Kenilworth Public Schools

Curriculum Guide

Content Area: Physics
Grade: 11-12
BOE Approved: 3/13/17

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Submitted by: Phil Giordano
BOE Revision Approved: 3/8/21

Physics-Grades 11-12 Scope and Sequence

Unit 1- Motion and Stability: Forces and Interactions	Unit 2- Energy and Motion	Unit 3- Waves and Their Applications in Technologies for Information
Weeks 1-12	Weeks 13-28	Weeks 29-38
Unit Description: The concepts and relationships between displacement time, speed, and velocity will be introduced. The difference between accelerated motion and non-accelerated motion will be observed. Kinematic equations for constant acceleration will be explained. This unit also explores freely falling bodies as examples of motion with constant acceleration. Scalar and vector quantities and graphical vector addition will be discussed. Students will use the Pythagorean theorem and tragicomic functions to find resultant vectors and vector components. Students will explore projectile motion, negotiating air resistance. Students will describe relative motion in terms of vector operations. Free-body diagram will be introduced and force will be defined. Newton's first law and the relationship between mass and inertia will be taught. The relationships between net force, mass, and acceleration will be examined and as well as action reaction pairs. Students will examine	*Unit Description:* Work and calculations of work done in a variety of situations will be examined. Students will identify and show calculations using various energy equations. Students will explore the conditions necessary for conservation of mechanical energy. The relationships between work, time, power, force, and speed will be explored. Momentum will be defined in terms of mass and velocity, introducing the concept of impulse. Students will explore the law of conservation of momentum and distinguish between various types of collisions. Circular motion will be introduced and students will examine gravitational force. Torque and simple machines will be discussed.	*Unit Description:* In this unit simple harmonic motion will be introduced. Students will identify parts and characteristics of waves and explain superposition of waves. Sound wave production and the Doppler effect will be explained. Students will calculate intensity. Standing waves will be covered as a way to explain music. Students will identify components of the electromagnetic spectrum. Students will apply laws of reflection, and explain how lenses change the path of light. Students will investigate color and refraction and describe lasers.

familiar forces of weight, normal force, and friction		
Unit Targets: • Describe motion in terms of reference • Calculate displacement and velocity • Construct and interpret velocity graphs • Describe motion in terms of acceleration • Compare graphical representations of accelerating objects • Apply kinematic equations • Calculate motion of a falling object • Distinguish between scalar and vector • Apply Pythagorean Theorem to calculate magnitude of a vector • Resolve vectors into components • Add vectors Recognize examples of projectile motion • Describe path of parabola Solve problems involving relative velocity • Describe how force affects the motion of an object • Describe an object's acceleration in terms of mass and force • Identify action-reaction pairs	*Unit Targets:* • Define work by relating it to force and displacement • Calculate net work • Identify several forms of energy • Calculate kinetic energy • Distinguish between kinetic and potential energy • Classify different types of potential energy • Identify situations in which conservation of mechanical energy is valid • Solve problems involving conservation of energy • Calculate power • Compare momentum of moving objects • Describe change in momentum in terms of force and time • Describe change in momentum in terms of conservation of momentum • Identify different types of collisions • Determine changes in momentum and energy during a collision • Solve problems involving centripetal acceleration and centripetal force • Explain Newton's Law of Motion	*Unit Targets:* • Identify components of electromagnetic spectrum • Calculate frequency and wavelength • Recognize light has a finite speed • Describe how brightness is affected by distance • Apply law of reflection • Describe images formed by a mirror • Recognize how additive colors affect the colors of light • Recognize how pigments affect color of reflected light • Explain how polarized light is formed • Recognize situations in which refraction will occur • Solve problems using Snell's Law Draw ray diagrams of light passing through a lens • Calculate magnification of lenses • Predict optical phenomena • Describe how light interferes with itself • Describe properties of a laser • Describe mechanical and electromagnetic waves and use their properties to explain natural phenomena and technology

Physics Grades 11-12 Unit 1

Unit Title: Motion and Stability: Forces and Interactions	
Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data and use math to support claims, and apply scientific ideas to solve design problems in order to develop an understanding of ideas related to why some objects keep moving and some objects fall to the ground. Students will also build an understanding of forces and Newton's second law. Finally, they will develop an understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students will also be able to apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of patterns, cause and effect, and systems and systems models are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in planning and conducting investigations, analyzing data and using math to support claims, and applying scientific ideas to solve design problems and to use these practices to demonstrate understanding of the core ideas.	
Primary Interdisciplinary Connections: Mathematics, Civics, Business, History, Philosophy	
Career Readiness, Life Literacies, and Key Skills: 9.1.12.CFR.2 9.1.12.CFR.3 9.1.12.CFR.4 9.1.12.CFR.6 9.2.12.CAP.1 9.2.12.CAP.2 9.2.12.CAP.3 9.2.12.CAP.4 9.2.12.CAP.5 9.2.12.CAP.6 9.2.12.CAP.7 9.2.12.CAP.8 9.4.12.CI.1 9.4.12.CI.2 9.4.12.CI.3 9.4.12.CT.1 9.4.12.CT.2 9.4.12.CT.3 9.4.12.CT.4 9.4.12.DC.7 9.4.12.DC.8	
Learning Targets	
NJSLS Standards: HS-PS2-1. HS-PS2-2. HS-PS2-3. HS-PS2-4. HS-PS2-5 HS-PS2-6.	
Computer Science and Design Thinking Standards: 8.2.12.ED.1 8.2.12.ED.4 8.2.12.ED.5 8.2.12.ED.6 8.2.12.ITH.1 8.2.12.ITH.2 8.2.12.ITH.3 8.2.12.NT.1 8.2.12.NT.2 8.2.12.ETW.1 8.2.12.ETW.2 8.2.12.ETW.3	
Climate Change Standards: HS-ESS3-1 HS-ESS3-2 HS-ESS3-3 HS-ESS3-4	
ELA Companion Standards: RST.11-12.1 WHST.9-12.2 WHST.9-12.5 WHST.9-12.7 WHST.11-12.8 WHST.9-12.9 SL.11-12.5	
Content Statements:	
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.
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.
3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
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.
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.
6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Big Idea: : Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable. It takes energy to change the motion of objects. The energy change is understood in terms of forces.

Unit Essential Questions:	Unit Enduring Understandings:
• How would the universe be different if the laws of motion were suspended? • What would are lives be without friction? • What is the most important variable when determining the motion of an object? • How useful is the understanding of projectile motion to someone who is a solider? • Why should doctors care about vectors? • If you were lost in the woods, how could your knowledge of vectors be useful? • How can understanding various physical properties about motion be useful in understanding everyday occurrences? • How can an athlete in your sport improve their performance using one of Newton's three laws of motion? • What variables can you manipulate to affect the movement of objects?	• Net forces cause change in motion. • Objects in motion stay in motion • Students should understand the principles of mechanics to sharpen their intuition of nature. • Students should relate imbalance of force to change of motion.

Unit Learning Targets
Students will…

- Describe motion in terms of reference
- Calculate displacement and velocity
- Construct and interpret velocity graphs
- Describe motion in terms of acceleration
- Compare graphical representations of accelerating objects
- Apply kinematic equations
- Calculate motion of a falling object
- Distinguish between scalar and vector
- Apply Pythagorean Theorem to calculate magnitude of a vector
- Resolve vectors into components

- Add vectors
- Recognize examples of projectile motion
- Describe path of parabola
- Solve problems involving relative velocity
- Describe how force affects the motion of an object
- Describe an object’s acceleration in terms of mass and force
- Identify action-reaction pairs
- Describe everyday forces

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models.

▪Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data 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.(HS-PS2-5)

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.(HS-PS2-1)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 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. (HS-PS2-2), (HS-PS2-4)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

▪ Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

▪ Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

▪The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.(secondary to HS-PS2-6)

PS2.A: Forces and Motion

▪Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)
▪Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)
▪If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2), (HS-PS2-3)

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.(HS-PS2-4)
▪Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4), (HS-PS2-5)
▪Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),*(secondary to HS-PS1-1),(secondary to HS-PS1-3)*

PS3.A: Definitions of Energy

▪ "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary to HS-PS2-5)*

ETS1.A: Defining and Delimiting Engineering Problems

▪ Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS2-3)*

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 to HS-PS2-3)*

Crosscutting Concepts

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. (HS-PS2-4)

Cause and Effect

▪Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.(HS-PS2-1), (HS-PS2-5)
▪Systems can be designed to cause a desired effect. (HS-PS2-3)

Systems and System Models

▪When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

Structure and Function
▪Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.(HS-PS2-6)

Connections to Nature of Science
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
▪Theories and laws provide explanations in science.(HS-PS2-1), (HS-PS2-4)
▪Laws are statements or descriptions of the relationships among observable phenomena.(HS-PS2-1), (HS-PS2-4)

Evidence of Learning

Summative Assessment: Labs, Unit Test

Formative Assessments:

- Quizzes
- Chapter Tests
- Take home assignments

Lesson Plans

Activities/Interdisciplinary Connections	*Timeframe*
Advance Learners • Egg drop • Track lab • Vector lab • Field goal vector lab BSI/SE/ELL • Make a poster about vectors • Time interval freefall lab • Ramp lab	Weeks 1-12
Teacher Resources	*Teacher Note*
• McGraw/Hill Physics • Lab Materials • Technology Tools -Google Classroom -Seesaw -Pear Deck -BrainPOP -Book Creator -FlipGrid	

-Kahoot -Kami	

Differentiating Instruction:
Students with Disabilities, English Language Learners, and Gifted & Talented Students

Examples of Strategies and Practices that Support Students with Disabilities:
• Use of visual and multisensory formats
• Use of assisted technology
• Use of prompts
• Modification of content and student products
• Testing accommodations
• Authentic assessments

Examples of Strategies and Practices that Support Gifted & Talented Students:
• Adjusting the pace of lessons
• Curriculum compacting
• Inquiry-based instruction
• Independent study
• Higher-order thinking skills
• Interest-based content
• Student-driven instruction
• Real-world problems and scenarios

Examples of Strategies and Practices that Support English Language Learners:
• Pre-teaching of vocabulary and concepts
• Visual learning, including graphic organizers
• Use of cognates to increase comprehension
• Teacher modeling
• Pairing students with beginning English language skills with students who have more advanced English language skills
• Scaffolding
•Word walls
•Sentence frames
•Think-pair-share
•Cooperative learning groups

Physics Grades 11-12 Unit 2

Unit Title: Energy and Motion	
Unit Summary: Introduce work and show calculations of work done in a variety of situations. To identify and show calculations using various energy equations. To explore the conditions necessary for conservation of mechanical energy. Introduce the relationships between work, time, power, force, and speed. Define momentum in terms of mass and velocity, introduce the concept of impulse. Explore the law of conservation of momentum. Distinguish between various types of collisions. Introduce circular motion. Examine gravitational force. Explain torque and simple machines.	
Primary Interdisciplinary Connections: Mathematics, Civics, Business, History, Philosophy	
Career Readiness, Life Literacies, and Key Skills: 9.1.12.CFR.2 9.1.12.CFR.3 9.1.12.CFR.4 9.1.12.CFR.6 9.2.12.CAP.1 9.2.12.CAP.2 9.2.12.CAP.3 9.2.12.CAP.4 9.2.12.CAP.5 9.2.12.CAP.6 9.2.12.CAP.7 9.2.12.CAP.8 9.4.12.CI.1 9.4.12.CI.2 9.4.12.CI.3 9.4.12.CT.1 9.4.12.CT.2 9.4.12.CT.3 9.4.12.CT.4 9.4.12.DC.7 9.4.12.DC.8	
Learning Targets	
NJSLS Standards: HS-PS2-1. HS-PS2-2. HS-PS2-3. HS-PS2-4. HS-PS3-1. HS-PS3-2. HS-PS3-3. HS-PS3-4. HS-PS3-5. HS-PS2-6.	
Computer Science and Design Thinking Standards: 8.2.12.ED.1 8.2.12.ED.4 8.2.12.ED.5 8.2.12.ED.6 8.2.12.ITH.1 8.2.12.ITH.2 8.2.12.ITH.3 8.2.12.NT.1 8.2.12.NT.2 8.2.12.ETW.1 8.2.12.ETW.2 8.2.12.ETW.3	
Climate Change Standards: HS-ESS3-1 HS-ESS3-2 HS-ESS3-3 HS-ESS3-4	
ELA Companion Standards: RST.11-12.1 WHST.9-12.2 WHST.9-12.5 WHST.9-12.7 WHST.11-12.8 WHST.9-12.9 SL.11-12.5	
Content Statements:	
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.
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.
3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
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.
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.
6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
7	Plan and conduct an investigation to provide evidence that the transfer of thermal energy

	when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
8	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.
9	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 position of particles (objects).
10	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
11	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.

Big Idea: : Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable. It takes energy to change the motion of objects. The energy change is understood in terms of forces.

Unit Essential Questions:	**Unit Enduring Understandings:**
• How many amusement park rides do not use the principles of circular motion? • If you had fulcrum and a lever long enough, could you change the world? • How do we know things have energy? • How do you know something has energy? • In what ways do we witness the effects of something having energy? • What limits the efficiency of a car engine?	• Angular measurement is useful in modeling circular motion. • Centripetal motion is cause by a centripetal force. • A net torque of zero produces no motion. • We observe the effects of energy. • Energy is transformed from one form to another during changes in matter. • The amount of energy before a transformation is equal to the amount of energy after the transformation.

Unit Learning Targets
Students will…

- Define work by relating it to force and displacement
- Calculate net work
- Identify several forms of energy
- Calculate kinetic energy
- Distinguish between kinetic and potential energy
- Classify different types of potential energy
- Identify situations in which conservation of mechanical energy is valid
- Solve problems involving conservation of energy

- Calculate power
- Compare momentum of moving objects
- Describe change in momentum in terms of force and time
- Describe change in momentum in terms of conservation of momentum
- Identify different types of collisions
- Determine changes in momentum and energy during a collision
- Solve problems involving centripetal acceleration and centripetal force

Science and Engineering Practices

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. (HS-PS3-2), (HS-PS3-5)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data 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. (HS-PS3-4)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 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.

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)

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. (HS-PS3-1), (HS-PS3-2)
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light,

and thermal energy. (HS-PS3-2) (HS-PS3-3)

- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

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. (HS-PS3-1)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4)
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
- The availability of energy limits what can occur in any system. (HS-PS3-1)
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

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. (HS-PS3-5)

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. (HS-PS3-3), (HS-PS3-4)

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS3-3)*

Crosscutting Concepts

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. (HS-PS3-5)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
- 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. (HS-PS3-1)

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. (HS-PS3-3)

▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

Connections to Engineering, Technology, and Applications of Science
Influence of Science, Engineering, and Technology on Society and the Natural World
▪ Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

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. (HS-PS3-1)

Evidence of Learning

Summative Assessment: Labs, Unit Test

Formative Assessments:

- Quizzes
- Chapter Tests
- Take home assignments

Lesson Plans

Activities/Interdisciplinary Connections	*Timeframe*
Advance Learners • Egg drop • Track lab • Vector lab • Field goal vector lab BSI/SE/ELL • Make a poster about vectors • Time interval freefall lab • Ramp lab	Weeks 13-28
Teacher Resources	*Teacher Note*
• McGraw/Hill Physics • Lab Materials • Technology Tools -Google Classroom -Seesaw	

-Pear Deck -BrainPOP -Book Creator -FlipGrid -Kahoot -Kami	

Differentiating Instruction:
Students with Disabilities, English Language Learners,
and Gifted & Talented Students

Examples of Strategies and Practices that Support Students with Disabilities:
• Use of visual and multisensory formats
• Use of assisted technology
• Use of prompts
• Modification of content and student products
• Testing accommodations
• Authentic assessments

Examples of Strategies and Practices that Support Gifted & Talented Students:
• Adjusting the pace of lessons
• Curriculum compacting
• Inquiry-based instruction
• Independent study
• Higher-order thinking skills
• Interest-based content
• Student-driven instruction
• Real-world problems and scenarios

Examples of Strategies and Practices that Support English Language Learners:
• Pre-teaching of vocabulary and concepts
• Visual learning, including graphic organizers
• Use of cognates to increase comprehension
• Teacher modeling
• Pairing students with beginning English language skills with students who have more advanced English language skills
• Scaffolding
•Word walls
•Sentence frames
•Think-pair-share
•Cooperative learning groups

Physics Grades 11-12 Unit 3

Unit Title: Waves and Their Applications in Technologies for Information	
Unit Summary: Introduce simple harmonic motion. Identify parts and characteristics of waves. Explain superposition of waves. Explain how sound waves are produced. Explain the Doppler effect. Calculate intensity. Introduce Standing Waves and explain music. Identify components of the electromagnetic spectrum. Apply laws of reflection. Explain how lenses change the path of light. Investigate color. Investigate refraction. Describe lasers.	
Primary Interdisciplinary Connections: Mathematics, Civics, Business, History, Philosophy	
Career Readiness, Life Literacies, and Key Skills: 9.1.12.CFR.2 9.1.12.CFR.3 9.1.12.CFR.4 9.1.12.CFR.6 9.2.12.CAP.1 9.2.12.CAP.2 9.2.12.CAP.3 9.2.12.CAP.4 9.2.12.CAP.5 9.2.12.CAP.6 9.2.12.CAP.7 9.2.12.CAP.8 9.4.12.CI.1 9.4.12.CI.2 9.4.12.CI.3 9.4.12.CT.1 9.4.12.CT.2 9.4.12.CT.3 9.4.12.CT.4 9.4.12.DC.7 9.4.12.DC.8	
Learning Targets	
NJSLS Standards: HS-PS4-1. HS-PS4-2. HS-PS4-3. HS-PS4-4. HS-PS4-5.	
Computer Science and Design Thinking Standards: 8.2.12.ED.1 8.2.12.ED.4 8.2.12.ED.5 8.2.12.ED.6 8.2.12.ITH.1 8.2.12.ITH.2 8.2.12.ITH.3 8.2.12.NT.1 8.2.12.NT.2 8.2.12.ETW.1 8.2.12.ETW.2 8.2.12.ETW.3	
Climate Change Standards: HS-ESS3-1 HS-ESS3-2 HS-ESS3-3 HS-ESS3-4	
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Content Statements:	
1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
2	Evaluate questions about the advantages of using a digital transmission and storage of information.
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.
4	Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
5	Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
Big Idea: : Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable. The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another. It takes energy to change the motion of objects. The energy change is understood in terms of forces.	

Unit Essential Questions:	**Unit Enduring Understandings:**
• How do waves interact? • Where do waves come from? • How do you know that waves carry energy? • How does the knowledge of waves help us understand our world better and improve the quality of our lives? • What causes tsunamis? • What do people's eye prescriptions really mean? • How do the properties of EM waves determine their uses? • What determines the colors you see in nature? • Why are optical fibers preferred over electrical cables to send information? • What limits the amount of data storage on an optical disk and why are lasers used to read them? • Why has the world gone digital?	• Wave motion is periodical. • Wave behavior can described in terms of how fast the disturbance spread in terms of distance between peaks. • Waves can super impose on each other. • Light can travel in a straight line, be refracted, or reflected. • The path of light can be predicted geometrically. • Image properties can be quantified. • Color depends on wavelength. • Light interference patterns are evidence of wave nature of light. • Understand the mechanism by which different waves transfer energy. • Visible light is part of a larger family of radiation known as the electromagnetic spectrum. • White light consists of a continuous spectrum of colors that can be reflected, transmitted or absorbed by different materials. • Light has both a particle and wave nature.

Unit Learning Targets
Students will…

- Define work by relating it to force and displacement
- Calculate net work
- Identify several forms of energy
- Calculate kinetic energy
- Distinguish between kinetic and potential energy
- Classify different types of potential energy
- Identify situations in which conservation of mechanical energy is valid
- Solve problems involving conservation of energy
- Calculate power
- Compare momentum of moving objects
- Describe change in momentum in terms of force and time
- Describe change in momentum in terms of conservation of momentum
- Identify different types of collisions
- Determine changes in momentum and energy during a collision
- Solve problems involving centripetal acceleration and centripetal force

Evidence of Learning

Summative Assessment: Labs, Unit Test

Formative Assessments:

- Quizzes
- Chapter Tests
- Take home assignments

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at 9–12 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. (HS-PS4-1)

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. (HS-PS4-3)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4)
- Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5)

Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes

- Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. *(secondary to HS-PS4-5)*

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. (HS-PS4-1)
- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2), (HS-PS4-5)
- 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.) (HS-PS4-3)

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. (HS-PS4-3)
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4)
- Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)

PS4.C: Information Technologies and Instrumentation
- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)

Crosscutting Concepts

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)
- 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. (HS-PS4-4)
- Systems can be designed to cause a desired effect. (HS-PS4-5)

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. (HS-PS4-3)

Stability and Change
- Systems can be designed for greater or lesser stability. (HS-PS4-2)

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). (HS-PS4-5)

Influence of Engineering, Technology, and Science on Society and the Natural World
- Modern civilization depends on major technological systems. (HS-PS4-2), (HS-PS4-5)

▪ Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

▪ A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)

Lesson Plans

Activities/Interdisciplinary Connections	*Timeframe*
Advance Learners • Egg drop • Track lab • Vector lab • Field goal vector lab BSI/SE/ELL • Make a poster about vectors • Time interval freefall lab • Ramp lab	Weeks 29-38
Teacher Resources	*Teacher Note*
• McGraw/Hill Physics • Lab Materials • Technology Tools -Google Classroom -Seesaw -Pear Deck -BrainPOP -Book Creator -FlipGrid -Kahoot -Kami	

Differentiating Instruction:
Students with Disabilities, English Language Learners, and Gifted & Talented Students

Examples of Strategies and Practices that Support Students with Disabilities:
• Use of visual and multisensory formats
• Use of assisted technology
• Use of prompts
• Modification of content and student products
• Testing accommodations
• Authentic assessments

Examples of Strategies and Practices that Support Gifted & Talented Students:
• Adjusting the pace of lessons
• Curriculum compacting
• Inquiry-based instruction
• Independent study
• Higher-order thinking skills
• Interest-based content
• Student-driven instruction
• Real-world problems and scenarios

Examples of Strategies and Practices that Support English Language Learners:
• Pre-teaching of vocabulary and concepts
• Visual learning, including graphic organizers
• Use of cognates to increase comprehension
• Teacher modeling
• Pairing students with beginning English language skills with students who have more advanced English language skills
• Scaffolding
•Word walls
•Sentence frames
•Think-pair-share
•Cooperative learning groups