E.1,8.2.12.B.4, 8.2.12.C.5		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Word walls Formula Displays Bilingual translation Highlight key vocabulary Annotation guides Visual aides Modeling Spanish Articles: NEWSELA *All presentations and problems available entirely in Spanish.	Word walls Visual aides Multimedia Leveled readers: NEWSELA Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Heterogeneous Groups Graphic organizers Extended time Parent communication Modified assignments	Curriculum compacting Challenge assignments Tiered activities Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks

PHYSICS		
HS-PS2-1: Dynamics: Forces and Interactions		
HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.		
Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects in motion, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.		
Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.		
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	
HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	
Engage Anticipatory Set	Hands On Activity: Newton's First Law Demonstration This demonstration will allow students to discover Newton's first law of motion. Students will observe a ball on a U-shaped ramp as the ramp is oriented differently. The purpose of this demonstration is to introduce students to Newton's laws of motion and will prepare students for learning about inertia as well as the other laws of motion. See the following video for additional explanation: https://youtu.be/MxkLT-EpkqE Newton's Second Law Demonstration: This demonstration will allow students to discover Newton's Second Law of Motion. Students will observe the motion of two carts and observe how changing the mass of a cart affects its acceleration. The purpose of this demonstration is to allow students to understand the relationship between the force on an object, its mass, and the acceleration of the object. See the following video for additional explanation: https://youtu.be/J-PDPtoGmzg Frictional Demonstration: This demonstration will allow students to discover the concept of a frictional force and the different types of frictional forces. Teachers will place a block at the top of a wooden board. One side of the board will be lifted until a critical angle is reached so the block begins moving down the board. This shows the presence of two frictional forces: kinetic and static friction. The following video provides additional explanation: https://youtu.be/nGrUuqJyOIk
Exploration	Dynamics:

Student Inquiry	Students will analyze Newton's Laws of Motion and the interaction between multiple forces acting on an object. Applying Newton's Laws of Motion: Students will analyze and apply Newton's Laws of Motion conducting the Friction Lab, Inertia Lab, and/or Hooke's Law Lab NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Daily lesson breakdown, unit plans, and pacing guides available.
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. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/
Elaboration Extension Activity	NJCTL Lessons: Virtual simulations, PHET Labs, and Lab activities are provided. https://njctl.org/courses/science/algebra-based-physics/ NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	Assessment Task: Students will be able to represent the unknown variables associated with forces acting on an object using algebraic equations and then calculate these unknown variables using multiple equations.

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

Unit 3a: Overview
Unit 3a: Uniform Circular Motion
Content Area: Physics
Pacing: 14 Instructional days
Essential Question
1. How do we use Free Body diagrams and Newton's Laws to solve circular motion problems? 2. What are the applications of circular motion? 3. How does apparent weight vary during circular motion?
Student Learning Objectives (Performance Expectations)
This essential knowledge does not produce a specific learning objective but serves as a foundation for other learning objectives in the course.
Unit Summary
By the end of this unit, students will know: How to relate the radius of the circle and the speed or rate of revolution of the particle to the magnitude of the centripetal acceleration. How to describe the direction of the particle's velocity and acceleration at any instant during the motion. How to analyze situations in which an object moves with specified acceleration under the influence of one or more forces so they can determine the magnitude and direction of the net force, or of one of the forces that makes up the net force, in situations such as the following: (1) Motion in a horizontal circle (e.g., mass on a rotating merry-go-round, or car rounding a banked curve). (2) Motion in a vertical circle (e.g., mass swinging on the end of a string, cart rolling down a curved track, rider on a Ferris wheel). By the end of this unit, students will be able to: Learn various concepts and ideas related to circular motion. They will use the following equations in solving problems. o a= v2 /r o v = 2πr/T o T= 1/f o F = ma
Technical Terms
Centripetal acceleration, period, frequency, uniform circular motion, revolutions, horizontal circle vs. vertical circle.

Formative & Summative Assessment Measures			
During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and a response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below. • Centripetal Acceleration Quiz • Uniform Circular Motion Test Other assessments on the NJCTL website are optional and can be used as needed.			
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: NJCTL Presentations/Classwork, Lab Materials, etc.		
Career ready Practices	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, CRP 9, CRP 11, CRP 12		
Technology Standards	8.1.12.A.1, 8.1.12.A.3, 8.1.12.E.1, 8.2.12.B.4, 8.2.12.C.5		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Word walls Formula Displays	Word walls Visual aides	Teacher tutoring Peer tutoring	Curriculum compacting Challenge assignments

Bilingual translation Highlight key vocabulary Annotation guides Visual aides Modeling Spanish Articles: NEWSELA *All presentations and problems available entirely in Spanish.	Multimedia Leveled readers: NEWSELA Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Study guides Heterogeneous Groups Graphic organizers Extended time Parent communication Modified assignments	Tiered activities Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks

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

BOE APPROVAL: 8/2018

PHYSICS		
Uniform Circular Motion		
Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of Uniform Circular Motion.		
Assessment Boundary: Assessment is limited to vertical circular motion or horizontal circular motion.		
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.A: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict effects of gravitational and electrostatic forces between distant objects	**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	
Uniform Circular Motion	
Engage Anticipatory Set	Rope Demonstration: This demonstration will allow students to discover how uniform circular motion arises when the velocity and acceleration components of an object's motion are at right angles. The goal is for students to recognize this by trying to move, while being held in by the centripetal force of a rope. Once the demonstration has concluded, teachers will ask discussion questions. Students should be writing down their observations and questions in a notebook See the following video for additional explanation: https://youtu.be/h5DuMGqyNA0 Bucket Demonstration: This demonstration will allow students to think about the difference between centripetal force and centrifugal force. The goal is for students to identify the components of force of a bucket of water, swung in a circle, such that the water does not fall out. Once the demonstration has concluded, teachers will ask discussion questions. Students should be writing down all their observations and questions in a notebook. See the following video for additional explanation: https://youtu.be/h_f8SeoTKrI
Exploration Student Inquiry	Uniform Circular Motion: Students will apply previous knowledge of dynamics to analyze the dynamics of uniform circular motion. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Daily lesson breakdown, unit plans, and pacing guides available.
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) will provide a foundation to understand the following: 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. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/
Elaboration Extension Activity	Finding g : Centripetal Acceleration Lab Centripetal Force: Mass of Stopper Lab NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	Assessment Task A: Using the two lab based activities above, teachers will evaluate the students' descriptions and predictions of Uniform Circular Motion.

Unit 3b: Overview
Unit 3b: Universal Gravitation
Content Area: Physics
Pacing: 15 Instructional days
Essential Questions
1. How are mass, separation, and gravitational force related? 2. How does the mass of a planet relate to its gravitational force? 3. How do we explain the apparent weightlessness of orbiting objects?
Student Learning Objectives (Performance Expectations)
HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration HS-PS2-4:Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system
Unit Summary
By the end of this unit, students will know: Newton's Law of Universal Gravitation That the motion of an object in orbit is under the influence of gravitational forces By the end of this unit, students will be able to: Determine the force that one spherically symmetrical mass exerts on another. Determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass. Recognize that the motion does not depend on the object's mass Describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit Derive expressions for the velocity and period of revolution in such an orbit.
Technical Terms
Newton's Law of Universal Gravitation, Kepler's Law, period of revolution, centripetal acceleration, gravitational constant
Formative & Summative Assessment Measures
During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class

work/homework questions and ta response system.
Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.
-Gravitational Force Quiz
-Universal Gravitation Test

Other assessments on the NJCTL website are optional and can be used as needed.

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: NJCTL Presentations/Classwork, Lab Materials, etc.
Career ready Practices	CRP 1, CRP 2, CRP 4, CRP 5, CRP 8 , CRP 9, CRP 11, CRP 12
Technology Standards	8.1.12.A.2, 8.2.12.B.1,8.2.12.B.4, 8.2.12.C.5
Modifications	

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

English Language Learners	Special Education	At-Risk	Gifted and Talented
Word walls	Word walls	Teacher tutoring	Curriculum compacting
Formula Displays	Visual aides	Peer tutoring	Challenge assignments
Bilingual translation	Multimedia	Study guides	Tiered activities
Highlight key vocabulary	Leveled readers: NEWSELA	Heterogeneous Groups	Collaborative teamwork
Annotation guides	Assistive technology	Graphic organizers	Higher level questioning
Visual aides	Notes/summaries	Extended time	Critical/Analytical thinking tasks
Modeling	Extended time	Parent communication	
Spanish Articles: NEWSELA	Answer masking	Modified assignments	
	Answer eliminator		
*All presentations and problems	Highlighter		
available entirely in Spanish.	Color contrast		

HS-PS2-4: Universal Gravitation		
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 Uniform Circular Motion.		
Assessment Boundary: Assessment is limited to vertical circular motion or horizontal circular motion.		
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.A: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict effects of gravitational and electrostatic forces between distant objects	**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		

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

PHYSICS		
HS-ESS1-4: Universal Gravitation		
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. **HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** **HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.**	
Engage Anticipatory Set	Baseball Demonstration: This demonstration will allow students to apply their knowledge of gravity in a friendly competition. Students will compete to see who can throw a baseball the farthest in a horizontal direction. Once the competition has concluded, teachers will ask students questions regarding the motion of the ball due to the force of gravity. The goal of this lab is for students to understand the topic of gravity and gravitational fields through teacher guided questions. See the following video for additional explanation: https://youtu.be/G4mXQxl_19E
Exploration Student Inquiry	Universal Gravitation: Students will build upon Uniform Circular Motion concepts and analyze Newton's Law of Universal Gravitation. Applying Newton's Law of Universal Gravitation: Students will analyze and apply Newton's Law of Universal Gravitation by conducting the Force of Gravity Lab. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Daily lesson breakdown, unit plans, and pacing guides available.

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): HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration 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. 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. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/
Elaboration Extension Activity	Mass of Jupiter Simulation Lab NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	Assessment Task A: In the activities above, students will use Newton's Law of Universal Gravitation and apply it to a multitude of phenomena.

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Unit 4: Overview
Unit 4: Energy
Content Area: Physics
Pacing: 27 Instructional days
Essential Question
1. How do we determine the work done on a physical system when the net force acting on it and its displacement are known? 2. How do we use the work/energy theorem to determine the motion of an object? 3. How do we apply energy conservation to determine the position and motion of an object?
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
By the end of this unit, students will know: Definition of work, including when it is positive, negative, or zero. How to apply the work-energy theorem. The concept of a conservative force. The concept of potential energy.

The concepts of mechanical energy and of total energy.
Conservation of energy.
The definition of power.

By the end of this unit, students will be able to:
Calculate the work done by a specified constant force on an object that undergoes a specified displacement.
Relate the work done by a force to the area under a graph of force as a function of position, and calculate this work in the case where the force is a linear function of position.
Use the scalar product operation to calculate the work performed by a specified constant force F on an object that undergoes a displacement in a plane.
Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object.
Calculate the work performed by the net force, or by each of the forces that make up the net force, on an object that undergoes a specified change in speed or kinetic energy.
Apply the theorem to determine the change in an object's kinetic energy and speed which results from the application of specified forces, or to determine the force that is required in order to bring an object to rest in a specified distance.
Describe examples of conservative forces and non-conservative forces.
Write an expression for the force exerted by an ideal spring and for the potential energy of a stretched or compressed spring.
Calculate the potential energy of one or more objects in a uniform gravitational field.
State and apply the relation between the work performed on an object by non-conservative forces and the change in an object's mechanical energy.
Describe and identify situations in which mechanical energy is converted to other forms of energy.
Analyze situations in which an object's mechanical energy is changed by friction or by a specified externally applied force.
Identify situations in which mechanical energy is or is not conserved.
Apply conservation of energy in analyzing the motion of systems of connected objects, such as an Atwood's machine.
Apply conservation of energy in analyzing the motion of objects that move under the influence of springs.
Recognize and solve problems that call for application both of conservation of energy and Newton's Laws.
Calculate the power required to maintain the motion of an object with constant acceleration (e.g., to move an object along a level surface, to raise an object at a constant rate, or to overcome friction for an object that is moving at a constant speed).
Calculate the work performed by a force that supplies constant power, or the average power supplied by a force that performs a specified amount of work.

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 & Summative Assessment Measures

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class

work/homework questions and a response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.
-Work and Energy Quiz
-Power Quiz
-Energy Test
Other assessments on the NJCTL website are optional and can be used as needed.

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 over-reliance 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	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

interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) SL.11-12.5			
Core Instructional Materials	Can include: NJCTL Presentations/Classwork, Lab Materials, etc.		
Career ready Practices	CRP 1, CRP 2, CRP 4, CRP 6, CRP 7, 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.E.1		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Word walls Formula Displays Bilingual translation Highlight key vocabulary Annotation guides Visual aides Modeling Spanish Articles: NEWSELA *All presentations and problems available entirely in Spanish.	Word walls Visual aides Multimedia Leveled readers: NEWSELA Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Heterogeneous Groups Graphic organizers Extended time Parent communication Modified assignments	Curriculum compacting Challenge assignments Tiered activities Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks

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 NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Unit plans, daily activities, and pacing guides available.
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. NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Daily lesson breakdown, unit plans, and pacing guides available.
Elaboration Extension Activity	Swinging Pendulum https://www.teachengineering.org/Activities/view/cub_energy_lesson03_activity2 NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	Assessment Task A: Energy Skate Park- Bar Graph Model http://betterlesson.com/lesson/resource/3218871/energy-skate-park?from=resource_image

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 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.	**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. **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	**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** Science assumes the universe is a vast single system in which basic laws are consistent.

Create a computational model or simulation of a phenomenon, designed device, process, or system.	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.	

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=l87Dr2lJEOk
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 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. 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.
Elaboration Extension Activity	Power Lab: Students will be running up a set of stairs as fast as they can. Power is defined as the amount of work done divided by the amount of time it takes to do the work. Students will use their knowledge of this to figure out how powerful their representative is. https://njctl.org/courses/science/algebra-based-physics/energy/attachments/power-lab/ Marshmallow Launcher Lab In this lab, students will bend a plastic spoon and release it to to launch a marshmallow (or any other small object) into the air. A bent plastic spoon stores EPE. Releasing the spoon converts the spoons EPE into KE giving the object an initial velocity (v) and at the top of its trajectory (h); the KE is converted into GPE. https://njctl.org/courses/science/algebra-based-physics/energy/attachments/marshmallow-launcher-lab-teacher-notes/
Evaluation	Students use the computational model to calculate the changes in the energy of one component of the system when changes in the

Assessment Tasks	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 Assessment Task D: Marshmallow Launcher Lab Conservation of Energy formulas properly calculated

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	**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	**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**

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.	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)	**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		
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	**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	**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

problems using models and simulations. Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	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.	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		

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		

Unit 5: Overview
Unit 5:Momentum
Content Area: Physics
Pacing: 16 Instructional days
Essential Question
1. How do we determine the impulse on a physical system when the forces on the system, and the time interval these forces act, are known? 2. What is the difference between elastic and inelastic collisions?
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 among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
Unit Summary
By the end of this unit, students will know: · relationship between certain physics quantities related to impulse and momentum. · fundamental law of physics -conservation of momentum. By the end of this unit, students will know: · use the following equations in solving problems: P = mv (Momentum) I = Δp = mv (Impulse)
Technical Terms
Momentum, Momentum Change and Impulse, Momentum of a System of Objects, Conservation of Momentum, Perfectly Inelastic Collisions & Explosions, Elastic

Collisions.

Summative & Formative Assessment Measures

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.
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- Momentum Quiz
- Conservation of Momentum Quiz
- Impulse Quiz
- Momentum Test

Other assessments on the NJCTL website are optional and can be used as needed.

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), (HS-PS2-2),(HS-PS2-3) 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-PS2-1), (HS-PS2-2),(HS-PS2-3) RST.11-12.2 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-PS2-1), (HS-PS2-2),(HS-PS2-3) RST.11-12.8 Write informative/explanatory texts, including the narration of historical events,	Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2),(HS-PS2-3) MP.2 Model with mathematics.(HS-PS2-1), (HS-PS2-2),(HS-PS2-3) 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-PS2-1), (HS-PS2-2),(HS-PS2-3) HSN-Q.A.1 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1), (HS-PS2-2),(HS-PS2-3) HSN-Q.A.2 Choose a level of accuracy appropriate to limitations on measurement when

scientific procedures/ experiments, or technical processes.(HS-PS2-1), (HS-PS2-2),(HS-PS2-3) 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-PS2-1), (HS-PS2-2),(HS-PS2-3) 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-PS2-1), (HS-PS2-2),(HS-PS2-3) SL.11-12.5		reporting quantities. (HS-PS2-1), (HS-PS2-2),(HS-PS2-3) HSNQ.A.3	
Core Instructional Materials	Can include: NJCTL Presentations/Classwork, Lab Materials, etc.		
Career ready Practices	CRP 2, CRP 4, CRP 5, CRP 6, CRP 8 , CRP 9, CRP 12		
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12..A.3, 8.1.12.E.1, 8.2.12.C.5		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Word walls Formula Displays Bilingual translation Highlight key vocabulary Annotation guides Visual aides Modeling Spanish Articles: NEWSELA *All presentations and problems available entirely in Spanish.	Word walls Visual aides Multimedia Leveled readers: NEWSELA Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Heterogeneous Groups Graphic organizers Extended time Parent communication Modified assignments	Curriculum compacting Challenge assignments Tiered activities Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks

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

5E Model	
HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	
Engage Anticipatory Set	Newton's Cradle Demonstration: This demonstration will allow students to observe how momentum is conserved through the use of a Newton's Cradle. The goal of this lab is for students to analyze how one raised Newton ball can transfer its momentum through multiple Newton balls. Students will observe that the system returns to rest due to the net impulse of the force of gravity over the time the system is in motion. Once the demonstration has concluded, teachers will ask discussion questions. For more information, see the following video: https://youtu.be/hZieoKKqyPM Tennis Ball/Basketball Demonstration: This demonstration will show students how momentum can be transferred between two objects in a closed system. Students will observe how two objects interact in terms of transfer of momentum when the mass of one object is significantly greater than that of the other object. The purpose of this demonstration is to relate transfer of momentum to conservation of momentum in a closed system. For more information see the following video: https://youtu.be/Mwpu1yk0DEs
Exploration Student Inquiry	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 NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Daily lesson breakdown, unit plans, and pacing guides available.

Explanation Concepts and Practices	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	NJCTL Lessons: Virtual simulations, PHET Labs, and Lab activities are provided. - Momentum Observation Lab Discovery - Explosion Lab Discovery https://njctl.org/courses/science/algebra-based-physics/ NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	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.

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		
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	
5E Model	
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	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
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. 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

	NJCTL Lessons: https://njctl.org/courses/science/algebra-based-physics/ Daily lesson breakdown, unit plans, and pacing guides available.
Explanation Concepts and Practices	f 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	In these above activities, teachers should evaluate students on their application of the engineering process which includes design, evaluation and refinement.

PHYSICS
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. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**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: 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-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 engineering 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 these above activities, teachers should evaluate students on their application of the engineering process which includes design, evaluation and refinement.

Unit 6: Overview
UNIT 6: Electric & Magnetic Field and Force
Content Area: Physics
Pacing: 22 Instructional days
Essential Questions
Electric Charge & Force 1. How many types of electric charge are there? What are they named? 2. Which particle of an atom carries a positive charge? Which carries the negative charge? 3. Why is it that when you take off a sweater in a dark room you can see tiny sparks and hear a crackling sound? 4. Compare and contrast Coulomb's Law with Newton's Law of Universal Gravitation. 5. A student touches an electroscope with his hand at the same time he brings a positively charged rod close to the electroscope without touching. When he removes his hand first and then moves the rod away from the electroscope the leaves move apart. Why? What type of charge is on the leaves? Electric Field and Potential 1. What is the definition of the Electric Field and what equation was used to derive this concept? 2. Why can Electric Field lines never cross or touch each other? Do Electric Field lines exist? 3. What is the significance of the density of the electric field lines about a charge? 4. How is the Electric Potential derived from the Electric Potential Energy?

5. What is an equipotential line? How does it relate to an Electric Field line?

Magnetism

1. Both Electric and Magnetic Forces will cause objects to repel and attract each other. What is a difference in the origin of these forces?
2. A Magnet has a north and a south pole. If you cut the magnet in half, describe what happens to each end of the two pieces.
3. Can you find a magnet with just a north pole?
4. What Field circles a current carrying wire?

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

By the end of the Electric Charge & Force section of this unit, students will know:

- The two types of electric charges
- The law of conservation of charge
- How charges interact
- How to charge various object using conduction and induction By the end of this unit, students will be able to:
- Use Coulomb’s Law to solve problems
- Make predictions about charges

By the end of the Electric Field & Potential section of this unit unit, students will know:
How to define electric fields and how they relate to electric force.
The relationship between electric potential, voltage and potential energy.
How charged objects respond to electric fields and potential differences.
By the end of the Electric Field & unit, students will be able to:
Use the following equations to solve problems: □ = □□/ □^2, □ = □□ □ = □□/ □ □□ = □□ □ = Δ□

SUBJECT: SCIENCE/PHYSICS

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

By the end of the Magnetism section of this unit, students will know:
How to determine the direction of the magnetic field created by a current carrying wire.
How to determine the force exerted by a magnetic field on a moving charged particle or current carrying wire.
By the end of the Magnetism section of this unit, students will be able to:
Find the magnitude of the magnetic field created by a current carrying wire using: □ = □0 □ 2□□
Find the magnitude of the force exerted by a magnetic field on a current carrying wire using: □□ = □□□
Find the magnitude of the force exerted by a magnetic field on a moving charge: □□ = □□□
Find the magnitude of the force between two current carrying wires using: □□ = □0 □1 □2 □ 2□□

Technical Terms

Magnetism, electric currents, electric energy, magnetic fields, electric fields, electric potential, magnetic force.

Formative & Summative Assessment Measures

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

Electric Charge Lab Quiz
Electric Charge and Force Test
Electric Potential Energy and Voltage Quiz
Electric Field and Potential Test
Magnetic Field and Force Quiz
Magnetism Test

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 5, CRP 6, CRP 7, CRP 8 , CRP 9, CRP 11		
Technology Standards	8.1.12,.A.1, 8.1.12.A.2, 8.1.12.E.1, 8.2.12.B.1, 8.2.12.C.5		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Word walls Formula Displays Bilingual translation Highlight key vocabulary Annotation guides Visual aides Modeling Spanish Articles: NEWSELA *All presentations and problems available entirely in Spanish.	Word walls Visual aides Multimedia Leveled readers: NEWSELA Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Heterogeneous Groups Graphic organizers Extended time Parent communication Modified assignments	Curriculum compacting Challenge assignments Tiered activities Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks

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	**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	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	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)	

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.

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.

Unit 7: Overview
Unit 7: Waves
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. **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.
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: NJCTL Presentations/Classwork, Lab Materials, etc.
Career ready Practices	CRP 1, CRP 2, CRP 4, CRP 5, CRP 6, 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.E.1, 8.2.12.C.5
Modifications	

English Language Learners	Special Education	At-Risk	Gifted and Talented
Word walls	Word walls	Teacher tutoring	Curriculum compacting
Formula Displays	Visual aides	Peer tutoring	Challenge assignments
Bilingual translation	Multimedia	Study guides	Tiered activities
Highlight key vocabulary	Leveled readers: NEWSELA	Heterogeneous Groups	Collaborative teamwork
Annotation guides	Assistive technology	Graphic organizers	Higher level questioning
Visual aides	Notes/summaries	Extended time	Critical/Analytical thinking tasks
Modeling	Extended time	Parent communication	
Spanish Articles: NEWSELA	Answer masking	Modified assignments	
	Answer eliminator		
*All presentations and problems available entirely in Spanish.	Highlighter Color contrast		

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	**PS4.A: Wave Properties**	**Cause and Effect**

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.	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.	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.		

Engage Anticipatory Set	GCSE Science Revision - Types of Waves 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.

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.	
Engage Anticipatory Set	GCSE Science Revision - Types of Waves 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.

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**	**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**	**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.

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.	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.	
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		
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	In these lessons

Concepts and Practices	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.