# FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

# OFFICE OF CURRICULUM AND INSTRUCTION

## Science

# Principles of Physics/Laboratory Physics
# Honors Laboratory Physics

**COURSE DESCRIPTION**

Grade Level: 10-12

Department: Science

Course Title: Physics

Credits: 5.0

Course Code: 042220-042240-042350

**Board of Education adoption date: August 22, 2011**

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# Physics - Introduction

## Introduction

## Course Philosophy

Physics is a science which attempts to understand the universe around us; past, present and future. It is the intent of this course to equip the high school physics students with a conceptual base of physical knowledge. From this base they can predict, control, calculate, measure, and observe their interactions with the physical world around them. This conceptual base will also foster their critical and analytical thinking for use throughout their lifetime. This course will emphasize learning the fundamental principles of nature from which concepts can be derived. The philosophy of this course is based around providing the student with an inquiry-based foundation in physics which will help prepare students to interact with and understand the world around them. The basic laws and rules of physics, if understood, are what students can use for the rest of their lives by applying them in real life situations. It is the goal of this course to facilitate students' understanding of these rules.

## Course Description

The Laboratory Physics course will begin with an introduction to physics and a brief review of past science inquiry practices and safety. As the course progresses, the students will gain an understanding that the same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls. They will gain this understanding through the use of various laboratory activities involving scenarios and examples that demonstrate the laws of motion in action. Students will also gain a practical understanding of gravity as a universal force of attraction between masses. We hope the course will help students understand that energy takes many forms and is a property of many substances. It is associated with heat, light, electricity, mechanical motion, sound, nuclei, and chemicals. Students will explore these forms and come to understand that energy is transferred in many ways. Students will then explore the nature of waves and how their movement impacts us every day; including sound and seismic waves, waves on water, and light waves. Students will study electromagnetism and gain an understanding of electromagnetic forces and how they affect matter and energy. They will understand the sun's role in energy generation and distribution and its impact upon earth. Optics will also be studied and students will come to understand how we are able to see objects and will gain an understanding of the nature of light and how it interacts with matter by transmission, absorption and scattering.

Students' understanding will be evaluated through methods such as pre-test and post-test analysis, lab activities, projects, mid-term and final examinations.

## Course Map and Proficiencies / Pacing

## Course Map

| Relevant Standards | Enduring Understandings | Essential Questions | Assessments | | |
|---|---|---|---|---|---|
| | | | **Diagnostic** | **Formative** | **Summative** |
| 5.1.12.A.1-4, B.1-2, C.1 | Scientific method and technology can help in collecting evidence and forming explanations | How is the scientific method used to answer questions and to solve problems? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |
| 5.1.12.A.1-4, B.1-2, C.1 | Collecting data using reliable measurements allows us to connect explanations to scientific knowledge and theory Mathematics is a tool used to model objects, events, and relationships in the natural and designed world | How are reliable measurements used in evaluating a properly run experiment?<br>**ALL** essential questions from all units | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |

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| 5.1.12.B.2, C.2, D.2<br><br>5.2.12.E.1-2 | The same basic principles and models can describe the motion of all objects | How can an object's motion and change in motion be represented verbally, physically, graphically, and mathematically?<br><br>How can an object's motion and change in motion be represented verbally, physically, graphically, and mathematically in two dimensions?<br><br>What is necessary for an object to travel in a circular path?<br><br>How can the rotational motion of an object be represented verbally, physically and mathematically? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |
| 5.2.12.E.3-4 | External, unbalanced forces are required to change a system's motion | How are Newton's Laws of Motion applied to describe the motion of an object or system?<br><br>What are the similarities and differences between different types of forces?<br><br>How can the forces exerted on an object or system be represented physically and mathematically?<br><br>How can the torques exerted on an object or system be represented physically and mathematically? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |

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| 5.2.12.E.3-4 | An object that exerts a force on a second object will have an equal and opposite force exerted on it by the second object | How are Newton's Laws of Motion applied to describe the motion of an object or system?<br><br>What are the similarities and differences between different types of forces?<br><br>How can the forces exerted on an object or system be represented physically and mathematically? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |
| 5.2.12.E.4 | Gravity is the universal force of attraction between all masses | How does gravitational force differ from other forces?<br><br>How does mass and distance affect the gravitational force of objects acting on each other? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |
| 5.2.12.D.4 | Momentum is conserved in a closed system | How can an object's momentum be represented verbally, graphically and mathematically?<br><br>How is the momentum of an object changed, and how can this change be represented verbally, graphically and mathematically?<br><br>Why is momentum conserved in collisions? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |

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| 5.2.12.D.1,4 | Energy is a property of objects and substances that exists and can be transferred between many forms | How can the energy of an object be represented verbally, physically, graphically and mathematically?<br><br>How does work done by and on a system affect the total energy of the system? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |
| 5.2.12.D.1,4 | Energy is conserved in a closed system | How can the conservation of energy in a system be represented graphically and mathematically?<br><br>What are the characteristics of a simple harmonic oscillator? | Pre-test<br><br>Lab safety pre-lab<br><br>Brainstorming topics<br><br>Pre-lab assessments and activities | Quizzes<br><br>Daily checks for understanding<br><br>Use of interactive white board for examples and instant feedback<br><br>Lab reports<br><br>Class closure questions<br><br>Daily homework assignment<br><br>Current events in physics | Marking period project<br><br>Questions on specific topics<br><br>Lab reports<br><br>Post-unit test |

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| **CC**<br>RST.3-4,7<br>WHST.1-2,7<br>**NJCCCS**<br>5.1.A.1-3, B.1-4, C.1-3, D.1-2<br>5.2.A.1-2, C.1, D.4, E.1,4<br>5.4.A.6<br>5.4.F.1 | The same basic principles and models govern the behavior of waves when they interact with matter and with other waves | How can the model of a simple harmonic oscillator be related to the model of a wave?<br><br>How are the properties of waves affected when waves interact?<br>What is the relationship between the physical quantities and perceived qualities of sound?<br><br>How do the physical quantities and perceived qualities of sound change depending on the relative motions of the source and the observer?<br><br>How have previous models and understanding of light contributed to the current model of light?<br><br>How can the characteristics of light be represented verbally, physically, graphically, and mathematically?<br><br>How can the characteristics of an image produced by an optical device be represented verbally, graphically and mathematically? | Pre-test (concept inventories)<br><br>Do-now activities<br><br>Student responses during class discussions | Student responses during class discussions<br><br>Do-now and closure activities<br><br>Quizzes (online and in-class)<br><br>Problem-solving session discussions<br><br>Interactive white board discussions after observational labs and activities<br><br>Student reflection and self-evaluation | Unit examination<br><br>Retake concept inventories<br><br>Formal lab report submission |

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| **CC**<br>RST.3-4,7<br>WHST.1-2,7<br>**NJCCCS**<br>5.1.A.1-3, B.1-4, C.1-3, D.1-2<br>5.2.A.1-2, B.1, C.1-2, D.1,4, E.1-4 | A charged body produces an electric field that mediates the interactions between the body and other charges | How can charged particles, the electric fields they produce and the interaction between those fields be represented verbally, graphically and mathematically?<br><br>How is the structure and properties of matter determined by the strength of electrical charges and electric field they produce?<br><br>What is the relationship between electrical field forces and the energy of charged particles moving within the electric field? | Pre-test (concept inventories)<br><br>Do-now activities<br><br>Student responses during class discussions | Student responses during class discussions<br><br>Do-now and closure activities<br><br>Quizzes (online and in-class)<br><br>Problem-solving session discussions<br><br>Interactive white board discussions after observational labs and activities<br><br>Student reflection and self-evaluation | Unit examination<br><br>Retake concept inventories<br><br>Formal lab report submission |
| **CC**<br>RST.3-4,7<br>WHST.1-2,7<br>**NJCCCS**<br>5.1.A.1-3, B.1-4, C.1-3, D.1-2<br>5.2.A.1-2, B.1, D.1,4, E.1-4 | Electrical circuits provide a mechanism of transferring electrical energy | How does electric potential cause the movement of electrons in an electric circuit?<br><br>How do basic circuit components produce heat, light and sound from electrical energy?<br><br>How does the arrangement of basic circuit components in series and parallel affect the function of those components? | Pre-test (concept inventories)<br><br>Do-now activities<br><br>Student responses during class discussions | Student responses during class discussions<br><br>Do-now and closure activities<br><br>Quizzes (online and in-class)<br><br>Problem-solving session discussions<br><br>Interactive white board discussions after observational labs and activities<br><br>Student reflection and self-evaluation | Unit examination<br><br>Retake concept inventories<br><br>Formal lab report submission |

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| **CC**<br>RST.3-4,7<br>WHST.1-2,7<br>**NJCCCS**<br>5.1.A.1-3, B.1-4, C.1-3, D.1-2<br>5.2.A.1-2, B.1, D.1, E.1-2,4 | Magnetic fields are produced by permanent magnets and electric currents, which mediate interactions between magnetic materials and moving charges. | How can magnets and the magnetic field they produce be represented verbally, graphically and mathematically?<br><br>How can the relationship between electric currents and magnetic fields be represented physically, graphically and mathematically?<br><br>What conditions are required in order to induce an electric current from a magnetic field, and vice versa? | Pre-test (concept inventories)<br><br>Do-now activities<br><br>Student responses during class discussions | Student responses during class discussions<br><br>Do-now and closure activities<br><br>Quizzes (online and in-class)<br><br>Problem-solving session discussions<br><br>Interactive white board discussions after observational labs and activities<br><br>Student reflection and self-evaluation | Unit examination<br><br>Retake concept inventories<br><br>Formal lab report submission |

## Proficiencies and Pacing

| **Unit Title** | **Unit Understanding(s) and Goal(s)** | **Recommended Duration** |
|---|---|---|
| Unit 1 - Scientific Processes, Mathematics and Safety | Scientific method and technology can help in collecting evidence and forming explanations.<br>Collecting data using reliable measurements allows us to connect explanations to scientific knowledge and theory.<br><br>At the conclusion of this unit, students will be able to:<br>1. Apply problem-solving, critical thinking and inquiry skills to explore scientific concepts.<br>2. Practice proper, appropriate and safe laboratory techniques in the physics classroom. | 1 week |
| Unit 2 - 1-Dimensional Kinematics | The same basic principles and models can describe the motion of all objects.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the motion of objects moving with constant velocity using multiple representations.<br>2. Describe the motion of objects undergoing uniform acceleration using multiple representations. | 3 Weeks |

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| Unit 3 - Newtonian Dynamics | External, unbalanced forces are required to change a system's motion.<br>An object that exerts a force on a second object will have an equal and opposite force exerted on it by the second object.<br><br>At the conclusion of this unit, students will be able to:<br>1. Construct free-body diagrams describing all forces acting on an object.<br>2. Determine the direction of an unbalanced net force and describe how an object's motion is affected. | 4 Weeks |
| Unit 4 - 2-Dimensional Kinematics | The same basic principles and models can describe the motion of all objects.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the motion of a projectile moving in 2 dimensions using multiple representations. | 2 Weeks |
| Unit 5 - Circular Motion and Universal Gravitation | The same basic principles and models can describe the motion of all objects<br>Gravity is the universal force of attraction between all masses.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the motion of an object moving in a circular path using multiple representations.<br>2. Construct free-body diagrams describing all forces acting on an object moving in a circular path.<br>3. Describe the force of gravitational attraction between two objects using multiple representations. | 2 Weeks |
| Unit 6 - Linear Momentum | Momentum is conserved in a closed system.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the momentum of a moving object using multiple representations.<br>2. Describe the results of an elastic and inelastic collision between two objects. | 2 Weeks |
| Unit 7 - Work and Energy | Energy is a property of objects and substances that exists and can be transferred between many forms.<br>Energy is conserved in a closed system.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the energy of a system based on the position and motion of the system.<br>2. Explain the transformation of energy within a system using multiple representations. | 3 Weeks |
| Unit 8 - Rotational Motion | The same basic principles and models can describe the motion of all objects.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the motion of an object rotating about a fixed axis using multiple representations.<br>2. Construct free-body diagrams describing all forces and distances acting on an object rotating about a fixed axis. | 2 Weeks |

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| Unit 9 - Simple Harmonic Motion and Waves | Energy is conserved in a closed system.<br>The same basic principles and models govern the behavior of waves when they interact with matter and with other waves.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the motion of a system undergoing simple harmonic motion using multiple representations.<br>2. Diagram the characteristics of a wave and how those characteristics are related to each other.<br>3. Diagram how waves behave when they interact with other waves. | 3 Weeks |
| Unit 10 - Sound | The same basic principles and models govern the behavior of waves when they interact with matter and with other waves.<br><br>At the conclusion of this unit, students will be able to:<br>1. Explain and describe the relationship between the physical quantities of waves and the perceived qualities of the sound they produce.<br>2. Describe and diagram how the perception of sound changes depending on the relative motions of the source and observer. | 2 Weeks |
| Unit 11 - Light and Optics | The same basic principles and models govern the behavior of waves when they interact with matter and with other waves.<br><br>At the conclusion of this unit, students will be able to:<br>1. Explain the current model of light using previous models as a basis.<br>2. Describe the characteristics of light, using multiple representations.<br>3. Describe the images produced by mirrors and lenses, using multiple representations. | 4 Weeks |
| Unit 12 - Electrostatics | A charged body produces an electric field that mediates the interactions between the body and other charges.<br>At the conclusion of this unit, students will be able to:<br>1. Explain and describe how the charges of particles of matter affect the structure and properties of matter.<br>2. Describe the interaction of charged particles, using multiple representations. | 3 Weeks |
| Unit 13 - Electricity | Electrical circuits provide a mechanism of transferring electrical energy.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe the functioning of electrical circuits, using multiple representations. | 2 Weeks |

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| Unit 14 - Magnetism | Magnetic fields are produced by permanent magnets and electric currents, which mediate interactions between magnetic materials and moving charges.<br><br>At the conclusion of this unit, students will be able to:<br>1. Describe how an electric current passing through a wire can create a magnetic field.<br>2. Describe magnetic fields and magnetic field forces, using multiple representations.<br>3. Describe the motion of charged particles in a magnetic field, using multiple representations. | 2 Weeks |

# Physics Unit 01 - Scientific Processes, Mathematics, and Safety

## Unit 01 - Scientific Processes, Mathematics, and Safety

**Enduring Understandings:**

Scientific method and technology can help in collecting evidence, forming explanations, connecting these explanations to scientific knowledge and theory, and in communicating and justifying these explanations.

The development of scientific ideas is essential for building scientific knowledge.

Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.

**Essential Questions:**

What is Physics and how does it relate to other sciences and the physical world?

How is the scientific method used to answer questions and to solve problems?

Why is the safe and proper use of technology important?

How can math be used to help represent real-world phenomena?

**Unit Goals:**

Students will develop problem-solving, decision-making and inquiry skill. They will understand how people, discoveries, and events have contributed to the advancement of science and technology.

**Recommended Duration:**
1 week

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| What practices and habits will insure safety in the classroom and laboratory?<br><br>How is the scientific method used to answer questions and to solve problems?<br><br>What is necessary in order to develop and test a scientific hypothesis?<br><br>What constitutes valid evidence and when do you know that you have enough and the right kind of evidence?<br><br>What is precision, accuracy, and uncertainty analysis?<br><br>How can results be best justified and explained to others?<br><br>Why communication among the scientific community is essential for presenting findings?<br><br>Why is it necessary for all scientists to use a common system of measurement?<br><br>What are the basic units of measurement and the various prefixes used in the scientific community?<br><br>How do science and technology influence each other?<br><br>How does scientific knowledge advance and build upon previous discoveries using the scientific method of problem solving?<br><br>What is the importance of history in understanding scientific theories and the advancement of science?<br><br>What is Physics?<br><br>What is the role of physics in the physical world around us? | Demonstrate self-management skills such as work ethic, dependability, promptness, the ability to set short and long term goals, work cooperatively, use time efficiently, and develop self-evaluation skills<br><br>Locate, develop, summarize, organize, synthesize, and evaluate information<br><br>Use scientific inquiry to ask scientifically-oriented questions, collect evidence, form explanations, connect explanations to scientific knowledge and theory, and communicate and justify explanations<br><br>Develop critical thinking, decision-making, problem-solving skills and data analysis skills<br><br>Use metric system (m-k-s), recognize metric prefix meanings, and convert to base units<br><br>Develop an understanding of the role that Physics serves as a foundation for many career opportunities in science and technology<br><br>Properly and safely use technology and scientific equipment to collect and analyze data to help form scientific testable scientific hypotheses<br><br>Understand that the development of ideas is essential for building scientific knowledge | Variety of lab equipment that may be used throughout the year. Including, but limited to, meter sticks, timers, scales, and computer hardware and software.<br><br>Teacher and student editions of text approved by the district.<br><br>Scientific calculators.<br><br>A math book for algebraic reference and example problems for conversions.<br><br>Internet resources | Mini-lab on lab safety and measurement<br><br>Write-up lab in approved laboratory format<br><br>Activity on Scientific Method such as "thought" experiment where students justify their logical solution<br><br>Guided discussion based upon results from survey and questionnaire<br><br>On-going infusion of important scientists and their developments throughout the course | Lab reports<br><br>Safety quiz<br><br>Pre-test to determine student knowledge-base skills<br><br>Post-test to determine student progress<br><br>Technology survey to determine student understanding of the concept<br><br>Questionnaire about careers in technology and science and their impact on our daily lives |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12 | Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A | Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B | Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C | Scientific knowledge builds on itself over time. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D | The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.a | Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.b | Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.c | Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.a | Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.b | Mathematical tools and technology are used to gather, analyze, and communicate results. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.c | Empirical evidence is used to construct and defend arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.d | Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.a | Refinement of understandings, explanations, and models occurs as new evidence is incorporated. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.b | Data and refined models are used to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.c | Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.a | Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.b | Science involves using language, both oral and written, as a tool for making thinking public. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |

## Differentiation

All three levels will cover the content in this unit. Differentiation will occur in the depth and complexity of the examples and discussions

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (multimedia presentations, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 02 - One-Dimensional Kinematics

## Unit 02 - One-Dimensional Kinematics

**Enduring Understandings:**

The same basic principles and models can describe the motion of all objects.

**Essential Questions:**

How can an object's motion and change in motion be represented verbally, physically, graphically, and mathematically?

**Unit Goals:**

Students will gain an understanding of how an object's motion can be described.

**Recommended Duration:**

3 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| What role does a reference frame play in determining the motion of an object?<br><br>How can motion be described and depicted?<br><br>What different types of motion are there?<br><br>What is meant by magnitude and direction when describing motion?<br><br>What is meant by vector and scalar quantity?<br><br>What are displacement, velocity, and acceleration?<br><br>How are speed and velocity different?<br><br>How can you identify the two factors on which speed depends?<br><br>What is the difference between instantaneous and average velocities?<br><br>How do displacement, a time interval, velocity, and acceleration relate to each other? | Determine if an object is moving and explain answer<br><br>Reinforce and continuously use scientific method and critical thinking processes<br><br>Collect data from moving objects and analyze information in the form of graphs and tables<br><br>Find patterns in data and use these patterns to develop models and explanations<br><br>Make predictions and design and perform experiments to test the models developed<br><br>Understand the importance of vectors and scalars in determining an object's motion<br><br>Draw and add vectors to find the resultant or missing component<br><br>Differentiate between resultant and vector components<br><br>Be able to draw motion diagrams to represent a given scenario<br><br>Interpret displacement, velocity, and acceleration versus time graphs | Variety of lab equipment that may be used throughout the year. Including, but not limited to, meter sticks, timers, scales of various sorts, and glassware<br><br><u>PASCO Equipment</u>:<br>Constant velocity vehicles, friction cars, objects to drop, ticker-tape timers with tape, motion sensors, rollerblades, skateboards, beanbags<br><br>Teacher and student editions of text approved by the district<br><br>Scientific calculators<br><br>A math book for algebraic reference and example problems for conversions<br><br>Internet resources<br><br>Videos (Internet, DVD, and VHS accessible) to watch frame by frame or regular speed<br><br>PUM (Physics Uniting Math)<br><br>Activities for motion (kinematics module)<br><br>Real-world handouts (e.g., traffic school papers detectives use for accidents) | Observations of objects moving in different ways (teacher walking across classroom, teacher waving arms around, teacher jumping up and down)<br><br>Drawing pictures to represent scenario (pictures, motion diagrams, vectors) or describing the motion using words and numbers<br><br>Objects that move with constant horizontal velocity such as a bowling ball or constant motion cars<br><br>Objects that change velocity (horizontally) such as friction cars (these can be attached to tickertape timers and tape to make motion diagram or you can use video and a frame by frame or sugar packets to drop alongside every second) | Pre-test on motion (one-dimensional motion)<br><br><u>Lab Activities</u>:<br>Speed of a bowling ball (data collection and analysis with interactive white board presentation of data)<br><br>Friction cars of changing horizontal speed (data collection and analysis and compare and contrast to bowling ball activity)<br><br>Free-falling objects (data collection and analysis, new model developing, and compare and contrast to friction cars)<br><br>Quizzes on making and interpreting graphs, describing motion (in words and pictorially), and determining acceleration, speed (and velocity), position, and time intervals<br><br>Homework (collected, checked, gone over in class) |

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| How do you analyze the relationship of velocity to acceleration?<br><br>How do you interpret instantaneous/average velocity and acceleration graphically?<br><br>How do you depict constant and changing velocity graphically?<br><br>How are slope and area applied to graphical representations of motion?<br><br>What are the similarities and differences between horizontal and vertical motion?<br><br>How does the pull of Earth and air resistance affect the acceleration of falling objects?<br><br>How do students represent and analyze a system of two moving objects that have constant velocity and acceleration? | Apply the mathematical and graphical relationships between position, time, velocity, and acceleration<br><br>Apply the mathematical concepts of slope and area between the curve and time axis to analyze displacement, velocity, and acceleration for a position versus time, velocity versus time, and acceleration versus time graphs<br><br>Compare and contrast horizontal motion and motion of a freely falling object<br><br>Apply the mathematical and graphical relationships between position, time, velocity, and acceleration to a two-bodied system | | Objects that change velocity (vertically) such as free-falling objects (Drop objects simultaneously; Should be different masses and shapes; also, have similar masses and shapes; Do frame by frame or attach to tickertape timer; If access to motion sensors, this data can be plotted)<br><br><u>Problem-solving steps and techniques</u>:<br><br>1. Read the problem multiple times<br><br>2. Make a list of given information and what needs to be found<br><br>3. Draw a picture with labels of the situation<br><br>4. Represent the problem with a mathematical expression, graph, or motion diagram<br>5. Adjust expression to solve for the unknown variable<br><br>6. Enter in the given information (including unit labels)<br><br>7. Solve for unknown<br><br>Teacher modeling<br><br>Individual work or group work (Think, pair, and share opportunities, white-boarding, student presentations, and class discussions)<br><br>Blogs, wikis, scientific journal readings, and current events | Check students' use of vocabulary and explanations throughout lessons.<br><br>Problem-solving and board work.<br><br><u>Closure</u>:<br><br>1. "What have I learned today and why do I believe it?"<br><br>2. "ABC" cards (multiple choice questions where students show their answer choice to teacher).<br><br>3. "How does this relate to...?"<br><br>4. "What still remains unclear?"<br><br>Weekly or daily journal writing (reflection of lessons and learning).<br><br>Quest - Motion (1-D).<br><br><u>Two-bodied motion assessment</u>:<br>Using various representations, predict, test, and evaluate where two objects (with initial given parameters) will meet. |

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| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12 | Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.A | Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B | Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.C | Scientific knowledge builds on itself over time. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.D | The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12 | Physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.A | All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.B | Substances can undergo physical or chemical changes to form new substances. Each change involves energy. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.C | Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.D | The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.E | It takes energy to change the motion of objects. The energy change is understood in terms of forces. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.a | Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.b | Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.c | Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.a | Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.b | Mathematical tools and technology are used to gather, analyze, and communicate results. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.c | Empirical evidence is used to construct and defend arguments. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.d | Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.a | Refinement of understandings, explanations, and models occurs as new evidence is incorporated. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.b | Data and refined models are used to revise predictions and explanations. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.c | Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.a | Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.b | Science involves using language, both oral and written, as a tool for making thinking public. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.a | The potential energy of an object on Earth's surface is increased when the object's position is changed from one closer to Earth's surface to one farther from Earth's surface. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.1 | Model the relationship between the height of an object and its potential energy. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.d | Energy may be transferred from one object to another during collisions. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.4 | Measure quantitatively the energy transferred between objects during a collision. |
| 2009 | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.a | The motion of an object can be described by its position and velocity as functions of time and by its average speed and average acceleration during intervals of time. |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.b | Objects undergo different kinds of motion (translational, rotational, and vibrational). |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.2 | Compare the translational and rotational motions of a thrown object and potential applications of this understanding. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.c | The motion of an object changes only when a net force is applied. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.3 | Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.d | The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship (a=Fnet/m) is independent of the nature of the force. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles;**

- Velocity and Acceleration instruction should receive conceptual and analytical treatment but be limited to 1 step mathematical problems.
- Strong emphasis should be on visualizing motion with d vs. t and v vs. t graphical analysis.

**Lab:**

- Velocity and Acceleration instruction should receive full conceptual and analytical treatment.
- Strong emphasis should be on visualizing motion with d vs. t, v vs. t and a vs. t graphical analysis including distance calculations from the graph where appropriate.

**Honors:**

- All content should receive full conceptual and analytical treatments.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 03 - Newtonian Dynamics

## Unit 03 - Newtonian Dynamics

**Enduring Understandings:**

External, unbalanced forces are required to change a system's motion.

An object that exerts a force on a second object will have an equal and opposite force exerted on itself by the second object.

**Essential Questions:**

How are Newton's Laws of Motion applied to describe the motion of an object or system?

What are the similarities and differences between types of forces?

How can the forces exerted on an object or system be represented physically and mathematically?

**Unit Goals:**

Students will gain an understanding of Newton's Laws of Motion and how they affect an object's motion.

**Recommended Duration:**

4 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| How can you physically/pictorially represent the forces exerted on a system?<br><br>How are balanced and unbalanced forces represented?<br><br>How do you determine the net force on an object?<br><br>How does Newton's first law relate to constant motion (v=0) and zero net force?<br><br>How can the relationship between mass, net force and acceleration be represented mathematically?<br><br>What is the cause and effect relationship between net force, mass, and acceleration as described in Newton's second law?<br><br>What is Newton's third law?<br><br>How can any side of a tug-of-war win if Newton's third law is true?<br><br>What are different kinds of forces?<br>What is the difference between a field force and a contact force?<br><br>What are the types of friction?<br><br>Why does friction occur?<br>How can friction be both harmful and helpful?<br><br>What is the nature of the spring force? | Identify a system and external objects that interact with it<br><br>Differentiate between types of interactions and how to label and draw them in physical representations<br><br>Draw force and motion diagrams to represent a given scenario<br><br>Identify situations of equilibrium and when they are not<br><br>Understand the mathematical relationship between the mass of an object, the forces exerted on it, and the acceleration of the object<br><br>Determine net force on an object in motion and at rest and predict the magnitude and direction of acceleration<br><br>Identify force pairs and understand that these pairs are two separate objects acting upon one another with potentially different net force magnitude and direction<br><br>Differentiate between field forces and contact forces<br><br>Identify different types of forces and their effects on motion<br>Identify the factors (coefficient of friction and the "normal" force) that affect frictional interactions<br><br>Explore the spring force exerted on an object as the stretch increases | Variety of lab equipment that may be used throughout the year including, but not limited to, meter sticks, timers, scales of various sorts, and glassware (in particular, spring scales, bathroom scales, carts with masses, pulleys, scooters or skateboards, ropes, access to elevator, incline planes, various surfaces, etc.)<br><br>Teacher and student editions of text approved by the district<br><br>Scientific calculators<br><br>Math book for algebraic reference and example problems for conversions<br><br>Internet resources<br><br>Videos (internet DVD, and VHS accessible) to watch frame by frame or regular speed.<br><br>PUM (Physics Union Mathematics) activities for forces (Dynamics Module) | Drop different "weight" objects into student's hands (tennis ball and medicine ball or tennis ball filled with sand)<br><br>Drawing pictures to represent scenario (pictures, force diagrams, vectors), describing using words, and describe using numbers<br><br>Observations of objects moving in various ways in relating motion and force diagrams for those scenarios<br><br>Observations of objects moving in different ways depending on amount of net force and mass of objects<br><br>Formulate the mathematical expression for Newton's second law<br><br>Use force diagrams and Newton's second law to represent forces and their components exerted on an object<br><br>Use two force sensors in collisions and other interactions to have students develop the concepts of Newton's third law.<br><br>Scale readings of hanging objects (attached to one scale and attached to two scales)<br><u>Lab Activities</u>:<br>Acceleration of a Dynamics Cart - Data collection, analysis, and conclusions as to affect of mass and force on acceleration. Observations of objects moving across different surfaces and the forces required to | Pre-test forces.<br><br>Force concepts inventory (FCME - Diagnostic)<br><br><u>Lab Activities</u>:<br>The coefficient of static friction on a horizontal surface and incline - Students collect data with spring scale or force sensor to calculate the coefficient of static friction between the sneaker (or object) and a horizontal board of wood. Students use the information to predict the angle at which the shoe would begin to slide down an incline.<br><br>Three-Dimensional Force Diagrams (with Styrofoam and pipe cleaners) accompanied with a story/scenario<br><br>Quizzes on drawing force diagrams, finding net force, calculating acceleration, mass versus "weight," interpreting |

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| What is gravitational interaction and what object exerts the gravitational force in everyday life?<br><br>How can the gravitational interaction on a system near the Earth's surface be calculated?<br><br>What is "weight?"<br><br>What is the difference between mass and "weight?"<br><br>What does a bathroom scale measure?<br><br>How can Newton's Laws, force diagrams, and motion diagrams be utilized to represent various applications, such as, but not limited to, inclines, elevators, etc.?<br><br>What is the role of inertial and non-inertial reference frames in applications of Newton's Laws?<br><br>What is the role of a "massless string?"<br>What is the role of a "frictionless pulley?"<br><br>How do students represent and analyze a system of two or more objects that have constant acceleration velocity? | Explain Hooke's Law<br><br>Identify the objects involved in gravitational interaction on Earth<br><br>Differentiate between mass and "weight" and understand that mass does not depend upon location but "weight" does<br><br>Recognize that the word "weight" is the force exerted by the Earth on an object<br><br>Recognize that a bathroom scale measures the force exerted by the scale on the object placed upon it.<br>Recognize that Newton's Laws do not apply to objects in an accelerated reference frame<br><br>Recognize that "massless strings" and "frictionless pulleys" connect objects without external consequences | | move those objects<br><br>Frictional Interactions - By dragging objects across various surfaces, students can take force readings required to get the object moving and to keep the object moving at constant velocity<br><br>Normal Force - Students analyze the forces exerted on objects of different mass that compress or stretch materials, in particular, the magnitude of the force perpendicular to the surface on the object<br>Formulate an expression for the force of the Earth exerted on an object by using a spring scale to measure the objects of various mass<br><br>Scale reading in an accelerating elevator (can also be done with a mass, spring scale, and a teacher pulling up on the scale or allowing it to drop slightly... any acceleration will give a different reading on the scale)<br><br>Problem-solving steps and techniques<br><br>Teacher modeling<br><br>Individual work, group work, think, pair, share opportunities, and class discussions | diagrams, and identifying force pairs<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question).<br>Application to previous topics<br><br>Journal writing.<br><br>Quest - Forces |

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|---|---|---|---|---|
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12 | Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A | Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B | Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C | Scientific knowledge builds on itself over time. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D | The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12 | Physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A | All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.C | Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D | The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E | It takes energy to change the motion of objects. The energy change is understood in terms of forces. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.a | Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.b | Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.c | Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.a | Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.b | Mathematical tools and technology are used to gather, analyze, and communicate results. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.c | Empirical evidence is used to construct and defend arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.d | Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.a | Refinement of understandings, explanations, and models occurs as new evidence is incorporated. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.b | Data and refined models are used to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.c | Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.a | Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.b | Science involves using language, both oral and written, as a tool for making thinking public. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.a | The potential energy of an object on Earth's surface is increased when the object's position is changed from one closer to Earth's surface to one farther from Earth's surface. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.1 | Model the relationship between the height of an object and its potential energy. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.d | Energy may be transferred from one object to another during collisions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.4 | Measure quantitatively the energy transferred between objects during a collision. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.a | The motion of an object can be described by its position and velocity as functions of time and by its average speed and average acceleration during intervals of time. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.b | Objects undergo different kinds of motion (translational, rotational, and vibrational). |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.2 | Compare the translational and rotational motions of a thrown object and potential applications of this understanding. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.c | The motion of an object changes only when a net force is applied. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.3 | Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.d | The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship (a=Fnet/m) is independent of the nature of the force. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles:**

- Newton's Laws instruction should be conceptual in nature, with basic mathematical calculations involving net force and acceleration.
- Free Body Diagram instruction should be both conceptual in nature and drawn with limited forces acting on the body.
- Friction instruction should be conceptual in nature, mathematical calculations involving the coefficient of friction is optional but friction should be addressed in free body diagrams.
- Hook's Law and springs instruction should be conceptual in nature, with basic mathematical calculations optional.

**Lab:**

- Newton's Laws instruction should receive full conceptual and analytical treatment.
- Free Body Diagram instruction should be both conceptual in nature and drawn with multiple forces acting on the body.
- Friction instruction should receive full conceptual and analytical treatment including calculations involving the coefficient of friction.
- Hook's Law and springs instruction should receive full conceptual and analytical treatment.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentations, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 04 - Two-Dimensional Kinematics

## Unit 04 - Two-Dimensional Kinematics

**Enduring Understandings:**

The same basic principles and models can describe the motion of all objects.

**Essential Questions:**

How can an object's motion and change in motion be represented verbally, physically, graphically, and mathematically in two dimensions?

**Unit Goals:**

Students will gain an understanding of Newton's Laws of Motion and how they affect an object's motion in two dimensions.

**Recommended Duration:**

2 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
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| What is projectile motion?<br><br>In ideal conditions, what are the horizontal and vertical motions of a projectile?<br><br>What is the shape of a projectile's trajectory?<br><br>Why is the shape of the trajectory of an object in projectile motion parabolic?<br><br>What variables affect the range, altitude, and time of flight?<br><br>What is necessary for an object to maintain circular motion?<br><br>What is the direction of the net force and acceleration on an object that is in circular motion? | Understand that projectile motion includes acceleration in the vertical direction and constant velocity in the horizontal direction<br><br>Draw horizontal and vertical motion diagrams for an object in projectile motion<br><br>Draw the force and motion diagrams of an object in projectile motion and use it to explain the motion diagrams<br><br>Apply vectors to projectile motion to demonstrate parabolic shape and determining resultant velocities<br><br>Draw and label the range, trajectory, and altitude of an object in projectile motion<br><br>Identify the variables that affect range, time of flight, and altitude<br><br>Understand circular motion and draw and label diagrams to explain it | Variety of lab equipment that may be used throughout the year including, but not limited to, meter sticks, timers, scales of various sorts, and glassware (in particular, projectile launchers, tennis balls, simultaneous marble drop apparatus, strings with rubber stoppers attached, bucket with long handle to swing in vertical and horizontal circles)<br><br>Teacher and student editions of text approved by the district<br><br>Scientific calculators.<br><br>A math book for algebraic reference and example problems for conversions<br><br>Internet resources | Observations of objects moving in different ways (thrown up into the air while thrower is stationary, thrown up into the air while the thrower is walking at a constant velocity, dropped from the edge of a table, rolled off a table, and/or tossed to a catcher)<br><br>Use the *Road Trip* to examine a filmed jump and see if it agrees with the conditions set forth by the characters in the movie<br><br>Use launchers to determine range and ideal launching angle<br><br>Have students try to get a ball to move in a circular path and report what was necessary to get it to move that way<br><br>Swing a bucket of water in a circle then have students swing their arm in a circle<br><br>Explain the circular motion of various amusement park rides | Pre-test on two-dimensional motion<br><br><u>Lab Activities</u>:<br>Projectile motion - Qualitative analysis. Students try to project ball into a bowl<br><br>Circular motion Quantitative analysis, examine videos or demonstrations for objects moving in circular motion (i.e., Ferris wheel, a ball in a hoop, etc.), qualitative analysis, and student conclusions<br><br>Project - Create a project to examine the banking angle of a turn<br><br>Quizzes on projectile motion and aspects, drawing force diagrams, finding net force (centripetal), calculating centripetal acceleration, and interpreting diagrams |

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| | Differentiate between centripetal and centrifugal motion<br><br>Give and explain examples of objects in circular motion and the forces that allow them to maintain that motion<br><br>Differentiate between terms centripetal and centrifugal<br><br>Realize that there is no object exerting a force directed away from the center of the circle<br><br>Use components to determine the net force that keeps an object in circular motion | Occasional computer access<br><br>Videos (internet, DVD, and VHS accessible) to watch frame by frame or regular speed | Use real-life experiences of objects moving in circular motion (race cars on a track, the Moon going around the Earth, the Earth going around the Sun) and ask students to think about what kind of forces are causing the objects to move in a circle<br><br>Drawing pictures to represent scenario (pictures, force diagrams, vectors), describing using words, and describe using numbers.<br><br>Problem-solving steps and techniques<br><br>Teacher modeling<br><br>Individual work, group work, think, pair, share opportunities, and class discussion | Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Quest - Motion (two-dimensional)<br><br>Unit test - Motion (one dimensional and two-dimensional) and forces |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12 | Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A | Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B | Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C | Scientific knowledge builds on itself over time. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D | The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12 | Physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A | All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.C | Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D | The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one |

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| | | | | object to another. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E | It takes energy to change the motion of objects. The energy change is understood in terms of forces. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.a | Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.b | Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.c | Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.a | Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.b | Mathematical tools and technology are used to gather, analyze, and communicate results. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.c | Empirical evidence is used to construct and defend arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.d | Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.a | Refinement of understandings, explanations, and models occurs as new evidence is incorporated. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.b | Data and refined models are used to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.c | Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.a | Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.b | Science involves using language, both oral and written, as a tool for making thinking public. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.a | The potential energy of an object on Earth's surface is increased when the object's position is changed from one closer to Earth's surface to one farther from Earth's surface. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.1 | Model the relationship between the height of an object and its potential energy. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.d | Energy may be transferred from one object to another during collisions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.4 | Measure quantitatively the energy transferred between objects during a collision. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.a | The motion of an object can be described by its position and velocity as functions of time and by its average speed and average acceleration during intervals of time. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.b | Objects undergo different kinds of motion (translational, rotational, and vibrational). |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.2 | Compare the translational and rotational motions of a thrown object and potential applications of this understanding. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.c | The motion of an object changes only when a net force is applied. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.3 | Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.d | The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship (a=Fnet/m) is independent of the nature of the force. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles:**

- Projectile motion instruction should be conceptual in nature, with basic mathematical calculations optional.
- Circular motion instruction and problems should be conceptual in nature, with basic mathematical calculations optional.

**Lab:**

- Projectile motion instruction should receive full conceptual and analytical treatment with the exception of changing Y projectiles.
- Circular motion instruction should receive full conceptual and analytical treatment with the exception of banked turns.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena:
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 05 - Circular Motion and Gravitation

## Unit 05 - Circular Motion and Gravitation

**Enduring Understandings:**

The same basic principles and models can describe the motion of all objects.

Gravity is the universal force of attraction between all masses.

**Essential Questions:**

What is necessary for an object to travel in a circular path?

How does gravitational force differ from other forces?

How does mass and distance affect the gravitational force of objects acting on each other?

**Unit Goals:**

Students will understand that all objects with mass exert forces on other objects with mass.

**Recommended Duration:**

2 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| In what ways is gravitational force explained by Newton's third law?<br><br>What is the Universal Law of Gravitation?<br><br>How does the gravitational force depend on distance between objects?<br><br>What is the mathematical expression for the Universal Law of Gravitation and how can variables be solved for using the expression?<br><br>How is circular motion related to gravitational forces?<br><br>What are Kepler's three planetary laws and how will they be used (including assumptions) to predict planetary motion?<br><br>What is a gravitational field and what are the factors?<br><br>What is the operational definition for a gravitational field? | Relate gravity (gravitational force) to Newton's third law<br><br>Understand that gravitational force is universal and attractive, not repulsive<br><br>Recognize that the gravitational force is proportional to the inverse square of its distance<br><br>Calculate gravitational force using the Universal law of gravitation (ULOG)<br><br>What types of interactions occur when considering gravitational forces?<br><br>Recognize the gravitational force as a field force<br><br>Recognize that gravitational forces can be the cause for an object's circular motion<br><br>Approximate planetary motion to circular motion around the Sun<br><br>Differentiate between gravitational forces, the resulting acceleration of an object, and the mechanism that causes the attraction in the field | Variety of lab equipment that may be used throughout the year including, but not limited to, meter sticks, timers, scales of various sorts, and glassware<br><br>Teacher and student editions of text approved by the district<br><br>Scientific calculators<br><br>A math book for algebraic reference and example problems for conversions<br><br>Internet resources<br><br>Videos (internet, DVD, and VHS accessible)<br><br><u>The Elegant Universe, Hour One, Parts 2 and 3</u><br><br>Blanket, baseball, and marble for Einstein's analogy<br><br>PUM (Physics Uniting Math) | Relating Newton's Third Law of Motion to ALL objects. Ask students if the Earth pulls on an apple, shouldn't the apple pull on the Earth? Focus on the magnitude of the force between Earth and apple. Compare to Earth and moon<br><br>Graph the acceleration due to the pull of the Earth at different altitudes and different latitudes<br><br>Calculate the "weight" of an object at these different altitudes and latitudes<br><br>Calculate for the mass of an object when it "weighs" a certain amount on the surface of different planets<br><br>Graph and find relationships between gravitational force and distance between objects<br><br>Graph and find relationships between gravitational force and the product of objects' masses<br><br>Observations of moon's path around the Earth and Earth's path around the Sun<br><br>Develop models on shape of path and what causes this path<br>Predict and test using planet's path around Sun | Pre-test on gravitational forces<br><br><u>Lab Activities</u>:<br>What's your "Weight?" - Data collection<br>Calculation, graphing, and data analysis. Students make conclusion of dependence of location and mass to "weight." Answer questions about mass, "weight," and location<br><br>Discovering Universal law of gravitation - Use prefabricated data of gravitational force and distance. Students graph and analyze. Use prefabricated data of gravitational force and product of masses<br><br>Students' graph and analyze. Interactive white board presentation of data to class<br><br>Quizzes on "weight" and mass, calculating acceleration due to gravity, ranking "weights" at different locations, using Universal Law of Gravitation to solve for unknown, interpreting graphs, describing motion (in words and pictorially), and planetary motion |

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| Why is 9.8 $m/s^2$ not gravity?<br><br>What does 9.8 N/kg mean about the Earth's interaction with objects of mass?<br><br>What is the difference between mass and "weight?"<br><br>How does "weight" depend upon location?<br><br>Why do we consider acceleration due to the gravitational pull of the Earth to be constant when, in actuality, it is not?<br><br>Why gravitational force is not considered the primary force at the atomic/sub-atomic level? | Calculate the gravitational field at different points around the Earth and on other planets<br><br>Use Einstein's analogy of the alteration of space-time to explain how two objects can interact without touching each other<br><br>Identify when acceleration due to gravity can be considered constant and when it is not<br><br>Differentiate between and calculate mass, "weight," and acceleration due to gravity<br><br>Understand that "weight" is not constant<br><br>Understand that objects at microscopic and macroscopic levels are affected by gravitational forces and may result in circular motion<br><br>Explain why gravity is a macro-concept and not a micro-concept | | Relate Newton's third law of motion to circular motion to get ideas on planetary motion<br><br><u>The Elegant Universe, Hour One, Parts 2 and 3</u><br><br>Blanket, baseball, and marble for Einstein's analogy<br><br>Historical significance of the motion of planets and the Universal law of gravitation (Copernicus, Tycho Brahe, Johannes Kepler, Isaac Netwon, and Henry Cavendish)<br><br>Graph and find relationships between gravitational field and product of object's masses<br><br>Compare and contrast motion of electrons around atomic nucleus to planets (This would require students to have prior knowledge of atomic structure and the property of matter that includes charges. Use at teacher's discretion) | Homework (Collected, checked, and gone over in class)<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>"What have I learned today and why do I believe it?"<br>"ABC" cards (multiple choice questions where students show their answer choice to teacher). "How does this relate to...?" "What still remains unclear?"<br>Weekly (or daily) journal writing (reflection of lessons and learning).<br><br>Quest - gravitational force |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12 | Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A | Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B | Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C | Scientific knowledge builds on itself over time. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D | The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12 | Physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A | All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.B | Substances can undergo physical or chemical changes to form new substances. Each change involves energy. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.C | Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D | The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E | It takes energy to change the motion of objects. The energy change is understood in terms of forces. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.a | Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.b | Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.c | Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.a | Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.b | Mathematical tools and technology are used to gather, analyze, and communicate results. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.c | Empirical evidence is used to construct and defend arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.d | Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.a | Refinement of understandings, explanations, and models occurs as new evidence is incorporated. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.b | Data and refined models are used to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.c | Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.a | Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.b | Science involves using language, both oral and written, as a tool for making thinking public. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.a | The potential energy of an object on Earth's surface is increased when the object's position is changed from one closer to Earth's surface to one farther from Earth's surface. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.1 | Model the relationship between the height of an object and its potential energy. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.a | The motion of an object can be described by its position and velocity as functions of time and by its average speed and average acceleration during intervals of time. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.b | Objects undergo different kinds of motion (translational, rotational, and vibrational). |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.2 | Compare the translational and rotational motions of a thrown object and potential applications of this understanding. |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.c | The motion of an object changes only when a net force is applied. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.3 | Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.d | The magnitude of acceleration of an object depends directly on the strength of the net force, and inversely on the mass of the object. This relationship (a=Fnet/m) is independent of the nature of the force. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles:**

- Weight vs. mass instruction should receive full conceptual and analytical treatment.
- Kepler's Laws instruction should be conceptual in nature, not mathematical.
- The Law of Universal Gravitation instruction should be conceptual in nature, with limited mathematical analysis.

**Lab:**

- Weight vs. mass instruction should receive full conceptual and analytical treatment.
- Kepler's Laws instruction should be conceptual in nature, with limited mathematical treatment.
- The Law of Universal Gravitation instruction should receive full conceptual and analytical treatment.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 06 - Momentum

## Unit 6 Plan - Linear Momentum

**Enduring Understandings:**

Momentum is conserved in a closed system.

**Essential Questions:**

How can an object's momentum be represented verbally, graphically and mathematically?

Why is momentum conserved in collisions?

**Unit Goals:**

Momentum is a physical quantity that only moving objects have.

Momentum is conserved within a system.

Students will understand that momentum is conserved in a closed system.

Using Newton's third law to explain momentum conservation.

To solve simple momentum problems, recoil problems, and to use law of conservation in problem solving.

**Recommended Duration:** 2 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| What is the momentum of an object?<br><br>How can the momentum of an object be calculated?<br><br>What are the different types of collisions?<br><br>Is force related to momentum? If so, how? If not, why?<br><br>How are an object's inertia and momentum related?<br><br>What is the difference between momentum and impulse? | Define what momentum is and be able to calculate it for various situations<br><br>Differentiate between different types of collisions and explain the resultant velocities<br><br>Differentiate momentum from force exerted on object and the object's inertia<br><br>Compare and contrast and object's momentum and inertia<br><br>Understand that the impulse is equal to the change in the momentum in a system<br><br>Calculate impulse and momentum<br><br>Recognize that momentum is conserved in a closed system- the total momentum before event is equal to the total momentum after event<br><br>Demonstrate knowledge of the law of conservation in multiple representations including but not limited to mathematical, pictorial and graphical. | Variety of lab equipment that may be used throughout the year. Including but not limited to meter sticks, timers, scales or various sorts, and glassware<br><br>ESPECIALLY collision carts (or low friction cars) with interchangeable bumpers (for elastic and inelastic), kick disks (for glancing and head on collisions)<br><br>Textbooks<br><br>Textbook ancillaries<br><br>Scientific calculators<br><br>Algebra book for reference and example problems for conversions.<br><br>Internet resources<br><br>Occasional computer access<br><br>Videos (internet, DVD and VHS accessible) to watch frame by frame or regular speed to view collisions between objects<br><br>PUM (Physics Uniting Math) Activities for conservation laws | Observations of objects colliding<br><br>Head on: Elastic and inelastic<br><br>Glancing: Elastic and inelastic<br><br>Two objects moving: Towards each other, same direction but different speeds<br><br>One object moving, one object stationary | Pre-test on conservation laws<br><br>Lab Activities:<br>Types of collisions<br>Qualitative analysis of different types of collisions. Develop model, predict and test<br><br>Students make conclusion of dependence type of collision, mass and resulting velocities.<br><br>Conservation of momentum: Quantitative analysis of collisions. Using models developed from types of collisions and patterns from quantitative data collected, develop law of conservation<br><br>Predict and test for objects with different motions<br><br>Quizzes on types of collisions, calculating momentum, relationships between mass, inertia, force, velocity, and momentum, ranking and comparing momentums, using conservation of momentum |

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| How can impulse and momentum be calculated to solve for the unknown variable?<br><br>What is the law of conservation of momentum and how does it apply to different collisions?<br><br>How can conservation of momentum be represented? | | | Relate change in velocity in given time period (acceleration)<br>to the force of impact and mass of object<br>(equate mathematic expressions for kinematics version of<br>acceleration to dynamics version of acceleration to derive<br>term for impulse)<br>Use expression to define "impulse" | |

## Differentiation

**Principles:**

- Momentum instruction and problems should be conceptual in nature with basic mathematical calculations on momentum and impulse.
- The momentum Impulse Theorem should be analyzed conceptually, with mathematical calculations optional.
- Collision instruction should be conceptual in nature, with mathematical calculations limited to 2 object interactions.
- Elastic vs. Inelastic interactions instruction should be conceptual in nature.

**Lab:**

- Momentum should receive full conceptual and analytical treatment.
- The momentum Impulse Theorem should receive full conceptual and analytical treatment.
- Collision instruction should be conceptual in nature, with mathematical calculations limited to at most 3 object interactions with emphasis.
- Elastic vs. inelastic interactions should be fully explored conceptually and limited exposure mathematically.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 07 - Work & Energy

## Unit 7 Plan Work and Energy

**Enduring Understandings:**

Energy is a property of objects and substances that exists and can be transferred between many forms.

Energy is conserved in a closed system.

**Essential Questions:**

How can the energy of an object be represented verbally, physically, graphically, and mathematically?

How does work done on a system affect the total energy of the system?

How can the conservation of energy in a system be represented graphically and mathematically?

**Unit Goals:**

Students will understand that energy is conserved within a system.

Students will define and differentiate between energy and matter.

Students will define and calculate work.

**Recommended Duration:** 3 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
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| What is the relationship between kinetic and potential energy?<br><br>What are different types of potential energy?<br><br>What are the different forms of energy?<br><br>What is the difference between an energy transformation and an energy transfer?<br><br>When do conservation laws apply to changing systems? | Differentiate the different forms of energy and give real life examples of each.<br><br>Differentiate between energy transformations and energy transference and demonstrate this knowledge with real world applications.<br><br>Apply the law of conservation of energy to describe changing systems<br><br>Demonstrate knowledge of the relationship between kinetic and potential energy using mathematical, pictorial and graphical representations<br><br>Relate the definition of work in a scientific setting and differentiate it from non-scientific connotations.<br><br>Understand the work-energy theorem<br><br>Explain the law of conservation of energy and how energy is conserved only in a closed system. | Putty (or objects that can be crushed and deformed), objects of similar shape but different mass, motion sensors (or way of measuring velocity of an object), staircase/bleacher steps<br><br>Textbooks<br><br>Textbook ancillaries<br><br>Scientific calculators<br><br>Algebra book for reference and example problems for conversions.<br><br>Internet resources<br><br>Occasional computer access<br><br>Videos (internet, DVD and VHS accessible) to watch frame by frame or regular speed<br><br>PUM (Physics Uniting Math) Activities for Conservation Laws (Energy Module) | Lab Activities:<br><br>Potential and Kinetic Energy<br><br>Qualitative analysis of different types of energy. Develop model, predict and test.<br><br>Students make conclusion of dependence type of energy, mass, height, and resulting velocities.<br><br>Conservation of energy:<br>Quantitative analysis of work and energy.<br>Students do work to get an object to some height, predict and test. Collect data to calculate potential and kinetic energy at max height. Allow object to fall through sensor or objects, collect data from sensor (velocity) and calculate potential and kinetic energy<br><br>Observations of various massed objects falling from different heights on putty.<br>Compare and contrast the resulting shape of putty when constant mass is dropped for increasing heights fro when it was just sitting on top of putty.<br><br>Use variables on this concept.<br><br>Chart different types of energy and when, where and for what situations each would apply. | Lab Activities-<br><br>Potential and Kinetic Energy Qualitative analysis of different types of energy. Develop model, predict and test Power Students collect data (time, distance/height, and force/weight) for walking up steps. Calculate power. Compare and contrast power of different students. Answer questions regarding power, force, time and 'strength' of students.<br><br>Quizzes on types of energy, calculating energy, work and power, work-energy theorem, using conservation of energy and conservation bar charts<br><br>Homework (collected, checked, reviewed in class)<br><br>Check students' use of vocabulary and explanations throughout lessons |

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| What is work?<br><br>How are work and energy related?<br><br>What is power and how is it calculated? | Calculate work and to distinguish when it is being done on a system as opposed to when it is being done by a system.<br><br>Calculate power recognize that it is a change in energy or work within a given time frame. | | | Closure-<br><br>"What have I learned today and why do I believe it?"<br><br>Represent and reason<br><br>Jeopardy questions<br><br>Weekly (or daily) journal Writing (reflection of lessons and learning)<br><br>Unit test-Conservation laws |

## Differentiation

**Principles:**

- Potential and kinetic energy instruction should be conceptual in nature, with basic mathematical calculations.
- Work instruction should be conceptual in nature, with basic mathematical calculations.
- Power instruction should be conceptual in nature, with basic mathematical calculations.
- Conservation of energy should be underlying theme.

**Lab:**

- Potential and kinetic energy instruction should encompass both conceptual and analytical treatment.
- Work and power instruction should encompass both conceptual and analytical treatment including basic application of the work energy theorem.
- Conservation of energy should be underlying theme.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 08 - Rotational Motion

## Unit Plan

**Enduring Understandings:**

The same basic principles and models can describe the motion of all objects.

External, unbalanced forces are required to change a system's motion.

**Essential Questions:**

How can the rotational motion of an object be represented verbally, physically and mathematically?

How can the torques exerted on an object or system be represented physically and mathematically?

**Unit Goals:**

There is a difference between circular and rotary motion that depends on the axis in which the object moves about.

Rotary terms can be translated into linear terms and vice versa.

An object's equilibrium depends on center of mass and torque exerted on the object.

Students will gain an understanding of the mechanics of rotational motion and be able to calculate torque, moment of inertia and angular acceleration of this motion.

**Recommended Duration: 2** weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| Distinguish between rotational motion and revolution.<br><br>Calculate angular speed.<br><br>Explain how angular speed, linear speed, and distance are related. Investigate angular momentum and rotational inertia | What is necessary for an object to travel in a circular path? | Variety of lab equipment that may be used throughout the year. Including but not limited to meter sticks, timers, scales of various sorts, and glassware<br><br>Especially stretchy material, spherical objects of mass (for Einstein's analogy)<br><br>Teacher and student editions of text approved by the district.<br><br>Scientific calculators.<br><br>Possibly a math book for algebraic reference and example problems for conversions<br><br>Internet resources | Relating Newton's third law of motion to all objects. Ask students if the Earth pulls on an apple, shouldn't the apple pull on the Earth?<br><br>"Lady Bug activity" found on Phet<br>(an inquiry based rotational motion exploration) | Pre-test<br><br>Check students' use of vocabulary and explanation throughout lessons<br><br>Problem solving and bard work (white boarding in groups)<br><br>Closure questions:<br><br>What have I learned today and why do I believe it?<br>How does this relate to...?<br>Design and solve physics questions.<br>What still remains unclear? |
| Explain how centripetal force causes circular motion and describe its relationship with gravitational force.<br><br>Relate to orbital motion | How is gravitational force defined and conceptualized? | | Use simulations on phet | Application problems<br>Journal writing<br><br>Daily or weekly quest: Rotational motion |

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| Define center of mass and center of gravity.<br>Explain how to locate an objects center of mass and center of gravity and use to explain toppling. Explain torque and static equilibrium. | | | Have students view rotational symmetry images (found on internet) then have them draw designs that are rotationally symmetrical<br>Take this in any direction needed. | Lab activities<br>Unit test |

## Differentiation

**Principles:**

- Conceptual instruction on this unit is optional.

**Lab:**

- Rotational motion instruction should be conceptual in nature, with emphasis on the concepts of center of mass, rotation vs. revolution, and the implications of moment of inertia.
- Analytical treatment of center of mass and moment of inertia are optional.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 09 - SHM & Waves

## Unit 9 Plan - Simple Harmonic Motion, Waves, and Wave Motion

**Enduring Understandings:**

Energy is conserved in a closed system.
The same basic principles and models govern the behavior of waves when they interact with matter and with other waves.

**Essential Questions:**
What are the characteristics of a simple harmonic oscillator?

How can the model of a simple harmonic oscillator be related to the model of a wave?

How are the properties of waves affected when waves interact?

**Unit Goals:**
Students will gain an understanding of Simple Harmonic Motion and its relationship to wave motion.

**Recommended Duration:** 3 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
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| What conditions are necessary for an object to be in simple harmonic motion?<br><br>What is simple harmonic motion and how does it differ from periodic motion?<br><br>How can the spring constant be found using Hooke's Law? | Identify the conditions of simple harmonic motion<br><br>Explain how force, velocity, and acceleration change as an object vibrates with simple harmonic motion<br><br>Calculate the spring's restoring force and spring constant using Hooke's law | Variety of lab equipment that may be used throughout the year. Including but not limited to meter sticks, timers, scales of various sorts, and glassware.<br><br>Especially<br><br>(SHM) springs with different spring constants, masses, pendulum bobs.<br><br>Textbooks<br><br>Textbook ancillaries | Observations of a spring's stretch when different masses are hung from it. Class plots force vs. stretch and analyze data. Slope of the line is spring constant. Predict what the stretch should be for a new mass<br><br>Test<br><br>Data of period of pendulum swing at different locations on the Earth for one meter long pendulum: graph | Pre-test on mechanical waves and wave motion<br><br>Lab Activities<br><br>Simple Harmonic Motion Hooke's Law- Students collect data and find patterns to determine factors that affect the period of vibration.<br><br>Present findings to class |
| What is the relationship between the restoring force and displacement?<br><br>How are frequency and period related?<br><br>How can the frequency and period be calculated using simple harmonic motion? | Identify the amplitude of vibration<br><br>Recognize the relationship between period and frequency.<br><br>Calculate the period and frequency of an object vibrating with simple harmonic motion. | Scientific calculators<br><br>Algebra book for reference and example problems for conversions. | Pet Applets for oscillating springs<br><br>Introduce new potential energy Elastic Potential Energy<br><br>Use Energy Bar Charts and make scenarios that will include kinetic energy, gravitational potential and elastic potential energy | Pendulums- Students collect data for one variable of possible factor that affects period of pendulum swing. Interactive white board presentation to class.<br><br>Class conclusion as to which factors affect period of pendulum swing<br><br>Quizzes on Hooke's Law, simple harmonic motion, pendulums, and factors that affect period of oscillation/vibration |

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| How can energy be used to explain simple harmonic motion? | Apply energy to simple harmonic motions and draw energy bar charts with elastic potential energy | Internet resources<br><br>active physics online<br><br>Occasional computer access<br><br>Videos (internet, DVD and VHS accessible) to watch frame by frame or regular speed to view objects in simple harmonic motion | Energy transforms for a swinging pendulum | Homework (collected, checked, reviewed in class)<br><br>Check students' use of vocabulary and explanations throughout lessons<br><br>Problem solving and board work<br><br>Closure Questions<br><br>Pre-test on mechanical waves and wave motion<br><br>Lab activities<br><br>Ripple tanks<br><br>Use ripple tanks to observe characteristics of mechanical waves (like water waves)<br><br>Answer questions about different characteristics<br><br>Speed of a wave in a string<br><br>Students calculate the speed of a wave in a string<br><br>Quizzes on parts of a wave, different types of waves, characteristics of waves, speed of a wave, interpreting and making graphs, drawing the resulting wave from two interference waves, standing waves<br><br>Unit test |

## Differentiation

**Principles:**

- Simple Harmonic Motion instruction should be conceptual in nature, not mathematical.
- Hook's Law and Spring Constants instruction should be conceptual in nature, not mathematical.
- Focus should be on using physical, graphical and pictorial representations to model simple harmonic motion and wave relationship with minimal emphasis on mathematics.

**Lab:**

- Simple Harmonic Motion instruction should be conceptual in nature, with basic calculations of period, frequency, string length and spring constants.
- Focus should be on using physical, graphical and pictorial representations to model simple harmonic motion and wave relationship with basic integration of mathematics.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 10 - Sound

## Unit Plan

**Enduring Understandings:**

The same basic principles and models govern the behavior of waves when they interact with matter and with other waves.

Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.

**Essential Questions:**

What is the relationship between the physical quantities and perceived qualities of sound?

How do the physical quantities and perceived qualities of sound change depending on the relative motions of the source and the observer?

**Unit Goals:**

1. Describe the relationship between the physical quantities of waves and the perceived qualities of the sound they produce.
2. Describe and diagram how the perception of sound changes depending on the relative motions of the source and observer.

**Recommended Duration:** 2 weeks

| **Guiding/Topical Questions** | **Content/Themes/Skills** | **Resources and Materials** | **Suggested Strategies** | **Suggested Assessments** |
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| How are sound waves produced?<br><br>What type of wave is a sound wave?<br><br>In what direction is the propagation of a sound wave?<br><br>What is the difference between a spherical wave, a plane wave and a standing wave? | Explain how sound waves are produced and transmitted<br><br>Relate plane waves to spherical waves | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (speaker, rubber bands, tuning forks, metal rods) | Class discussion focusing on review of wave properties and types of waves, developing model for sound propagation and sound waves<br><br>Demonstration/Mini-Lab: Sources of sound - Use deconstructed speaker, rubber band, tuning fork, voice to generate sounds. Students observe what is occurring in each case and report back to class | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |
| What factors affect the speed of sound? | Compare the speed of sound in various media and in different temperatures. Explain why temperature and the medium a sound travels through affects the speed of the sound wave | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Lab equipment (wood blocks, stopwatches, calculators, measuring tapes, thermometers, computers) | Class discussion focusing on relation of kinetic molecular theory, molecular collisions and sound propagation<br><br>Lab: Determining speed of sound - Measure time for sound to travel across athletic fields, time echoes when sound reflects off an object. Graph distance traveled vs. travel time. Compare results to theoretical speed of sound based on atmospheric temperature | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |

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| What are the qualities of sound that the human ear can perceive?<br><br>What is the relationship between the qualities of perceived sound and the physical quantities associated with them?<br><br>What is the audible range of human hearing? | Relate frequency to pitch<br><br>Relate harmonics to timbre<br><br>Calculate the intensity of sound waves<br><br>Relate intensity to decibel level and perceived loudness<br><br>Calculate the decibel level of perceived sound<br><br>Explain how the parts of the inner ear and identify its parts | Multimedia presentation<br><br>Interactive whiteboards<br><br>Online streaming videos<br><br>Tone generator software (Audacity) and speakers | Class discussion focusing on physical quantities and perceived qualities of sounds, relationships between them, intensity vs. relative intensity and mathematical relationships between physical quantities.<br><br>Demo: Hearing "test" to allow students to determine their audible frequency range.<br><br>Describe real-world examples of threshold of hearing and threshold of pain. | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |
| What are the properties that affect the sound a plucked string produces? | Diagram the formation of waves on a string, identifying all physical quantities<br><br>Explain how changing tension, length and linear density of a string affects the physical quantities and perceived qualities of the sound that is produced | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (guitar strings, rubber bands, meter sticks, balances, calculators)<br><br>String instruments (guitar, ukulele, violin, cello, piano) | Demo: Tin can telephones<br><br>Mini Lab: Plucking strings and rubber bands - students observe sounds created by strings and bands with different physical properties. Derivation of equation relating tension, length, density of string from student observations<br><br>Class discussion focusing on string properties and the effect on sounds produced<br><br>Demo: String instruments - Have students (and teachers) who play string instruments bring in their instruments and explain how the instruments are played | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |

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| What is resonance and how does it occur? | Explain the process of resonance and explain how it occurs | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos | Class discussion focusing on resonance and sound production from resonance<br><br>Demo: Singing wine glass<br><br>Demo: Blowing into soda bottles to generate musical notes<br><br>Demo: Paired tuning forks & resonance boxes<br><br>Video & Discussion: Tacoma Narrows Bridge collapse | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |
| What is the difference between a closed and open tube when creating sound?<br><br>How can the harmonics of a musical note be calculated?<br><br>What is an octave? | Diagram the differences between the harmonic series of closed and open pipes, identifying all nodes and antinodes present.<br><br>Calculate the harmonics of sounds created using open and closed pipes. | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (resonance tubes, tuning forks, meter sticks, computers)<br><br>Woodwind and brass instruments (flute, clarinet, trumpet, trombone) | Demo: Blowing into soda bottles (with different height liquids)<br><br>Class discussion focusing on resonance in open and closed tubes, diagramming and modeling wave patterns in closed and open tubes, deriving formulas for fundamental and harmonics for sounds generated from closed and open tubes.<br><br>Lab: Calculating speed of sound using water columns - Generating resonant tones from a closed tube, students will calculate the frequency and wavelength of the sound waves generated, as well as the speed of sound. Compare & contrast measured speed of sound and theoretical speed of sound<br><br>Demo: Brass instruments - Have students (and teachers) who play brass instruments bring in their instruments and explain how the instruments are played. | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |

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| What are beats?<br><br>How can beats be calculated using given frequencies of sound? | Explain and diagram beat formation due to interference of two different sound waves.<br><br>Calculate and relate frequency difference between two sound waves and frequency of audible beats. | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Tone generator software (Audacity) and speakers<br><br>Lab equipment (adjustable tuning forks with resonance boxes) | Demo: Beats created by adjustable tuning forks<br><br>Demo: Beats created by tone generator software using stereo speakers<br><br>Class discussion focusing on creation of beats from differing frequencies of two sound sources<br><br>Activity: Graphing interference effects from two provided sound waves (by hand or by using laptops/Excel) | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |
| What is the Doppler Effect?<br><br>What conditions are necessary for the Doppler Effect to be observed?<br><br>How can you calculate the difference in perceived sound due to the Doppler Effect? | Diagram the creation of a Doppler Effect between a sound source and the observer of that sound.<br><br>Determine the direction of a frequency shift based on the relative motions between a sound source and the observer of that sound.<br><br>Calculate the change in frequency due to the Doppler Effect. | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Tone generator software (Audacity) and speakers<br><br>Lab equipment (Doppler ball) | Activity: Tossing Doppler Effect balls - Students will observe and describe perceived sounds generated from sound source.<br><br>Demo: Moving sound source - Quickly move a sound source towards and away from students (i.e. skateboard/bike), by shaking speaker box while generating tones.<br><br>Class discussion focusing on modeling Doppler Effect based on prior knowledge of wave mechanics and relative motion of sound source, derivation of mathematical formula based on Doppler Effect model, and calculations solving for perceived change in frequency due to Doppler Effect effect. | Pre-test on Sound<br><br><u>Lab Activities</u>:<br>Intensity and Frequency of sound<br><br>Quizzes on calculating intensity, frequency and wavelength<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question). Application to previous topics<br><br>Journal writing<br><br>Unit Test |

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| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.3 | Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.4 | 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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.1 | Write arguments focused on discipline-specific content. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.2 | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.7 | 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. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.1 | Use atomic models to predict the behaviors of atoms in interactions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.C.1 | Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.4 | Measure quantitatively the energy transferred between objects during a collision. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles:**

- Provide students speed of sound values at given temperatures (opposed to having them calculate them).
- Speed of sound instruction and problems should be conceptual in nature, with basic mathematical calculations.
- Sound intensity instruction and problems should be conceptual in nature, not mathematical.
- Doppler Effect instruction and problems should be conceptual in nature, not mathematical.
- Resonance, closed and open tubes should be conceptual in nature, not mathematical.
- Beat frequency instruction and problems should be conceptual in nature, with basic mathematical calculations.
- Inner ear and identifying its parts is optional.

**Lab:**

- Provide students speed of sound values at given temperatures (opposed to having them calculate them).
- Speed of sound instruction should receive full conceptual and analytical treatment.
- Sound intensity instruction should be conceptual in nature, with calculations for intensity at distances from source.
- Doppler Effect instruction should be conceptual, with calculations for change in perceived frequency.
- Resonance, closed and open tubes should be conceptual, with basic calculations for wavelength, frequency and sound.

- Inner ear and identifying its parts is optional.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
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- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 11 - Light & Optics

## Unit Plan

**Enduring Understandings:**
The same basic principles and models govern the behavior of waves when they interact with matter and with other waves.
Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.

**Essential Questions:**
How have previous models and understanding of light contributed to the current model of light?
How can the characteristics of light be represented verbally, physically, graphically, and mathematically?
How can the characteristics of an image produced by an optical device be represented verbally, graphically and mathematically?

**Unit Goals:**
1. Explain the current model of light using previous models as a basis.
2. Describe the characteristics of light, using multiple representations.
3. Describe the images produced by mirrors and lenses, using multiple representations.

**Recommended Duration:** 4 weeks

| **Guiding/Topical Questions** | **Content/Themes/Skills** | **Resources and Materials** | **Suggested Strategies** | **Suggested Assessments** |
|---|---|---|---|---|
| What is light, and what are the characteristics of light?<br><br>What is a laser and what advantage do lasers have over other light sources? | Understanding the particle and wave nature of light, and that they can both be applied depending on the scenario<br><br>Defining rectilinear propagation, reflection and refraction, and describing situations when each would occur<br><br>Describe the properties of laser light as compared to white light<br><br>Explain scenarios where laser light may be more advantageous in certain applications | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (Prisms, mirrors, lasers, screens, meter sticks) | Activity: Properties of light - Using light sources and lasers to discover and demonstrate rectilinear propagation, reflection and refraction<br><br>Class discussion focusing on history of the development of the current model of light, observed properties of light, and the current model of light. Discussion of lasers and differences between lasers and other light sources | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |
| How are colors related to light?<br><br>What affects the observed color of an object? | Describe how additive colors affect the color of light<br><br>Describe how pigments affect the color of reflected light off of an object | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (light sources, acetate gels, laptops) | Class discussion focusing on review of components of white light (from previous science course) and the additive nature of white light.<br><br>Demo: Additive colors - Use gels to remove colors from LCD projected image.<br><br>Online Activity: Additive colors | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| What factors affect the propagation and brightness of light? | Describe how the brightness of a light source is affected by distance? | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (light sources, screens, light sensor, laptops) | Activity: Flashlights - Students will observe how flashlight intensity changes depending on distance from projection screens. Using light sensor, students will develop model for relationship between brightness and distance<br><br>Class discussion focusing on modeling inverse square rule, relationship between brightness and distance from source | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What is the difference between specular and diffuse reflection?<br><br>What is an image, and how is it different from the object that is the source of light that creates it?<br><br>What is the Law of Reflection, and how does it affect image formation in plane mirrors?<br><br>How does the number of images depend on the angle formed between two plane mirrors? | Distinguish between specular and diffuse reflection.<br>Describe the nature and characteristics of images formed by plane mirrors.<br>Apply the Law of Reflection to plane mirrors | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (light sources, screens, plane mirrors, meter sticks, laptops) | Lab: Plane mirror reflection - Using pins, a pin board and a flat mirror, students will develop a model for reflection off mirrors. Students will relate object and image distance, angles of incidence and reflection<br><br>Class discussion focusing on types and characteristics of mirrors, reflection, plane mirrors, ray diagrams, calculations involving images created from plane mirrors | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| What are the physical properties of curved mirrors that affect image formation?<br><br>How do we determine the focal point of a curved mirror determined using mathematical calculations and ray diagrams?<br><br>What is the difference between a real and virtual image?<br><br>How are the type, distance, orientation and size of image produced by curved mirrors determined using ray diagrams and mathematical methods?<br><br>What is the difference between parabolic and spherical mirrors? | Compare the similarities and differences between the physical quantities of concave and convex spherical mirrors<br><br>Draw ray diagrams to determine the properties of an image formed by concave and convex spherical mirrors Describe the difference between real and virtual images<br><br>Use the mirror equation to calculate the properties of an image formed by concave and convex spherical mirrors<br><br>Describe how parabolic mirrors differ from spherical mirrors | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (light sources, screens, spherical mirrors, meter sticks, laptops) | Class discussion focusing on characteristics of spherical mirrors, differences between real and virtual images<br><br>Activity: Ray diagrams - Students will produce ray diagrams for image formation for every possible situation (convex/concave, outside/at/inside focal length) and develop a model to describe images formed by spherical mirrors.<br><br>Lab: Spherical mirrors & images - Students will quantitatively explore properties and magnification of images produced by spherical mirrors | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| What is the Law of Refraction?<br><br>How is Snell's Law used to determine the angle of refraction when light passes between mediums? | Identify situations in which refraction will occur<br><br>Identify which direction light will bend as it passes from one medium to another | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (Prisms, mirrors, glass blocks, lasers, screens, meter sticks) | Online activity: Bending light<br><br>Demo: Refraction - Bending of laser light through various mediums (water, glass, plastic), including different shapes of objects<br><br>Activity: Refraction through glass - Using pins, a pin board and crown glass, students will develop a model for refraction through a different medium. Students will relate angles of incidence and refraction going into and out of the glass<br><br>Class discussion focusing on refraction, ray diagrams, critical angles, and calculations involving refraction through various media | Pre-test on Light<br><br>Lab Activities: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br>Closures:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |
| How do we determine the focal point of a lens using mathematical calculations and ray diagrams?<br><br>How are the type, distance, orientation and size of image produced by lenses determined using ray diagrams and mathematical methods? | Compare the similarities and differences between the physical quantities of concave and convex lenses. Draw ray diagrams to determine the properties of an image formed by concave and convex lenses<br><br>Use the thin-lens equation to calculate the properties of an image formed by concave and convex lenses, and to calculate the magnification of lenses | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (light sources, screens, spherical lenses, meter sticks, laptops) | Class discussion focusing on characteristics of lenses, differences between real and virtual images<br><br>Activity: Ray diagrams - Students will produce ray diagrams for image formation for every possible situation (convex/concave, outside/at/inside focal length) and develop a model to describe images formed by lenses<br><br>Lab: Lenses & images - Students will quantitatively explore properties and magnification of images produced by lenses.<br><br>Online activity: Geometric optics | Pre-test on Light<br><br>Lab Activities: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br>Closures:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| How does light travel through single slit openings, double slit openings, diffraction gratings and thin films?<br><br>How does the passage of light through openings and around objects support the wave model of light? | Describe how interference between light waves creates patterns of light and dark fringes.<br>Diagram the passage of light through openings, around objects and through thin films and explain how interference patterns are created from these occurrences<br><br>Calculate distance of slit openings. Distance between double-slit openings, width of objects and thickness of thin-films through measurement of interference patterns | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (light sources, screens, spherical lenses, meter sticks, laptops) | Class discussion focusing on review of interference patterns, modeling of interference patterns caused by various openings and around objects<br><br>Online activity: Single-slit interference<br><br>Online activity: Double-slit interference<br>Online activity: Wave interference<br><br>Lab: Measuring grooves in CDs and DVDs - use lasers and space between interference pattern fringes to measure width of CD/DVD grooves<br><br>Lab: Measure the thickness of hair - use lasers and interference patterns to measure thickness of students' hair<br><br>Demo - Newton's Rings | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What characteristics of light affect the resolution of an image formed from optical instruments? | Describe how diffraction of excess light determines the ability of optical instrument to resolve an image. | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (lenses, mirrors, screens) | Class discussion focusing on relating diffraction and resolution of images from optical instruments. | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| What is polarized light?<br><br>How is polarized light generated, and what are the applications of polarizing filters? | Explain how plane-polarized light is formed and detected.<br><br>Determine applications for polarizing filters. | Multimedia presentation<br><br>Interactive white boards<br><br>Lab equipment (lenses, mirrors, screens) | Class discussion focusing on creation of plane-polarized light, applications of plane-polarization<br><br>Demo: Polarizing filters - Use polarizing screens to filter light to alter visible images, using LCD projector as a light source | Pre-test on Light<br><br><u>Lab Activities</u>: Light Intensity<br>Plane mirror Lab<br>Curved Mirror Lab<br>Lens Lab<br><br>Quizzes on drawing Ray diagrams, Solving mirror and magnification equation<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question)<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.3 | Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.4 | 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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.1 | Write arguments focused on discipline-specific content. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.2 | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.7 | 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. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.2 | Account for the differences in the physical properties of solids, liquids, and gases. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.4.12.A.6 | Argue, citing evidence (e.g., Hubble Diagram), the theory of an expanding universe. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.4.12.F.1 | Explain that it is warmer in summer and colder in winter for people in New Jersey because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its orbit around the Sun. |

## Differentiation

**Principles:**

- Minimize unit conversion requirements by providing students with all measurements in SI units.
- Brightness of light instruction and problems should be conceptual in nature, not mathematical.
- Optical instrument instruction and problems should be conceptual and graphical in nature, not mathematical.
- Reflection and refraction instruction and problems should be conceptual and graphical in nature, not mathematical.
- Focus on applications of optical instruments and properties of the lenses and mirrors depending on the function.
- Focus on applications of polarization as opposed to specific mechanisms for polarization.

**Lab:**

- Brightness of light instruction and problems should be conceptual in nature.
- Optical instrument instruction and problems should be conceptual and graphical in nature, with basic calculations using magnification and mirror equation.
- Reflection and refraction instruction and problems should be conceptual and graphical in nature, with basic calculations using Snell's Law.
- Use concepts and calculations to explain applications of optical instruments and properties of the lenses and mirrors depending on the function.
- Use concepts and calculations to explain applications of polarization of light.

**Honors:**

- All content should receive full conceptual and analytical treatments with color theory being optional.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 12 - Electrostatics

## Unit Plan

**Enduring Understandings:**
A charged body produces an electric field that mediates the interactions between the body and other charges.
Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.

**Essential Questions:**
How can charged particles, the electric fields they produce and the interaction between those fields be represented verbally, graphically and mathematically?
How is the structure and properties of matter determined by the strength of electrical charges and the electric field they produce?
What is the relationship between electrical field forces and the energy of charged particles moving within the electric field?

**Unit Goals:**
1. Explain and describe how the charges of particles of matter affect the structure and properties of matter.
2. Describe the interaction of charged particles, using multiple representations.

**Recommended Duration:** 3 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
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| How many different types of charges are there?<br><br>What are the subatomic particles associated with charge?<br><br>What does it mean if an object is neutral? | Understand the basic principles of electric charges and the subatomic particles associated with them<br><br>Determine the net charge on a particle or object | Multimedia presentations<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access | Class discussion focusing on review of subatomic particles, their charges, ions and ion formation<br><br>Online activity: Build an atom | Pre-test on electrostatics<br><br><u>Lab Activities</u>:<br>Charging objects<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question).<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |
| How processes can an object undergo in order to gain a charge?<br><br>What are the different interactions that can occur between objects with charge?<br><br>What is an electroscope and how is it utilized? | Distinguish between charging through contact, polarization and induction<br><br>Identify interactions between particles and objects possessing similar and different electric charges<br><br>Use an electroscope to determine whether an object possesses net charge | Multimedia presentations<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access<br><br>Lab equipment (glass/rubber rods, fur, silk, balloons, tissue paper, water, sticky tape electroscopes) | Class discussion focusing on methods of gaining charge, charge interactions between particles<br><br>Lab: Electrostatics & electroscopes - Students will generate charges on objects and observe, analyze and create a model describing the interactions between objects possessing similar and different electric charges. Students will develop a model for the mechanisms necessary for an object to become charged.<br><br>Demo: Van der Graaf generator<br><br>Online activity: Balloons & Static Electricity<br><br>Online activity: John Travoltage | Pre-test on electrostatics<br><br><u>Lab Activities</u>:<br>Charging objects<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question).<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| How is a conductor different from an insulator in the way charges are transferred?<br>How are charges distributed in a conductor and an insulator? | Distinguish between conductors and insulators. Identify properties associated with conductors in electrostatic equilibrium<br><br>Develop models to represent charges distributed in conductors and insulator | Multimedia presentations<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access | Class discussion focusing on properties of conductors and insulators, charge distributions and how they can be modeled for conducting and insulating materials<br><br>Demo - Tin foil capacitor<br><br>Online activity: Conductivity | Pre-test on electrostatics<br><br><u>Lab Activities</u>:<br>Charging objects<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question).<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What are the similarities and differences between electric force and gravitational force?<br><br>What factors affect electrostatic interactions?<br><br>How is electric force calculated using Coulomb's Law?<br><br>How can you represent the net force on an object with charge? | Develop models identifying factors that affect electrostatic interactions<br><br>Compare and contrast gravitational force with electric force, including how mass interactions are analogous to charge interactions<br><br>Calculate electric force using Coulomb's Law<br><br>Create free body diagrams showing forces acting on a charged particle by other charged particles in the system<br><br>Determine the position of a charged particle in a system where all forces acting on the particle are in equilibrium | Multimedia presentations<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access | Class discussion focusing on review of free body diagrams, constructing free body diagrams showing forces on electrically charged objects, calculating electric force through free body diagram analysis, relating gravitational and electric force, definition of Coulomb's law and calculations using Coulomb's Law equation<br><br>Online activity - Charges & fields | Pre-test on electrostatics<br><br><u>Lab Activities</u>:<br>Charging objects<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question).<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| What is the operational definition of an electric field?<br>What conditions are necessary for an electric field to exist?<br><br>How are electric fields represented?<br>How can you determine the electric field generated by multiple point charges?<br><br>How can the electric field force acting on an object in that field be determined? | Define an electric field, and describe the conditions necessary for it to form.<br>Draw and interpret electric field lines<br><br>Calculate net electric field at various locations from a particle, object, or system | Multimedia presentations<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access<br><br>Lab equipment (AC generators, AC voltmeters, electrodes and wires) | Class discussion focusing on review of contact forces, introduction to fields and field forces, presence of fields surrounding charged particles, electric field lines and diagrams, interactions between source and test charges, calculating electric field strength, vector analysis of electric fields generated by a system of point charges,<br><br>Lab: Plotting electric fields - Students measure and plot equipotential lines between two point charges, point charge and plate & two plates, then plot electric field lines perpendicular to equipotential lines. Students will also use a conducting ring and relate charge models to field models.<br><br>Online activity: Electric Field Hockey<br><br>Online activity: Charges & Fields | Pre-test on electrostatics<br><br><u>Lab Activities</u>:<br>Charging objects<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question).<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What is electric potential energy?<br><br>How is electric potential energy similar to gravitational and elastic potential energy?<br><br>How does electric potential energy differ between systems of similarly and differently charged particles?<br>What is the difference between electric potential energy, electric potential difference, voltage, and change in voltage?<br>How is the electric potential energy of a charge object calculated? | Define electrical potential energy, relating concepts to gravitational and elastic potential energy.<br>Calculate electrical potential energy for various systems of charge distributions.<br>Differentiate between electrical potential energy, potential difference, and voltage.<br>Calculate electrical potential for various systems of charge distributions. | Multimedia presentations<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access | Class discussion focusing on previously developed models representing work and potential energy, conservation of energy, applying models for gravitational potential energy to electrical potential energy, relating electric fields to electric potentials and the motion of charged objects moving through those fields.<br><br>Online activity - Charges & Fields | Pre-test on electrostatics<br><br><u>Lab Activities</u>:<br>Charging objects<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question).<br>Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.1 | Write arguments focused on discipline-specific content. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.2 | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.7 | 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. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.1 | Use atomic models to predict the behaviors of atoms in interactions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.2 | Account for the differences in the physical properties of solids, liquids, and gases. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.B.1 | Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form. |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.C.1 | Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.C.2 | Account for any trends in the melting points and boiling points of various compounds. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.1 | Model the relationship between the height of an object and its potential energy. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.4 | Measure quantitatively the energy transferred between objects during a collision. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.2 | Compare the translational and rotational motions of a thrown object and potential applications of this understanding. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.3 | Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles:**

- Charge interaction instruction should be conceptual in nature, not mathematical.
- Electric force instruction should be conceptual in nature, not mathematical.
- Electric field and electric field forces instruction should be conceptual in nature, not mathematical.
- Electric potential and potential energy instruction should be conceptual in nature, not mathematical.
- Focus should be on using graphical and pictorial representations to model charge interactions, free-body diagrams showing electric force, work-energy bar charts for charges moving in an electric field.

**Lab:**

- Electric force instruction should be conceptual in nature, with basic calculations using Coulomb's law with simple vectors.
- Electric field and electric field forces instruction should be conceptual in nature, with basic calculations for electric field and electric field force with simple vectors.
- Electric potential and potential energy instruction should be conceptual in nature, with basic calculations for potential on a moving charge in an electric field.
- Focus should be on using graphical, pectoral and mathematical representations to model charge interactions, free-body diagrams showing electric force, work-energy bar charts for charges moving in an electric field, as well as basic calculations using simple vectors.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentations, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 13 - Electricity

## Unit Plan

**Enduring Understandings:**

Electrical circuits provide a mechanism of transferring electrical energy.

Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.

**Essential Questions:**

How does electric potential cause the movement of electrons in an electric circuit?

How do basic circuit components produce heat, light and sound from electrical energy?

How does the arrangement of basic circuit components in series and parallel affect the function of those components?

**Unit Goals:**

1. Describe the functioning of electrical circuits, using multiple representations.

**Recommended Duration:** 2 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| What is the difference between voltage and change in voltage (potential difference)?<br><br>What are various sources of potential difference, and how do they function? | Differentiate between voltage and potential difference.<br><br>Understand how a battery generates a potential difference between the positive and negative side of the battery.<br><br>Identify sources of potential difference. | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (batteries) | Class discussion focusing on voltage, potential differences, sources of electromotive force due to potential differences, electrical potential diagrams.<br><br>Demo: Dissected battery<br><br>Online activity: Battery-resistor circuit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What is conventional current?<br><br>How is conventional current different from electron flow? | Describe the basic properties of electric current, relating current, amount of electric charge, and time<br><br>Describe current as being generated by the movement of electrons<br><br>Compare motion of electrons and direction of conventional current | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (batteries, electroscope, wires) | Class discussion focusing on current, definitions of current, conventions describing direction of current and movement of charge through a wire, relationship between presence of potential difference and movement of charges in a conductor<br><br>Demo: Electroscopes - Use a wire to transfer charge from a charged electroscope to another uncharged one. Use a charged electroscope to light a bulb<br><br>Online activity: Circuit Constriction Kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| What is resistance?<br><br>What factors affect the resistance of a material to electron flow? | Explain how resistivity of the material a wire is made from, wire length and cross sectional area are related in affecting the resistance of that wire | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (nichrome wires, aluminum wires, copper wires, bulbs, batteries/power source, wire clips, resistors) | Class discussion focusing on resistance, resistance to flow of charge, resistivity of various materials, function of resistors<br><br>Lab: Resistivity - Students develop a procedure to model relationship between resistance, resistivity of a material (nichrome, aluminum, copper), length and cross-sectional area of wires. Students use different lengths of wires to power light bulbs<br><br>Online Activity: Battery-Resistor Circuit<br><br>Online activity: Resistance in a Wire | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What is a complete circuit?<br><br>How can the elements of a circuit be represented? | Explain that circuit elements for DC circuits must complete an entire conducting loop<br><br>Identify closed and open circuits based on circuit diagrams<br><br>Construct DC circuit diagrams, using appropriate symbols for batteries, resistors and wires | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches) | Class discussion focusing on circuits, closed conducting loops and constructing circuit diagrams pictorially and schematically using appropriate symbols<br><br>Lab: Basic circuits - Students will build a simple circuit using a battery, a light bulb, wires and a switch. Students will construct circuit diagram, showing open and closed states<br><br>Demo: Burning steel wool with 9V battery<br><br>Online activity: Circuit constriction kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| How can circuit components be connected in series and connected in parallel? | Describe how circuit elements can be connected in series or in parallel<br><br>Construct and interpret DC circuit diagrams showing components in series and parallel | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches) | Class discussion focusing on definitions of series and parallel configurations of circuits, identifying components in series and in parallel pictorially, schematically and in constructed circuits.<br><br>Activity: Identifying components in series and parallel - Stations with different examples of circuits for student identification.<br><br>Online activity: Circuit constriction kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What is the difference between a voltmeter and ammeter?<br><br>How are ammeters and voltmeters connected to DC electrical circuits in order to measure values in that circuit? | Explain the function of ammeters and voltmeters in measuring current and voltage in a DC circuit<br><br>Describe how ammeters and voltmeters must be connected to DC circuits to function correctly<br><br>Construct DC circuits and measure current and voltage at different points in the circuit | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches, voltmeters, ammeters) | Lab: Voltmeters and ammeters - Students will construct a simple circuit (battery, light bulb, resistor) and determine the proper method for connecting voltmeters and ammeters to the circuit<br><br>Class discussion focusing on the function of ammeters and voltmeters, how these components need to be connected in order for proper functioning<br><br>Online activity: Circuit constriction kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |
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| What is the relationship between current, voltage and resistance in a DC circuit? | Derive Ohm's Law from measurements and given values of voltage, current and resistance in a DC circuit | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches, voltmeters, ammeters) | Lab: Ohm's Law - Students will measure the current through wire for different voltages and resistance and create model for relationship between current, voltage and resistance. Students will differentiate between Ohmic and non-Ohmic materials and explain why behaviors differ<br><br>Class discussion focusing on derivation and application of Ohm's Law to relating voltage, resistance and current<br><br>Online activity: Circuit constriction kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |
| How does the connection of circuit components in series and in parallel affect current, voltage and resistance for the overall circuit?<br><br>How does the connection of circuit components in series and parallel affect current, voltage and resistance for sections of a circuit? | Explain and diagram how current, resistance and voltage in a circuit are affected when batteries and resistors are connected in series and in parallel<br><br>Measure and calculate equivalent resistance for resistors connected in series, in parallel, and in combination, and measure and calculate potential differences across each resistor<br><br>Use equivalent resistances to calculate current and potential differences in an overall circuit, as well as across individual sections of circuits | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches, voltmeters, ammeters) | Lab: Batteries in Series and Parallel - Students will measure voltage and current through batteries in series and in parallel, and determine the effect on potential difference in a circuit based on these configurations<br><br>Lab: Resistors in Series and Parallel - Students will measure voltage and current through resistors in series and in parallel, and determine the effect on potential difference in a circuit based on these configurations. Students will determine the equivalent resistance of a circuit, and then relate values for individual resistors to overall equivalent resistance. Students will graph relationships between current, voltage and resistance for series and parallel circuits<br><br>Classroom discussion focusing on determining equations for equivalent resistance in circuits with resistors in series and parallel, calculating equivalent resistance for circuits, voltage and electric current through each component<br><br>Online activity: Circuit constriction kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| How are the electromotive force and terminal voltage of a battery different? | Describe and calculate the internal resistance of a battery<br><br>Determine the potential difference across a circuit load, given the potential difference across a battery's terminals | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches, voltmeters, ammeters) | Lab: Internal resistance of a battery - Measure the internal resistance of a battery through measuring open circuit voltage and short circuit current<br><br>Class discussion focusing on internal resistance of a battery, difference between terminal voltage and electromotive force<br><br>Online Activity: Circuit Constriction Kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |
| What are Kirchkoff's rules?<br><br>How are Kirchkoff's rules applied to circuits? | Describe and diagram how the change in voltage for a closed loop in each section of a circuit is zero<br><br>Describe and diagram how the sum of the currents going into a junction is the same as the sum of the currents leaving a junction<br><br>Calculate the voltage, current and resistance in complex circuits, using the junction and loop rules | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches, voltmeters, ammeters) | Lab: Note & Junction Rules - Students will measure and analyze voltages in closed loops in circuits, measure and analyze currents moving into and out of junctions. Students will develop Kirchkoff's Rules from experimental findings, and then use them to analyze complex circuits<br><br>Class discussion focusing on Kirchkoff's Rules, diagramming node and junction rules on circuit diagrams of complex circuits, calculation of current and voltages passing through resistors in complex circuits<br><br>Online Activity: Circuit Constriction Kit | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test |

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| What is electric power, and how is it related to current and voltage?<br><br>How much energy is used by household appliances? | Describe the relationship between electric power, current, voltage and the rate at which electrical energy is converted to other forms of energy<br><br>Calculate the electric power dissipated across a resistor, and the amount of electrical energy converted into other forms of energy<br><br>Calculate the resistance of an electrical element using electrical power ratings<br><br>Calculate the amount of energy used by an electrical device in a given amount of time, and the cost of operating that device using the cost of electrical energy and power ratings | Multimedia presentation<br><br>Interactive white boards<br><br>Online streaming videos<br><br>Laptop computers with Internet access<br><br>Lab equipment (wires, light bulbs, batteries/power sources, switches, voltmeters, ammeters)) | Class discussion focusing on derivations for expressions of electrical power using voltage, electrical potential energy, time and current, power dissipation, conservation of energy, power use and cost of electricity<br><br>Lab: Heating water with a resistor - Students will use a resistor to transfer electrical energy into heat energy in the water. Students will calculate the energy dissipated by the resistor, energy efficiency, and energy consumption<br><br>Activity: EnergyStar Ratings - Students will research meaning behind EnergyStar Ratings on household appliances, calculate electrical cost of various appliances and draw conclusions relating cost of appliances and energy efficiency | Pre-test on electricity<br><br><u>Lab Activities</u>:<br>Building Circuits,<br>Using Multi-Meters<br><br>Quizzes on mathematically solving circuits and circuit elements<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics<br><br>Journal writing<br><br>Unit test | |

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| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.3 | Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.4 | 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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.1 | Write arguments focused on discipline-specific content. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.2 | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.7 | 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. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |

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| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.1 | Use atomic models to predict the behaviors of atoms in interactions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.2 | Account for the differences in the physical properties of solids, liquids, and gases. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.B.1 | Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.1 | Model the relationship between the height of an object and its potential energy. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.4 | Measure quantitatively the energy transferred between objects during a collision. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.2 | Compare the translational and rotational motions of a thrown object and potential applications of this understanding. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.3 | Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles:**

- Resistance and resistivity instruction and problems should be conceptual in nature, not mathematical.
- Basic simple circuits (potential source, wires, 1 resistor) should receive full conceptual and analytical treatment.
- Circuits with resistors in series and parallel should be analyzed conceptually, with calculations for equivalent resistance as optional.
- Electric power instruction should be conceptual in nature, with math limited to calculating energy costs.
- Terminal EMF, Kirchkoff's Rules, batteries in series and parallel are all optional topics at this level.

**Lab:**

- Resistance and resistivity instruction and problems should be conceptual in nature, not mathematical.
- Basic simple circuits (potential source, wires, 1 resistor) should receive full conceptual and analytical treatment.
- Circuits with resistors in series and parallel should receive full conceptual and analytical treatment.
- Limit number of circuit resistors in labs and problems to a set maximum to avoid over complexity.
- Electric power instruction should be conceptual in nature, with basic calculations for power dissipated and energy efficiency.
- Terminal EMF, Kirchkoff's Rules, batteries in series and parallel are all optional topics at this level.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners.
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content.
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
- Online physics applets and resources to predict, develop and test models for physics phenomena.
- Develop student blogs for reporting of lab data in place of traditional lab reports/journals/notebooks.
- Online assessments for providing instant feedback to students (Quizlet, SurveyMonkey, Moodle, HotPotato, Google).
- Web-based tools for sharing files, online collaboration and assignment submission (Moodle, DropBox).
- Access to online textbook and other physics education resources to provide multiple viewpoints and methods for explaining physics content.

## College and Workplace Readiness

- Provide opportunities for students to engage in reflective practice and self-evaluation
- Assign students authentic texts (scientific journal articles, newspaper and magazine articles and blog posts) to develop critical reading skills
- Use interactive white board to continually develop student interpersonal communication and presentation skills.
- Develop assignment schedules to provide students with opportunities to increase time management and efficiency.
- Continued use of web-based applications for productivity, networking and communication, as well as desktop-based applications for generating reports and presentations.
- Relate physics content, scientific processes, critical thinking and problem-solving skills to solve problems in everyday student experiences.

# Physics Unit 14 - Magnetism

## Unit Plan

**Enduring Understandings:**
Magnetic fields are produced by permanent magnets and electric currents, which mediate interactions between magnetic materials and moving charges.
Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.

**Essential Questions:**
How can magnets and the magnetic field they produce be represented verbally, graphically and mathematically?
How can the relationship between electric currents and magnetic fields be represented physically, graphically and mathematically?
What conditions are required in order to induce an electric current from a magnetic field, and vice versa?

**Unit Goals:**
1. Describe how an electric current passing through a wire can create a magnetic field.
2. Describe magnetic fields and magnetic field forces, using multiple representations.
3. Describe the motion of charged particles in a magnetic field, using multiple representations.

**Recommended Duration:** 2 weeks

| Guiding/Topical Questions | Content/Themes/Skills | Resources and Materials | Suggested Strategies | Suggested Assessments |
|---|---|---|---|---|
| How are magnetic substances similar to charges? How are they different?<br><br>What are magnetic domains, and what are they dependent on? | Identify polar nature of magnets, and determine and describe the attractive and repulsive forces between poles of two magnets<br><br>Explain magnetism in terms of the domain theory of magnetism<br><br>Explain why certain materials display magnetic properties, while other materials do not | Multimedia presentation<br><br>Interactive white board<br><br>Online streaming videos<br>Laptop computers with internet access<br>Lab equipment (magnets) | Lab: Magnets - Students will observe interactions between various shapes and types of magnets. Students will cause one magnet to "float" using knowledge of opposite poles<br><br>Class discussion focusing on magnets, types of magnets, constructing free body diagram for floating magnets, comparison between gravitational, electric and magnetic fields and the relative strength of each | Pre-test on magnetism<br><br><u>Lab activities</u>:<br>Inducing current<br><br>Quizzes on right hand rules, polarity of an electromagnet, EMF calculations<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics |
| What is a magnetic field?<br><br>How is a magnetic field represented using field lines?<br><br>How can magnetic field lines be used to determine the poles of a magnet?<br><br>How can the polarity of a magnet be determined? | Diagram magnetic fields and magnetic field interactions between the poles of an individual magnet, and poles of two neighboring magnets<br><br>Construct a diagram lines representing the Earth's magnetic field, and compare the Earth's magnetic poles to geographic poles | Multimedia presentation<br><br>Interactive white board<br><br>Online streaming videos<br>Laptop computers with internet access<br>Lab equipment (magnets, compasses, magnetic field viewer) | Demo: Magnetic field lines - Using magnetic field viewer, students will observe magnetic field lines, and make observations with compasses placed around magnet<br><br>Demo: Hanging magnet - Students will observe the behavior of a hanging bar magnet, and make conclusions regarding the presence of a magnetic field in the classroom<br><br>Class discussion focusing on representing magnetic fields using magnetic field line diagrams, dipole nature of magnets, theoretical monopole magnets, Earth's magnetic field, polarity switches and possible effects<br><br>Online activity: Magnet and compass | Pre-test on magnetism<br><br><u>Lab activities</u>:<br>Inducing current<br><br>Quizzes on right hand rules, polarity of an electromagnet, EMF calculations<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics |

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| How is the right-hand rule used to relate the directions of magnetic fields, moving charges through the field, and the magnetic force acting on the charge?<br><br>In what situations is it appropriate to use the Right-Hand Rule versus the Left-Hand Rule?<br><br>How is the Right-Hand Rule used to describe a magnetic field generated by a current passing through a wire? | Use the right-hand and left-hand rule, depending on charge, to find the direction of force on a charge moving through a magnetic field<br><br>Use the right-hand and left-hand rule, depending on charge, to determine the motion of a charged particle moving through overlapping electric and magnetic fields<br><br>Determine direction and force exerted on a current-carrying wire in a magnetic field<br><br>Use the right-hand rule to determine the direction of a magnetic field formed around a current-carrying wire<br><br>Use magnetic field forces and the right-hand rule to determine the direction and magnitude of forces between two parallel current-carrying wires | Multimedia presentation<br><br>Interactive white board<br><br>Online streaming videos<br>Laptop computers with internet access<br>Lab equipment (copper wire, batteries, magnets) | Lab: Building homopolar motors - Students will build motors using copper wire, battery and magnet, then make conclusions regarding forces acting on wire to cause motion<br><br>Lab: Building faraday motors - Students will build motors using copper wire, battery and magnet, then make conclusions regarding forces acting on wire to cause motion<br><br>Lab: Magnetic field & wires - Using compasses, students will determine the magnetic field around current-carrying straight wire and a current-carrying coiled wire. Students will switch the direction of the current, make observations, and create a model for describing the magnetic field around a current-carrying wire<br><br>Class discussion focusing on the forces acting on charges and wires carrying charge as they move through a magnetic field, the application of cross-products and the right hand rule to the vectors of force, magnetic field and movement of charges, free body diagrams diagramming these forces, and using free body diagrams to explain the movement of homopolar and Faraday motors | Pre-test on magnetism<br><br><u>Lab activities</u>:<br>Inducing current<br><br>Quizzes on right hand rules, polarity of an electromagnet, EMF calculations<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics |

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| What is an electromagnet and what is necessary to construct an electromagnet? | Use the right-hand rule to determine the direction of a magnetic field formed around a current-carrying wire, shaped in a coil<br><br>Describe how a core of magnetic material is affected by the magnetic field produced by the flow of current through coiled wires | Multimedia presentation<br><br>Interactive white board<br><br>Online streaming videos<br>Laptop computers with internet access<br><br>Lab equipment (copper wire, batteries, magnets, compasses) | Lab: Building electromagnets - Students will build electromagnets and determine how number of coils, types of cores and amount of current affect strength of the electromagnet<br><br>Online activity: Magnets and electromagnetism -<br>Class discussion focusing on effect of external magnetic fields on magnetic domains in the core of an electromagnet, functioning and explanation of an electromagnet | Pre-test on magnetism<br><br><u>Lab activities</u>:<br>Inducing current<br><br>Quizzes on right hand rules, polarity of an electromagnet, EMF calculations<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics |
| What conditions are necessary for a current to be induced in a wire? | Explain how a magnetic field can be used to produce an electric current in a wire<br><br>Determine the direction of current induced in a wire based on a change in magnetic field | Multimedia presentation<br><br>Interactive white board<br><br>Online streaming videos<br>Laptop computers with internet access lab<br>equipment (copper wire, batteries, magnets, voltmeters) | Online activity: Faraday's Law<br><br>Class discussion focusing on applying Faraday's Law and Lenz's Law to explain the direction of an induced current due to interactions between a wire loop and a change in magnetic field | Pre-test on magnetism<br><br><u>Lab activities</u>:<br>Inducing current<br><br>Quizzes on right hand rules, polarity of an electromagnet, EMF calculations<br><br>Problem-solving and board work<br><br>Checking use of vocabulary and student explanations during lessons<br><br><u>Closures</u>:<br>Jeopardy type questions (you give answer and students need to pose the question) Application to previous topics |

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| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.3 | Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.RST.11-12.4 | 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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.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. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.1 | Write arguments focused on discipline-specific content. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.2 | Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. |
| **2010** | College- and Career-Readiness Standards and K-12 English Language Arts | Grades 11-12 Literacy in Science and Technical Subjects | LA.11-12.WHST.11-12.7 | 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. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.1 | Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.2 | Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.A.3 | Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.1 | Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.2 | Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.3 | Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.B.4 | Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.1 | Reflect on and revise understandings as new evidence emerges. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.2 | Use data representations and new models to revise predictions and explanations. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.C.3 | Consider alternative theories to interpret and evaluate evidence-based arguments. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.1 | Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.1.12.D.2 | Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.1 | Use atomic models to predict the behaviors of atoms in interactions. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.A.2 | Account for the differences in the physical properties of solids, liquids, and gases. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.B.1 | Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.D.1 | Model the relationship between the height of an object and its potential energy. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.1 | Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.2 | Compare the translational and rotational motions of a thrown object and potential applications of this understanding. |
| **2009** | Science | Grades: 9-12 | SCI.9-12.5.2.12.E.4 | Measure and describe the relationship between the force acting on an object and the resulting acceleration. |

## Differentiation

**Principles:**

- ALL topics in this unit should receive conceptual explanations only.
- Focus on free-body diagrams to explain the motion of the motors, and properties of magnets.
- Faraday's Law and Lenz's Law should be explained only in the context of the demonstrations.  Any in-depth explanation may be too advanced for this level.

**Lab:**

- ALL topics in this unit should receive conceptual explanations with basic mathematical applications.
- Mathematical calculations may be appropriate for to calculate forces on wires and particles moving through a magnetic field.
- Focus on free-body diagrams to explain the motion of the motors, and properties of magnets.
- Faraday's Law and Lenz's Law should be explained only in the context of the demonstrations.  Any in-depth explanation may be too advanced for this level.

**Honors:**

- All content should receive full conceptual and analytical treatments.

**For All Levels:**

- Facilitate group discussions to assess understanding among varying ability levels of students.
- Provide more opportunities for complex calculations and problems for advanced students.
- Draw and label diagrams to represent data for visual learners
- Provide choice to students for groups selections and roles within cooperative groups.
- Apply new content to previously developed models, when possible.
- Provide real-life and cross-curricular connections to classroom content
- Use technology resources to facilitate data collection, data analysis and reporting.

## Technology

- Data collection hardware (like PASCO or Vernier sensors) and supporting data analysis software (like DataStudio) for developing experiments and collecting data.
- FlipCams and cell phone cameras for collecting pictures and video of real-life events for observation and analysis.
- Spreadsheet software (Excel, Google) for organizing and analyzing data by creating charts and graphs, and for mathematical interpretation of data (through algebraic and statistical functions).
- Presentation software (Multimedia presentation, Google) for presenting findings and reporting conclusions.
- Streaming video services for analyzing and applying physics knowledge to practical situations.
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