PUBLIC SCHOOLS OF EDISON TOWNSHIP

OFFICE OF CURRICULUM AND INSTRUCTION

AP Physics 1

Length of Course:	Term
Elective/Required:	Elective
Schools:	High Schools
Eligibility:	Grade 11-12
Credit Value:	6 Credits
Date Approved:	September 24, 2018 (Curriculum)
	August 17, 2021 (Credit Value)

TABLE OF CONTENTS

Modifications will be made to accommodate IEP mandates for classified students.

STATEMENT OF PURPOSE

The AP Physics 1 curriculum was written in accordance to College Board requirements. The course is designed to be the equivalent of the first semester college algebra-based physics course.

The course covers Newtonian mechanics (including rotational dynamics and angular momentum); work, energy, and power; and mechanical waves and sound. It will also introduce electric circuits. The course is focused on a series of learning objectives that clarify the knowledge and skills students should demonstrate to qualify for college credit and placement. Each learning objective combines physics content with one or more of seven foundational science practices.

- The student can use representations and models to communicate scientific phenomena and solve scientific problems.
- The student can use mathematics appropriately.
- The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
- The student can plan and implement data collection strategies in relation to a particular scientific question.
- The student can perform data analysis and evaluation of evidence.
- The student can work with scientific explanations and theories.
- The student is able to connect and relate knowledge across various scales, concepts and representations in and across domains.)

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Course Objectives

By the end of the AP Physics 1 course, students will be able to:

- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/HS-PS2-6)** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
- **(NJSLS/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.
- **(NJSLS/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 position of particles (objects).
- **(NJSLS/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.
- **(NJSLS/HS-PS3-4)** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Course Objectives (cont.)

- **(NJSLS/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.

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

- **(NJSLS/HS-PS4-2)** Evaluate questions about the advantages of using a digital transmission and storage of information.

Engineering Design

- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/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

Timeline

First Quarter Units – 1 & 2

Unit 1: Kinematics

- <u>1D Motion</u>
  Reference Frames and Displacement
  Average and Instantaneous Velocity
  Acceleration
  Free-Fall Acceleration
- <u>2D Motion</u>
  Projectile motion

Unit 2: Dynamics

- Forces
  Contact Forces
  Field Forces
  Free Body diagrams
- Newton's 3 Laws
- 1D Motion
- 2 D Motion

Second Quarter Units – 3 & 4

Unit 3: Work and Energy

- Work done by Constant Force
- Work done by Varying force
- Kinetic Energy
- Work done by Kinetic Energy
- Potential Energy
- Work done by Potential Energy
- Conservative and Non-Conservative
- Conservation of Mechanical Energy
- Power

Unit 4: Momentum

- Momentum and Its Relation to Force
- Conservation of Momentum
- Collisions and Impulse
- Elastic collisions in One Dimension
- Inelastic Collisions
- Collisions in Two Dimensions

Third Quarter Units- Units 5, 6 & 7

Unit 5: Circular Motion and Gravitations

- <u>Kinematics of Circular Motion</u>
- <u>Dynamics of Circular Motion</u>
  Horizontal
  Vertical

Banked Curves

- Planetary Motion
  Newton's Law of Universal Gravitation
  Gravity Near the Earth's Surface
  Satellites and "Weightlessness"
- Kepler's Laws

Unit 6: Rotational Motion

- Rotational Kinematics
- Rolling Motion (Without Slipping
- Rotational Dynamics
- Static Equilibrium
- Rotational Kinetic Energy
- Angular Momentum and Its Conservation

Unit 7: Simple Harmonic Motion, Simple Pendulum and Mass-Spring System

- Simple Harmonic Motion-Springs
- Energy in SHM
- Period and Sinusoidal Nature of SHM
- The Simple Pendulum
- Damped Harmonic Motion

Fourth Quarter Units – Units 8 & 9

Unit 8: Mechanical Waves and Sound

- Properties of Mechanical Waves
- Relationships between medium, frequency, wavelength, speed
- Harmonics, string and wind instruments

Unit 9: Electric Forces and DC Circuits

- Coulomb's Law
- Electric Field
- Resistance
- DC Circuits

Unit of Study: 1 Kinematics	Pacing: 5 weeks

Essential Questions: How do we describe the motion of objects? How do we create mathematical models that represent the motion of objects and use mathematical models to predict the motion of objects? How is a vector represented and what are some of its applications? How can vectors be manipulated mathematically? How does motion in the vertical direction affect motion in the horizontal direction? What situations require relative motion analysis?

Big Idea:

1. Objects and systems have properties such as mass and charge. Systems may have internal structure.
2. Fields existing in space can be used to explain interactions.
3. The interactions of an object with other objects can be described by forces.

NGSS Performance Expectations: (Students who demonstrate understanding can:)

NJSLS/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.

NJSLS/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.

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

Unit Assessment: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

- Quarterly exam
- labs,
- activities
- summative assessments

ELA/ Literacy

WHST.9-12.7 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-LS1-3)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

(HS-LS1-3)SL.11-12.5 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-LS1-2)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)

Math

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-5)

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

CRP11. Use technology to enhance productivity.

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies** **Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
PS2.A: Forces and Motion • Given a graph of position or velocity as a function of time, recognize in what time intervals the position, velocity and acceleration of an object are positive, negative, or zero and sketch a graph of each quantity as a function of time. • Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.	**Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Systems can be designed to cause a desired effect**.	• Velocity of a Nonaccelerating Object • What's Your Reaction Time: • Initial Velocity of a Popper Toy • Horizontally Launched Projectile Challenge • Initial Velocity of a Toy Dart Launched at an angle • Acceleration Due to Gravity • Chapter 2,3 Giancoli textbook problems • AP practice problems • Interdisciplinary connection problems • Diagnostic pre- and post- assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback.	(What is the authentic evidence that students have achieved the targeted standards/unit objectives? Formative, Summative and Performance Based) **<u>Formative Assessments</u>**: Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **<u>Summative Assessments</u>:** Quizzes, Tests. **<u>Performance Assessments/Laboratory Investigations</u>:** Research/Lab Reports

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. **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 (tradeoffs) may be needed. **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take	mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena to describe explanations. **Constructing Explanations and Designing Solutions** • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. • Design a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. • Evaluate a	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. **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 Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**		

into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	• Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena.		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Links to Best Practices Chapter 2,3 Giancoli Phet labs Cenco AP Labs	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings

Unit of Study: 2 Dynamics				Pacing: 5 weeks
Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**

PS2.A: Forces and Motion • Newton's second law accurately predicts changes in the motion of macroscopic objects. • Represent and describe the two types of forces that a surface can exert on an object - a normal force, and a friction force parallel to the surface and dependent on the normal force and textures of the two surfaces. • Use Newton's Second Law along with the mathematical relationship among friction force and normal force to predict unknown quantities involving one-dimensional motion with constant velocity and one-dimensional motion with constant acceleration. • Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. • Understand and apply the relationship	**Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena to describe explanations. **Constructing Explanations and Designing Solutions** • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. • Design a solution to a complex real world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and tradeoff consideration. • Evaluate a solution to a complex real world	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. **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. **Scale, Proportion, and Quantity** • Algebraic thinking is used to examine scientific data and predict the effect of a change in one		• Inertial Mass • Atwood's Machine • Weight Versus Mass • The Friction Coefficient of your block • Hooke's Law • Terminal Velocity • Friction on a Ramp • Atwood's Machine • Chapter 4 Giancoli textbook problems • AP practice problems • Interdisciplinary connection problems • Diagnostic pre- and post- assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback.	**Formative Assessments**: Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **Summative Assessments**: Quizzes, Tests. **Performance Assessments/Laboratory Investigations:** Research/Lab Reports

between the net force exerted on an object, its inertial mass, and its acceleration to a variety of situations. **PS2.B: Types of Interactions** • Generated sources of evidence, prioritized criteria, and tradeoff considerations. **Using Mathematical and Computational Thinking** • Use computational representations of phenomena to describe explanations.	problem, based on scientific knowledge, student- growth vs. exponential growth).	variable on another (e.g., linear descriptions of the relationships among observable phenomena. **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 Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**		

		• Theories and laws provide explanations in science. • Laws are statements or explanations in science. • Laws are statements or		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 4 Giancoli Phet labs Cenco AP Labs	Instructional Adjustments: Modifications, student difficulties, possible misunderstandings
Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force Assessment Boundary: For Newton's Second Law of Motion Assessment is limited to macroscopic objects moving at non- relativistic speed and non-calculous based problem solving.	

Unit of Study: Unit 3 – Work and Energy	**Pacing: 4 weeks**

Essential Questions: How are humans dependent upon transformations of energy? If you hold an object while you walk at a constant velocity, are you doing work on the object? Why or why not? What factors affect the collision of two objects, and how can you determine whether the collision is elastic or inelastic? How is the energy of a system defined? How is work represented graphically? What is mechanical energy and what factors affect its conservation?

Big Ideas:

3. The interactions of an object with other objects can be described by forces.
4. Interactions between systems can result in changes in those systems.
5. Changes that occur as a result of interactions are constrained by conservation laws.

NGSS Performance Expectations: (Students who demonstrate understanding can:)

NJSLS/**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.**

NJSLS/**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 position of particles (objects).**

NJSLS/**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.**

ELA/Literacy –

RST.11-12.1 WHST.9-12.7 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-PS3-4)

WHST.11-12.8 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-PS3-3), (HS-PS3-4),(HS-PS3-5)

WHST.9-12.9 SL.11-12.5 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience;

integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5) Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4),(HS-PS3-5)

Mathematics –

MP.2 MP.4 HSN-Q.A.1 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1),(HS-PS3-2),(HS-PS3-5)

HSN-Q.A.2 HSN-Q.A.3 Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5) Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5) 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-PS3-1),(HS-PS3-3) Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3) Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11. Use technology to enhance productivity.
CRP12. Work productively in teams while using cultural global competence.

Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**

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	**Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena to describe explanations. • Constructing Explanations and Designing Solutions • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. • Design a solution to a complex real world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and tradeoff	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. **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. **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	Activity: Understanding Work – use a variety of everyday situations to develop an understanding of the concepts of work and energy Activity: Angles and Work – utilize everyday situations to develop a method of determining work done at an angle Activity: Types of Energy – develop terminology based on everyday situations to describe different types of energy Activity: Representing Work/Energy – use a variety of methods to represent Work/Energy and the concept of conservation (verbal, pictorial, graphical, mathematical) Class Activity: Conservation of Energy – provide examples of situations where energy is conserved, but due to assumptions it does not remain constant for the system Lab: Determining Power – develop an understanding of what power represents by allowing students to develop a lab in which they determine the power of a	**Formative Assessments**: Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **Summative Assessments**: Quizzes, Tests. **Performance Assessments/Laboratory Investigations:** Research/Lab Reports

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	considerations. • Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Using Mathematical and Computational Thinking** • Use mathematical or computational representations of phenomena to describe explanations.	growth). **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 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	system Lab: Elastic and Inelastic Collisions Lab Textbook: Giancoli Chapter 6 Activity: Individual/Group Problem Solving (textbook, AP practice problems, problems involving interdisciplinary connections)	

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 **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		phenomena.		

them. (secondary to HS-PS3-3)				

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 6 Giancoli Phet labs Cenco AP Labs	Instructional Adjustments: Modifications, student difficulties, possible misunderstandings
Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary 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. 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 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. Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.	

Unit of Study: Unit 3 – Work and Energy	**Pacing: 2-3 weeks**

Essential Questions: How are humans dependent upon transformations of energy? If you hold an object while you walk at a constant velocity, are you doing work on the object? Why or why not? What factors affect the collision of two objects, and how can you determine whether the collision is elastic or inelastic? How is the energy of a system defined? How is work represented graphically? What is mechanical energy and what factors affect its conservation?

Big Ideas:

3. The interactions of an object with other objects can be described by forces.
4. Interactions between systems can result in changes in those systems.
5. Changes that occur as a result of interactions are constrained by conservation laws.

NGSS Performance Expectations: (Students who demonstrate understanding can:)

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

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

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS3-4)

WHST.9-12.7 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-PS3-3), (HS-PS3-4),(HS-PS3-5)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4),(HS-PS3-5)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1),(HS-PS3-2),(HS-PS3-5)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)

MP.4 Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1),(HS-PS3-3)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11. Use technology to enhance productivity.
CRP12. Work productively in teams while using cultural global competence.

UNIT 3: WORK AND ENERGY

Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
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	**Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena to describe explanations. **Constructing Explanations and Designing Solutions** • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. • Design a solution to a complex real world problem, based on scientific knowledge, student- generated	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in	Activity: Understanding Work – use a variety of everyday situations to develop an understanding of the concepts of work and energy Activity: Angles and Work – utilize everyday situations to develop a method of determining work done at an angle Activity: Types of Energy – develop terminology based on everyday situations to describe different types of energy Activity: Representing Work/Energy – use a variety of methods to represent Work/Energy and the concept of conservation (verbal, pictorial, graphical, mathematical) Class Activity: Conservation of Energy – provide examples of situations where energy is conserved, but due to assumptions it does not remain constant for the system Lab: Determining Power –	**<u>Formative Assessments</u>**: Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **<u>Summative Assessments</u>:** Quizzes, Tests. **<u>Performance Assessments/Laboratory Investigations</u>**: Research/Lab Reports

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	sources of evidence, prioritized criteria, and tradeoff considerations. • Evaluate a solution to a complex real world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and tradeoff considerations. **Using Mathematical and Computational Thinking** • Use mathematical or computational representations of phenomena to describe explanations.	explanations of phenomena. **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** **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**	develop an understanding of what power represents by allowing students to develop a lab in which they determine the power of a system Lab: Elastic and Inelastic Collisions Lab Textbook: Giancoli Chapter 6 Activity: Individual/Group Problem Solving (textbook, AP practice problems, problems involving interdisciplinary connections)	

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 **ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk		**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.		

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)				

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 6 Giancoli Phet labs Cenco AP Labs	Instructional Adjustments: Modifications, student difficulties, possible misunderstandings

Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary 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. 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 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. Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.

Unit of Study: Unit 4 Momentum	Pacing: 2-3 weeks

Essential Questions:

- What role does Newton's third law play in the conceptual and mathematical understanding of impulses and momentum?
- How is the impulse and momentum demonstrated by air bags in cars, thick-soled running shoes, and knee bending during a landing?
- How are collisions determined to be elastic or inelastic?
- How does a ballistic pendulum demonstrate both the conservation of energy and momentum?

Big Idea:

3. The interactions of an object with other objects can be described by forces
4. Interactions between systems can result in changes in those systems.
5. Changes that occur as a result of interactions are constrained by conservation laws.

NGSS Performance Expectations: (Students who demonstrate understanding can:)

NJSLS/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.

NJSLS/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.

NJSLS/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 position of particles (objects).

NJSLS/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.

NJSLS/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.

NJSLS/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.

NJSLS/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.

ELA/Literacy –

RST.11-12.1 WHST.9-12.7 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-PS3-4)

WHST.11-12.8 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-PS3-3), (HS-PS3-4),(HS-PS3-5)

WHST.9-12.9 SL.11-12.5 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5) Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4),(HS-PS3-5)

Mathematics –

MP.2 MP.4 HSN-Q.A.1 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1),(HS-PS3-2),(HS-PS3-5)

HSN-Q.A.2 HSN-Q.A.3 Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5) Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5) 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-PS3-1),(HS-PS3-3) Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3) Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP11. Use technology to enhance productivity. CRP12. Work productively in teams while using cultural global competence.

UNIT 4: Momentum

Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**

PS2.A: Forces and Motion • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • Predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. • 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	**Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Create a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical models and/or computer simulations	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system	• Impulse and Momentum • Conservation of Momentum in Collisions • Conservation of Momentum – Ballistic Pendulum • Chapter 7 Giancoli textbook problems • AP practice problems • Interdisciplinary connection problems	Formative, Summative and Performance Based) **Formative Assessments:** Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **Summative Assessments:** Quizzes, Tests. **Performance Assessments/Laborat**

outside the system. **PS2.B: Types of Interactions** • 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** • 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	to predict the effects of a design solution on systems and/or the interactions between systems. **Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Constructing Explanations and Designing Solutions** • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. • Design a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. • Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and	• 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. • 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. 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. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. **Connections to Engineering, Technology, and Applications of Science Influence of Science,**	• Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback.	**ory Investigations:** Research/Lab Reports

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. **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.	tradeoff considerations. **Developing and Using Models** • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. **Asking Questions and Defining Problems** • Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**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. • 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 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 constant		

ETS1.A: Defining and Delimiting Engineering Problems • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. **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 (tradeoffs) may be needed. **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. • 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.				

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 7 Giancoli Phet labs Cenco AP Labs	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings
Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. 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. 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. Emphasis is on explaining the meaning of mathematical expressions used in the model. 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. 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: Momentum assessment is limited to systems of two macroscopic bodies moving in one dimension. Momentum assessment is limited to qualitative evaluations and/or algebraic manipulations. 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. Assessment is limited to algebraic relationships and describing those relationships qualitatively.

Unit of Study: 5 Circular Motion and Gravitations	Pacing: 3-4 weeks

Essential Questions: ▼ Why do you stay in your seat on a roller coaster when it goes upside down in a vertical loop? ▼ How is the motion of a falling apple similar to that of the moon in orbit around the Earth? ▼ What conditions are necessary for a planet to obtain a circular orbit around its host star? ▼ How can Newton's second law of motion be related to the universal law of gravitation? ▼ How can the motion of the center of mass of a system be altered?

Big Idea:
1. Objects and systems have properties such as mass and charge. Systems may have internal structure
2. Fields existing in space can be used to explain interactions.
3. The interactions of an object with other objects can be described by forces
4. Interactions between systems can result in changes in those systems.

NGSS Performance Expectations: (Students who demonstrate understanding can:)

NJSLS/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.

NJSLS/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.

NJSLS/HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

NJSLS/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.

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

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11. Use technology to enhance productivity.
CRP12. Work productively in teams while using cultural global competence.

UNIT 5: Circular Motion and Gravitation

Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**

PS2.A: Forces and Motion • Newton's second law accurately predicts changes in the motion of macroscopic objects. • Represent and describe the two types of forces that a surface can exert on an object - a normal force, and a friction force parallel to the surface and dependent on the normal force and textures of the two surfaces. • Use Newton's Second Law along with the mathematical relationship among friction force and normal force to predict unknown quantities involving one-dimensional motion with constant velocity and one-dimensional motion with constant acceleration. • Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. • Understand and apply the relationship	**Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena to describe explanations. **Constructing Explanations and Designing Solutions** • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. • Design a solution to a complex real world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and tradeoff considerations. • Evaluate a solution to a complex real world problem, based on	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. **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. **Scale, Proportion, and Quantity** • Algebraic thinking is used to examine scientific data	**<u>Formative Assessments</u>:** Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **<u>Summative Assessments</u>**: Quizzes, Tests. **<u>Performance Assessments/Laboratory Investigations</u>:** Research/Lab Reports

between the net force exerted on an object, its inertial mass, and its acceleration to a variety of situations. **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. • Relate the period, orbital radius and speed of an object in a circular orbit, and use the model speed = $2\pi R/T$ to predict unknown quantities. ESS1.B: Earth and the Solar System Kepler's laws	scientific knowledge, student- generated sources of evidence, prioritized criteria, and tradeoff considerations. **Using Mathematical and Computational Thinking** • Use mathematical or computational representations of phenomena to describe explanations.	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** **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 Nature of Science** **Science Models, 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.		**Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter5 Giancoli Phet labs Cenco AP Labs	Instructional Adjustments: Modifications, student difficulties, possible misunderstandings
Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields. Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. Assessment Boundary: For Newton's Second Law of Motion Assessment is limited to one-dimensional motion and to macroscopic objects moving at non- relativistic speed. 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.	

Unit of Study: Unit 6 – Rotational Motion	Pacing: 1-2 weeks

Essential Questions: Can the kinematics equations be applied to rotating systems? How can Newton's law be applied to rotating systems? How does a net torque affect the angular momentum of a rotating system?

Big Ideas:

3. The interactions of an object with other objects can be described by forces.
4. Interactions between systems can result in changes in those systems.
5. Changes that occur as a result of interactions are constrained by conservation laws.

NGSS Performance Expectations: (Students who demonstrate understanding can:

NJSLS/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.

NJSLS/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

NJSLS/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.

NJSLS/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.

NJSLS/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 position of particles (objects).

NJSLS/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.

NJSLS/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.

NJSLS/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.

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

ELA/Literacy –

RST.11-12.1 WHST.9-12.7 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-PS3-4)

WHST.9-12.7 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-LS1-3)
WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
(HS-LS1-3)SL.11-12.5 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-LS1-2)
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)

WHST.11-12.8 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-PS3-3), (HS-PS3-4),(HS-PS3-5)

WHST.9-12.9 SL.11-12.5 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5) Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4),(HS-PS3-5)

Mathematics –

MP.2 MP.4 HSN-Q.A.1 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1),(HS-PS3-2),(HS-PS3-5)

HSN-Q.A.2 HSN-Q.A.3 Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5) Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5) 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-PS3-1),(HS-PS3-3) Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3) Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11. Use technology to enhance productivity.
CRP12. Work productively in teams while using cultural global competence.

UNIT: 6 Rotational Motion

Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
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;	**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	**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**	Activity: Understanding Equilibrium and Torque – utilize our understanding of linear dynamics and apply it to rotational situations Activity: Angular Kinematics – utilize our understanding of linear kinematics and apply it to rotational situations Activity: Angular Momentum – utilize our understanding of momentum and apply it to rotational situations Activity: Rotational Energy – utilize our understanding of work/energy and apply it to rotational situations Class Activity: Conservation of Angular Momentum – utilize rotating objects, such as a bicycle wheel, to demonstrate the importance of understanding angular	**Formative, Summative and Performance Based)** **<u>Formative Assessments</u>:** Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **<u>Summative Assessments</u>**: Quizzes, Tests. **<u>Performance Assessments/Laboratory Investigations</u>:** Research/Lab Reports

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	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 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	• 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) **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**	momentum Lab: Design Lab Lab: Rotating Arm/Platform Lab: Ballistic Pendulum Textbook: Giancoli Chapter 8 and Chapter 9 Activity: Individual/Group Problem Solving (textbook, AP practice problems, problems involving interdisciplinary connections)	

matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3) **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	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	• 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)		

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 **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) **ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints	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).			

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)				

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 8 Giancoli Phet labs Cenco AP Labs	**Instructional Adjustments**: Modifications, student difficulties, possible misunderstandings

Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields. Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.

Assessment Boundary: For Newton's Second Law of Motion Assessment is limited to one-dimensional motion and to macroscopic objects moving at non- relativistic speed. 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.

Unit of Study: Unit 7 – Simple Harmonic Motion, Simple Pendulum and Mass-Spring Systems	Pacing: 4 weeks

Essential Questions: What is a simple harmonic oscillator? What factors affect the period of oscillation for a mass oscillating on a spring and for a simple pendulum? How does the back-and-forth motion of a box on a spring mirror the motion of a pendulum?

Big Ideas:
3. The interactions of an object with other objects can be described by forces.
5. Changes that occur as a result of interactions are constrained by conservation laws.

NGSS Performance Expectations: (Students who demonstrate understanding can:

NJSLS/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.

NJSLS/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.

NJSLS/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.

NJSLS/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 position of particles (objects).

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS3-4)

WHST.9-12.7 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-PS3-3), (HS-PS3-4),(HS-PS3-5)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4),(HS-PS3-5)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1),(HS-PS3-2),(HS-PS3-5)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)

MP.4 Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1),(HS-PS3-3)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3)

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11. Use technology to enhance productivity.
CRP12. Work productively in teams while using cultural global competence.

Unit 7: Simple Harmonic Motion, Simple Pendulum and Mass-Spring Systems

Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies** **Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**

.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) **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)	**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)	**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—	Activity: Simple Harmonic Oscillator Activity: Pendulum Textbook: Giancoli Chapter 11 Activity: Individual/Group Problem Solving (textbook, AP practice problems, problems involving interdisciplinary connections)	Formative, Summative and Performance Based) **<u>Formative Assessments</u>:** Diagnostic pre- and post- assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **<u>Summative Assessments</u>:** Quizzes, Tests. **<u>Performance Assessments/Laboratory Investigations</u>:** Research/Lab Reports

• 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)	**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. (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).			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 11 Giancoli Phet labs Cenco AP Labs	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings

Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields. Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.

Assessment Boundary: For Newton's Second Law of Motion Assessment is limited to one-dimensional motion and to macroscopic objects moving at non- relativistic speed. 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.

Unit of Study: Unit 8 – Mechanical Waves and Sound	Pacing: 1 week

Essential Questions: How are velocity, frequency, and wavelength used to describe a wave? What factors affect how a wave is reflected? How is it possible for two waves to occupy the same space at the same time? What conditions are necessary to form a standing wave?

Big Ideas:
6. Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

NGSS Performance Expectations: (Students who demonstrate understanding can:

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

Technology

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Career Ready Practices

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11. Use technology to enhance productivity.
CRP12. Work productively in teams while using cultural global competence.

Unit 8: Mechanical Waves and Sound

Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points

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) • 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.) (HS-PS4-3)	**Asking Questions and Defining Problems** • Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2) **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. (HS-PS4-1)	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1) • 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)	Activity: Slinky Lab Finding the speed of sound in Air (Tuning Forks and Open at one end tube) Practice: Harmonics WS	Formative, Summative and Performance Based) **<u>Formative Assessments</u>**: Diagnostic pre- and post-assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **<u>Summative Assessments</u>**: Quizzes, Tests. **<u>Performance Assessments/Laboratory Investigations</u>:** Research/Lab Reports

	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)	**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)		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 12 Giancoli Phet labs Cenco AP Labs	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings
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.	

Unit of Study: Unit 9 – Electric Forces and DC Circuits (Resistors Only)	Pacing: 1 week

Essential Questions: What is the cause of static electricity? How are electric forces similar to gravitational forces? How does an electric circuit demonstrate conservation of charge? What factors affect the resistance of a wire?

Big Ideas:
1. Objects and systems have properties such as mass and charge. Systems may have internal structure.
3. The interactions of an object with other objects can be described by forces.
4. Interactions between systems can result in changes in those systems.
5. Changes that occur as a result of interactions are constrained by conservation laws.

NGSS Performance Expectations: (Students who demonstrate understanding can:

NJSLS/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.

ELA/Literacy –

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

Unit 9: Electric Forces and DC Circuits

Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points

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.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)	**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) .	**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)	Activity: Coulomb's Law Activity: Ohm's Law Activity: Simplifying circuits – Series and Parallel Lab: Determining Resistance Textbook: Giancoli Chapter 16, Chapter 18 and Chapter 19 Activity: Individual/Group Problem Solving (textbook, AP practice problems, problems involving interdisciplinary connections)	Formative, Summative and Performance Based) **Formative Assessments:** Diagnostic pre- and post- assessment, Class Discussions, Worksheets with teacher feedback, Drafts of lab reports with teacher feedback, Drafts of lab reports with teacher feedback. **Summative Assessments**: Quizzes, Tests. **Performance Assessments/ Laboratory Investigations**: Research/Lab Reports

• 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)	**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. (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)	**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)		

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)	**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).			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices Chapter 16-18 Giancoli Phet labs Cenco AP Labs	**Instructional Adjustments: Modifications**, student difficulties, possible misunderstandings

Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields:

Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.