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Advanced Placement Physics 1

Content Area: PHS Science
Grade Span: Grade 11-12
Revised by: Elana Youssef
Presented by: Jessica Pritchard
Approval date: August 2023

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COURSE OVERVIEW

Description

Advanced Placement Physics 1 is a rigorous and demanding college-level course, written in accordance with College Board requirements. It is designed for students with an interest in science, medicine, engineering, mathematics or a related field. The emphasis of the course is on in-depth understanding and analysis of concepts covered, with an extraordinary amount of home study required. Students are expected to complete a summer assignment given by the teacher. This course prepares students for one Advanced Placement Examinations in Algebra Based Physics. AP Physics 1 is a standard University level course for science and/or engineering students. The ability to understand and analyze the structure and the dynamics of the universe is emphasized. While students in Advanced Placement Physics 1 study many of the topics of Physics I and Advanced Physics, they proceed with greater independence of thought and develop a great deal more insight into the realm of physics by engaging in a more sophisticated approach to the topics under study. Assessment tools will include tests, quizzes, homework, experiment-designs, written and verbal analysis of a topic or reading, and presentations.

The student requesting AP Physics 1 must have a complete commitment to learning physics with excellent study skills and must possess a strong command of mathematics. This course is very content-heavy and requires some memorization. Primarily students need to develop the ability to apply material and will need superior analytical and critical thinking skills. It is expected that students participate during every class, and have the self-advocacy skills to ask for help when they do not understand. College-level expectations and rigor are maintained throughout the course. Students will engage both in college level concepts and experimentation.

Goals

This course ordinarily forms the first part of the college sequence that serves as the foundation in physics for students majoring in the physical sciences or engineering. The course is parallel to or preceded by Algebra II or Algebra II Honors. Methods of Algebra are used wherever appropriate in formulating physical principles and in applying them to physical problems. The sequence is more intensive and analytic than that in the Physics 1 course. Strong emphasis is placed on solving a variety of challenging problems, some requiring algebra.

Each learning objective combines physics content with one or more of seven foundational science practices:

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

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

Physical Science

- **(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).
- **(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

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

Reading Science and Technical Subjects

- **RST.11-12.1:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
- **RST.11-12.7:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

- **RST.11-12.8.:** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information
- **RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Writing History, Science and Technical Subjects

- **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.
- **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.
- **WHST.9-12.9:** Draw evidence from informational texts to support analysis, reflection, and research.

Speaking and Listening (Comprehension and Collaboration)

- **SL.11-12.5: Initiate and participate effectively in a range of collaborative discussions (one-on- one, in groups, and teacher-led) with peers on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.**
    - Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well reasoned exchange of ideas.
    - Collaborate with peers to promote civil, democratic discussions and decision-making, set clear goals and assessments (e.g. student developed rubrics), and establish individual roles as needed.
    - Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.
    - Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. SL.11-12.2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

Mathematical Practice

- **MP.2:** Reason abstractly and quantitatively.
- **MP.4:** Model with mathematics.

Number and Quantity

- **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling.
- **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities

Scope and Sequence		
Unit	**Topic**	**Length**
1	Kinematics	5 weeks
2	Dynamics	5 weeks
3	Circular Motion and Gravitations	3-4 weeks
4	Energy	4 weeks
5	Momentum	2-3 weeks
6	Simple Harmonic Motion	4 weeks
7	Torque and Rotational Motion	1-2 weeks

Resources	
Core Text: Course Title: AP Physics 1 Textbook or Software Title: College Physics for the AP® Physics 1 Course Author or Editor: Gay Stewart; Roger A. Freedman; Todd Ruskell; Philip R. Kesten Publisher: Bedford, Freeman, and Worth Copyright Date: 2019 Latest revision date: 2019	**Suggested Resources:** ● Schoology ● AP Classroom ● WebAssign ● Albert io.

UNIT 1: Kinematics

Summary and Rationale
The Kinematics Unit will introduce the study of motion, the focus will be on: 1D Motion as it applies to reference frames, displacement average, instantaneous velocity acceleration, and free -fall acceleration. It will also discuss 2D motion as it applies to projectile motion. The big ideas of this unit include: 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.
Recommended Pacing
5 Weeks
State Standards

Science Standards (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.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
Companion Standards	
Reading Science and Technical Subjects	RST.11-12.1 RST.11-12.7 RST.11-12.8 RST.11-12.9
Writing History, Science and Technical Subjects	WHST.9-12.7 WHST.11-12.8 WHST.9-12.9
Speaking and Listening	SL.11-12.5
Mathematical Practice	MP.2 MP.4
Number and Quantity	HSN-Q.A.1 HSN-Q.A.2
Instructional Focus	

Unit Enduring Understandings	
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 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** ● Theories and laws provide explanations in science. ● Laws are statements or descriptions of the relationships among observable phenomena.	
Unit Essential Questions	
1. How do we describe the motion of objects? 2. How do we create mathematical models that represent the motion of objects and use mathematical models to predict the motion of objects? 3. How is a vector represented and what are some of its applications? 4. How can vectors be manipulated mathematically? 5. How does motion in the vertical direction affect motion in the horizontal direction? 6. What situations require relative motion analysis?	
Objectives	
Students will know: **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. **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.	**Students will be able to:** **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 trade off considerations. ● Evaluate a solution to a complex real world problem, based on scientific knowledge, student

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. **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	generated sources of evidence, prioritized criteria, and trade off considerations.
Interdisciplinary Connections, 21st Century Skills, Integration of Technology, Career Education	
Technology Literacy/Technology Standards: ● **8.2.12.ETW.2:** Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment. ● **8.2.12.ETW.3:** Identify a complex, global environmental or climate change issue, develop a systematic plan of investigation, and propose an innovative sustainable solution ● **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task ● **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.	**Career Awareness Exploration/Career Readiness, Life Literacies and Key Skills:** **Reflect, Analyze, or Create:** ● **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas **Critical Thinking and Problem Solving:** ● **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice
Resources	
Assessment Checkpoints	**Sample Activities:**
Formative Assessments: Turn&Talk, Questioning, Write-Pair-Share, Structured Critique, Class Participation (Bell Ringers/Exit Tickets), 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. **Homework:** Reading the textbook, doing practice problems, take home quizzes, lab reports, and watching tutorial videos. (5 hours per week)	● Velocity of a non-accelerating 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 ● AP practice problems ● AP Physics Projects Packet ● Pederson Science Lab Investigations ● AP Physics 1 and 2 Inquiry-Based Lab Investigations: Teacher's Manual

<table>
<tr><td>Summative Assessments:
Unit Exams, Final Exam, Project

Benchmark Performance Assessments/Laboratory Investigations:
Analysis Lab Report
Full Length Lab Report (1 per marking period)

Alternative Assessments:
● Complete a PBL activity
● Create and conduct a laboratory experiment</td><td></td></tr>
<tr><td>Accommodations and Modifications:</td><td>Instructional & Supplemental Material:</td></tr>
<tr><td>ELL * 504* GATE * IEP * At Risk

WIDA Can Do Descriptors

Additional ELL Resources

http://www.nj.gov/education/cccs/2014/wl/glossary.pdf</td><td>Core Instructional
● iPads
● College Physics for the AP® Physics 1 Course

Supplemental
● Schoology
● AP Classroom
● WebAssign
● Albert io.

LGBTQ and Persons with Disabilities Resources:
● https://www.nj.gov/education/standards/dei/</td></tr>
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UNIT 2: Dynamics

Summary and Rationale	
Unit 2 will revisit the concepts learned in unit 1 to explore force, which is the interaction of an object with another object. Topics will include systems, the gravitational field, contact forces, Newton's First Law, Newton's Second Law, and applications of Newton's Second Law.	
Recommended Pacing	
5 weeks	
State Standards	
Science Standards (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.
HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
Companion Standards	
Reading Science and Technical Subjects	RST.11-12.1 RST.11-12.7
Writing History, Science and Technical Subjects	WHST.9-12.7 WHST.9-12.9
Speaking and Listening	SL.11-12.5
Mathematical Practice	MP.2 MP.4
Number and Quantity	HSN-Q.A.1 HSN-Q.A.2
Instructional Focus	
Unit Enduring Understandings	
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 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

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 phenomena.

Unit Essential Questions

1. How can the properties of internal and gravitational mass be experimentally verified to be the same?
2. How do you decide what to believe about scientific claims?
3. How does something we cannot see determine how an object behaves?
4. How do objects with mass respond when placed in a gravitational field?
5. Why is the acceleration due to gravity constant on Earth's surface?
6. Are different kinds of forces really different?
7. How can Newton's laws of motion be used to predict the behavior of objects?
8. Why does the same push change the motion of a shopping cart more than the motion of a car?

Objectives

Students will know:	**Students will be able to:**
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.	**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 -

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- 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 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 trade off considerations.

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generated sources of evidence, prioritized criteria, and trade off considerations.

- Evaluate a solution to a complex real world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade off considerations.

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<tr><td colspan="2">Interdisciplinary Connections, 21st Century Skills, Integration of Technology, Career Education</td></tr>
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<u>Technology Literacy/Technology Standards:</u>

- **8.2.12.ETW.2:** Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment.
- **8.2.12.ETW.3:** Identify a complex, global environmental or climate change issue, develop a systematic plan of investigation, and propose an innovative sustainable solution
- **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task
- **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

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<u>Career Awareness Exploration/Career Readiness, Life Literacies and Key Skills:</u>

Reflect, Analyze, or Create:

- **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas

Critical Thinking and Problem Solving:

- **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice

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<tr><td colspan="2" align="center">Resources</td></tr>
<tr><td>Assessment Checkpoints</td><td>Sample Activities:</td></tr>
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Formative Assessments:
Turn&Talk, Questioning, Write-Pair-Share, Structured Critique, Class Participation (Bell Ringers/Exit Tickets), 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.

Homework:
Reading the textbook, doing practice problems, take home quizzes, lab reports, and watching tutorial videos. (5 hours per week)

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- Inertial Mass
- Atwood's Machine
- Weight Versus Mass
- The Friction Coefficient of your block
- Hooke's Law
- Terminal Velocity
- Friction on a Ramp
- AP Physics Projects Packet
- Pederson Science Lab Investigations
- AP Physics 1 and 2 Inquiry-Based Lab Investigations: Teacher's Manual

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Summative Assessments: Unit Exams, Final Exam, Project **Benchmark Performance Assessments/Laboratory Investigations:** Analysis Lab Report Full Length Lab Report (1 per marking period) **Alternative Assessments:** ● Complete a PBL activity ● Create and conduct a laboratory experiment	
Accommodations and Modifications:	**Instructional & Supplemental Material:**
ELL * 504* GATE * IEP * At Risk WIDA Can Do Descriptors **Additional** ELL Resources http://www.nj.gov/education/cccs/2014/wl/glossary.pdf	**Core Instructional** ● iPads ● College Physics for the AP® Physics 1 Course **Supplemental** ● Schoology ● AP Classroom ● WebAssign ● Albert IO. **LGBTQ and Persons with Disabilities Resources:** ● https://www.nj.gov/education/standards/dei/

UNIT 3: Circular Motion and Gravitation

Summary and Rationale
Unit 3 will build on the understanding of motion and force as more complex models of motion are explored such as the circular path of a satellite orbiting a planet. Topics will include vector fields, fundamental forces, gravitational and electric forces, gravitational field/acceleration due to gravity on different planets, inertial vs. gravitational mass, centripetal acceleration vs. centripetal force, and free-body diagrams for objects in uniform circular motion. The big ideas are as follows: 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.
Recommended Pacing
3-4 weeks
State Standards

Science Standards (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.
HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
Companion Standards	
Reading Science and Technical Subjects	RST.11-12.1 RST.11-12.8
Writing History, Science and Technical Subjects	WHST.9-12.7 WHST.11-12.8

	WHST.9-12.9
Speaking and Listening	SL.11-12.5
Mathematical Practice	MP.2 MP.4
Number and Quantity	HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3

Instructional Focus

Unit Enduring Understandings

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 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 phenomena.

Unit Essential Questions

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

Objectives

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	**Students will be able to:** **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.

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 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 = 2πR/T to predict unknown quantities. ESS1.B: Earth and the Solar System Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.	**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 trade off considerations. ● Evaluate a solution to a complex real world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and trade off considerations.
Interdisciplinary Connections, 21st Century Skills, Integration of Technology, Career Education	
Technology Literacy/Technology Standards: ● **8.2.12.ETW.2:** Synthesize and analyze data collected to monitor the effects of a	**Career Awareness Exploration/Career Readiness, Life Literacies and Key Skills:** **Reflect, Analyze, or Create:**

technological product or system on the environment. ● **8.2.12.ETW.3:** Identify a complex, global environmental or climate change issue, develop a systematic plan of investigation, and propose an innovative sustainable solution ● **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task ● **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.	● **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas **Critical Thinking and Problem Solving:** ● **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice
Resources	
Assessment Checkpoints	**Sample Activities:**
Formative Assessments: Turn&Talk, Questioning, Write-Pair-Share, Structured Critique, Class Participation (Bell Ringers/Exit Tickets), 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. **Homework:** Reading the textbook, doing practice problems, take home quizzes, lab reports, and watching tutorial videos. (5 hours per week) **Summative Assessments:** Unit Exams, Final Exam, Project **Benchmark Performance Assessments/Laboratory Investigations:** Analysis Lab Report Full Length Lab Report (1 per marking period) **Alternative Assessments:** ● Complete a PBL activity ● Create and conduct a laboratory experiment	● Exploring Circular Motion Lab ● Physics and Art Activity ● Hovercraft ● AP Physics Projects Packet ● Pederson Science Lab Investigations ● AP Physics 1 and 2 Inquiry-Based Lab Investigations: Teacher's Manual
Accommodations and Modifications:	**Instructional & Supplemental Material:**
ELL * 504* GATE * IEP * At Risk	**Core Instructional** ● iPads ● College Physics for the AP® Physics 1 Course

WIDA Can Do Descriptors **Additional** ELL Resources http://www.nj.gov/education/cccs/2014/wl/glossary.pdf	**Supplemental** ● Schoology ● AP Classroom ● WebAssign ● Albert IO. **LGBTQ and Persons with Disabilities Resources:** ● https://www.nj.gov/education/standards/dei/

UNIT 4: Energy

Summary and Rationale	
Unit 4 focuses on defining work, energy, and power, and exploring the relationships between them. Topics include open and closed systems of energy, work and mechanical energy, and the conservation of energy, the work-energy principle, and power. The big ideas of this unit are as follows: 1. The interactions of an object with other objects can be described by forces. 2. Interactions between systems can result in changes in those systems. 3. Changes that occur as a result of interactions are constrained by conservation laws.	
Recommended Pacing	
4 weeks	
State Standards	
Science Standards (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.
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.
Companion Standards	
Reading Science and Technical Subjects	RST.11-12.1 RST.11-12.8
Writing History, Science and Technical Subjects	WHST.9-12.7 WHST.11-12.8 WHST.9-12.9
Speaking and Listening	SL.11-12.5
Mathematical Practice	MP.2 MP.4
Number and Quantity	HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3
Instructional Focus	
Unit Enduring Understandings	
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 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 phenomena.

Unit Essential Questions

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

Objectives

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	**Students will be able to:** **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.

different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** ● Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) ● Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) ● Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) ● The availability of energy limits what can occur in any system. (HS-PS3-1) ● Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.C: Relationship Between Energy and Forces** ● When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3- 5) **PS3.D: Energy in Chemical Processes** ● Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the **ETS1.A: Defining and Delimiting Engineering Problems**	● Design a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. ● Evaluate a solution to a complex real world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and trade off considerations.

● Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS- PS3-3)	
Interdisciplinary Connections, 21st Century Skills, Integration of Technology, Career Education	
<u>Technology Literacy/Technology Standards:</u> ● **8.2.12.ETW.2:** Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment. ● **8.2.12.ETW.3:** Identify a complex, global environmental or climate change issue, develop a systematic plan of investigation, and propose an innovative sustainable solution ● **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task ● **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.	**<u>Career Awareness Exploration/Career Readiness, Life Literacies and Key Skills:</u>** **Reflect, Analyze, or Create:** ● **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas **Critical Thinking and Problem Solving:** ● **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice
Resources	
● **Assessment Checkpoints**	**Sample Activities:**
Formative Assessments: Turn&Talk, Questioning, Write-Pair-Share, Structured Critique, Class Participation (Bell Ringers/Exit Tickets), 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. **Homework:** Reading the textbook, doing practice problems, take home quizzes, lab reports, and watching tutorial videos. (5 hours per week) **Summative Assessments:** Unit Exams, Final Exam, Project **Benchmark Performance Assessments/Laboratory Investigations:**	● Understanding Work – use a variety of everyday situations to develop an understanding of the concepts of work and energy ● Angles and Work – utilize everyday situations to develop a method of determining work done at an angle ● Types of Energy – develop terminology based on everyday situations to describe different types of energy ● Representing Work/Energy – use a variety of methods to represent Work/Energy and the concept of conservation (verbal, pictorial, graphical, mathematical) ● Conservation of Energy – provide examples of situations where energy is conserved, but due to assumptions it does not remain constant for the system

Analysis Lab Report Full Length Lab Report (1 per marking period) **Alternative Assessments:** • Complete a PBL activity • Create and conduct a laboratory experiment	• Determining Power – develop an understanding of what power represents by allowing students to develop a lab in which they determine the power of a system • Elastic and Inelastic Collisions Lab • Individual/Group Problem Solving (textbook, AP practice problems, problems involving interdisciplinary connections). • AP Physics Projects Packet • Pederson Science Lab Investigations • AP Physics 1 and 2 Inquiry-Based Lab Investigations: Teacher's Manual
• **Accommodations and Modifications:**	• **Instructional & Supplemental Material:**
ELL * 504* GATE * IEP * At Risk WIDA Can Do Descriptors **Additional** ELL Resources http://www.nj.gov/education/cccs/2014/wl/glossary.pdf	**Core Instructional** • iPads • College Physics for the AP® Physics 1 Course **Supplemental** • Schoology • AP Classroom • WebAssign • Albert IO. **LGBTQ and Persons with Disabilities Resources:** • https://www.nj.gov/education/standards/dei/

UNIT 5: Momentum

Summary and Rationale	
Unit 5 focuses on the relationship between force, time, and momentum; and the exploration of using the law of conservation of momentum to analyze physical situations. Topics will include momentum and impulse, representations of changes in momentum, open and closed systems of momentum, and conservation of linear momentum. The big ideas of this unit are as follows: 1. The interactions of an object with other objects can be described by forces 2. Interactions between systems can result in changes in those systems. 3. Changes that occur as a result of interactions are constrained by conservation laws.	
Recommended Pacing	
2-3 weeks	
State Standards	
Science Standards (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.
HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
HS-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
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
Companion Standards	
Reading Science and Technical Subjects	RST.11-12.1 RST.11-12.8

Writing History, Science and Technical Subjects	WHST.9-12.7 WHST.11-12.8 WHST.9-12.9
Speaking and Listening	SL.11-12.5
Mathematical Practice	MP.2 MP.4
Number and Quantity	HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3

Instructional Focus

Unit Enduring Understandings

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 need to be defined.
- 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, 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 Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Science assumes the universe is a vast single system in which basic laws are constant.

Unit Essential Questions

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

Objectives	
Students will know: **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 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 associated with the configuration (relative position of the particles). In some cases the relative position energy can be	**Students will be able to:** **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. ● Create a computational model or simulation of a phenomenon, designed device, process, or system. ● Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. **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 trade off considerations. ● Evaluate a solution to a complex real world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade off 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.

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. **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 (trade offs) may be needed. **ETS1.B: Developing Possible Solutions**	

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- 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.

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Technology Literacy/Technology Standards:

- **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.
- **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task
- **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

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Career Awareness Exploration/Career Readiness, Life Literacies and Key Skills:

Reflect, Analyze, or Create:
- **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas

Critical Thinking and Problem Solving:
- **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice

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.

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Formative Assessments:
Turn&Talk, Questioning, Write-Pair-Share, Structured Critique, Class Participation (Bell Ringers/Exit Tickets), 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.

Homework:

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- Impulse and Momentum
- Conservation of Momentum in Collisions
- Conservation of Momentum – Ballistic Pendulum
- AP practice problems
- Interdisciplinary connection problems
- AP Physics Projects Packet
- Pederson Science Lab Investigations
- AP Physics 1 and 2 Inquiry-Based Lab Investigations: Teacher's Manual

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Reading the textbook, doing practice problems, take home quizzes, lab reports, and watching tutorial videos. (5 hours per week) **Summative Assessments:** Unit Exams, Final Exam, Project **Benchmark Performance Assessments/Laboratory Investigations:** Analysis Lab Report Full Length Lab Report (1 per marking period) **Alternative Assessments:** ● Complete a PBL activity ● Create and conduct a laboratory experiment	
Accommodations and Modifications:	**Instructional & Supplemental Material:**
ELL * 504* GATE * IEP * At Risk WIDA Can Do Descriptors **Additional** ELL Resources http://www.nj.gov/education/cccs/2014/wl/glossary.pdf	**Core Instructional** ● iPads ● College Physics for the AP® Physics 1 Course **Supplemental** ● Schoology ● AP Classroom ● WebAssign ● Albert io. **LGBTQ and Persons with Disabilities Resources:** ● https://www.nj.gov/education/standards/dei/

UNIT 6: Simple Harmonic Motion

Summary and Rationale	
This unit will apply tools, techniques, and models learned from previous units to introduce and analyze simple harmonic motion. Topics include period of simple harmonic oscillators and energy of a simple harmonic oscillator. The big ideas of this unit are as follows: 1. The interactions of an object with other objects can be described by forces. 2. Changes that occur as a result of interactions are constrained by conservation laws.	
Recommended Pacing	
4 weeks	
State Standards	
Science Standards (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.
HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision
HS-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).
Companion Standards	
Reading Science and Technical Subjects	RST.11-12.1 RST.11-12.8
Writing History, Science and Technical Subjects	WHST.9-12.7 WHST.11-12.8 WHST.9-12.9
Speaking and Listening	SL.11-12.5
Mathematical Practice	MP.2 MP.4
Number and Quantity	HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3
Instructional Focus	

Unit Enduring Understandings	
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. ● 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—	
Unit Essential Questions	
1. What is a simple harmonic oscillator? 2. What factors affect the period of oscillation for a mass oscillating on a spring and for a simple pendulum? 3. How does the back-and-forth motion of a box on a spring mirror the motion of a pendulum?	
Objectives	
Students will know:	**Students will be able to:**
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 intoor 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)	**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

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- 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)

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order to make valid and reliable scientific claims or determine an optimal design solution.

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.

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.

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).

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Interdisciplinary Connections, 21st Century Skills, Integration of Technology, Career Education

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<u>Technology Literacy/Technology Standards:</u>

- **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.
- **8.2.12.ETW.2:** Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment.

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<u>Career Awareness Exploration/Career Readiness, Life Literacies and Key Skills:</u>

Reflect, Analyze, or Create:

- **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas

Critical Thinking and Problem Solving:

- **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice

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- **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task
- **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

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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.

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Formative Assessments:
Turn&Talk, Questioning, Write-Pair-Share, Structured Critique, Class Participation (Bell Ringers/Exit Tickets), 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.

Homework:
Reading the textbook, doing practice problems, take home quizzes, lab reports, and watching tutorial videos. (5 hours per week)

Summative Assessments:
Unit Exams, Final Exam, Project

Benchmark Performance Assessments/Laboratory Investigations:
Analysis Lab Report
Full Length Lab Report (1 per marking period)

Alternative Assessments:

- Complete a PBL activity
- Create and conduct a laboratory experiment

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- Slinky Lab
- Finding the speed of sound in Air (Tuning Forks)
- Simple Harmonic Motion Lab
- AP Physics Projects Packet
- Pederson Science Lab Investigations
- AP Physics 1 and 2 Inquiry-Based Lab Investigations: Teacher's Manual

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<tr><td>Accommodations and Modifications:</td><td>Instructional & Supplemental Material:</td></tr>
<tr><td>

ELL * 504* GATE * IEP * At Risk

WIDA Can Do Descriptors

Additional ELL Resources

http://www.nj.gov/education/cccs/2014/wl/glossary.pdf

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Core Instructional

- iPads
- College Physics for the AP® Physics 1 Course

Supplemental

- Schoology
- AP Classroom
- WebAssign
- Albert IO.

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	LGBTQ and Persons with Disabilities Resources: ● https://www.nj.gov/education/standards/dei/

UNIT 7: Torque and Rotational Motion

Summary and Rationale	
This unit will explore the motion of an object rotating around an axis and introduce torque, the measure of a force that can cause rotational motion. Topics include rotational kinematics, torque and angular acceleration, angular momentum and torque, and conservation of angular momentum. The big ideas of this unit are as follows: 1. The interactions of an object with other objects can be described by forces. 2. Interactions between systems can result in changes in those systems. 3. Changes that occur as a result of interactions are constrained by conservation laws.	
Recommended Pacing	
1-2 weeks	
State Standards	
Science Standards (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.
HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system
HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
HS-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.
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
Companion Standards	
Reading Science and Technical Subjects	RST.11-12.1 RST.11-12.7 RST.11-12.8 RST.11-12.9
Writing History, Science and Technical Subjects	WHST.9-12.7 WHST.11-12.8 WHST.9-12.9
Speaking and Listening	SL.11-12.5
Mathematical Practice	MP.2 MP.4
Number and Quantity	HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3
Instructional Focus	
Unit Enduring Understandings	

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)
- 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. (HS- PS2-2)
- 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)

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)

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)

Unit Essential Questions

1. Can the kinematics equations be applied to rotating systems?
2. How can Newton's law be applied to rotating systems?
3. How does a net torque affect the angular momentum of a rotating system?

Objectives

Students will know:

PS1.A: Structure and Properties of Matter

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

PS2.A: Forces and Motion

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

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2- 4),(HS-PS2-5)
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-

Students will be able to:

Planning and Carrying Out Investigations

- Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)

Analyzing and Interpreting Data

- Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

Using Mathematics and Computational Thinking

- Mathematical and computational thinking at the 9–12 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.

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 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 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 (trade offs) may be needed.	● 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).
Interdisciplinary Connections, 21st Century Skills, Integration of Technology, Career Education	

Technology Literacy/Technology Standards:	**Career Awareness Exploration/Career Readiness, Life Literacies and Key Skills:**
● **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. ● **8.2.12.ETW.2:** Synthesize and analyze data collected to monitor the effects of a technological product or system on the environment. ● **8.2.12.ETW.3:** Identify a complex, global environmental or climate change issue, develop a systematic plan of investigation, and propose an innovative sustainable solution ● **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task ● **9.4.12.TL.2:** Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.	**Reflect, Analyze, or Create:** ● **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze, and use creative skills and ideas **Critical Thinking and Problem Solving:** ● **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice **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.
Resources	
Assessment Checkpoints	**Sample Activities:**
Formative Assessments: Turn&Talk, Questioning, Write-Pair-Share, Structured Critique, Class Participation (Bell Ringers/Exit Tickets), 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. **Homework:** Reading the textbook, doing practice problems, take home quizzes, lab reports, and watching tutorial videos. (5 hours per week) **Summative Assessments:** Unit Exams, Final Exam, Project **Benchmark Performance Assessments/Laboratory Investigations:** Analysis Lab Report Full Length Lab Report (1 per marking period) **Alternative Assessments:** ● Complete a PBL activity	● Understanding Equilibrium and Torque – utilize our understanding of linear dynamics and apply it to rotational situations ● Angular Kinematics – utilize our understanding of linear kinematics and apply it to rotational situations ● Angular Momentum – utilize our understanding of momentum and apply it to rotational situations ● Rotational Energy – utilize our understanding of work/energy and apply it to rotational situations ● Conservation of Angular Momentum – utilize rotating objects, such as a bicycle wheel, to demonstrate the importance of understanding angular momentum ● Design Lab: Rotating Arm/Platform ● AP Physics Projects Packet ● Pederson Science Lab Investigations ● AP Physics 1 and 2 Inquiry-Based Lab Investigations: Teacher's Manual

- Create and conduct a laboratory experiment	
Accommodations and Modifications:	**Instructional & Supplemental Material:**
ELL * 504* GATE * IEP * At Risk WIDA Can Do Descriptors **Additional** ELL Resources http://www.nj.gov/education/cccs/2014/wl/glossary.pdf	**Core Instructional** - iPads - College Physics for the AP® Physics 1 Course **Supplemental** - Schoology - AP Classroom - WebAssign - Albert IO. **LGBTQ and Persons with Disabilities Resources:** - https://www.nj.gov/education/standards/dei/