

UNIT 1 Introduction

(1-2 weeks)

Unit Description: “Introduction to Physics” Unit 1 provides students with an introduction to physics and to the lab workspace and safety features of the classroom lab experience. Topics including dimensional analysis, lab safety, and unit conversions will be covered.

Essential Question:

- What makes a good scientific experiment?
- What elements should be present in a good scientific argument?

Key Learning Objectives

Students will be able to:

- Describe and demonstrate lab safety protocols.
- Quantitatively convert within a system of measurement (dimensional analysis).
- Use dimensional analysis (factor label) to convert between different units of measurement.
- Demonstrate proper use of measurement tools.
- Properly use terminology associated with experimentation (variables, hypothesis, purpose, and data).
- Demonstrate appropriate work habits both independently and when working with others.

Key Unit Assignment:

1-1 Lab Safety: Students will demonstrate lab safety and participate in a written lab safety test.

1-2 Dimensional Analysis: In order to understand dimensional analysis, students will complete a variety of measurement conversion exercises and activities designed to introduce them to the type of measurement utilized within the physics classroom.

- [Option](#)

1-3 Portfolio/Interactive Notebook Students will use their Office 365 student account and EUHSD email to create a digital portfolio or paper portfolio that will serve as storage of their lab reports, research projects (short and long term), and other key documents.

1-4 Experimentation: Students will design and perform a simple experiment in order to identify variables, collect data and write a CER.

ADDITIONAL UNIT RESOURCES

[LABS](#)
Projects
Worksheets & Activities
[Readings & Websites](#)

[Possible Unit Plan/Instructional Sequence](#)

[Possible Essential Standards](#)

UNIT 2 Kinematics

(4 wks)

Unit Description: “Kinematics” Unit 2 will focus on motion, including vector and scalar quantities while practicing using the kinematic equations. Kinematic equations can be derived from inquiry-based investigations between variables such as position, velocity, time and acceleration where extensions will include graphing and diagrammatic models. Graphing and linear motion relationships will be explored. Students will describe, quantitatively and qualitatively, how objects move. Through planned investigations, practice problems, and guided inquiry students will study motion. They will plan and carry out their own investigations and summarize their findings in a lab report. Students will read a variety of informational text and participate in small and large group discussions on the content, as well as write a summary reflection of their experience.

Essential Question:

- How can the distance an object travels be determined?
- How are velocity and acceleration different?

Key Learning Objectives:

Students will be able to:

- Use appropriate academic content language in written evaluation and discussions.
- Plan and carry out investigations involving kinematics.
- Develop and use graphical models to explain or predict data associated with motion (displacement, velocity, acceleration).
- Use mathematics and computational thinking to quantify variables and identify units(velocity, acceleration, displacement).
- Identify and explain the difference between scalars and vectors
- Students will *qualitatively* predict the effect of angle on displacement.
- Engage in argument from evidence about a current topic of transportation.
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Unit Standards:

PE-PS2-1: Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

PS2A: Forces and Motion Newton’s second law accurately predicts changes in the macroscopic objects.

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

ETS1.B: Developing Possible Solutions When evaluating solutions it is important to take into account a range of constraints, including costs, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.

Science and Engineering Practices - Engaging in argument from evidence - Developing and using models - Planning and carrying out investigations - Analyzing and Interpreting data - Using mathematics and computational thinking - Asking questions and defining problems - Constructing explanations and designing solutions - Obtaining, evaluating and communicating information	Crosscutting Concept - Systems and system models - Cause and Effect: Mechanisms and Explanations - Patterns - Scale/Proportion and Quantity
Key Unit PERFORMANCE TASKS: 2-1 Constant Velocity Lab: Students will <i>plan and carry out an investigation</i> to determine the relationship between position and time of an object. Students will <i>analyze and interpret the data to develop and use graphical models</i> that will identify the pattern between position and time. Students will <i>present</i> their findings with the class. Option 1 2-2 Acceleration Lab: Students will <i>plan and carry out an investigation</i> to determine the relationship between velocity and time. Students will <i>analyze and interpret the data to develop and use graphical models</i> that will identify the pattern between position and time during acceleration. Students will use <i>mathematical and computational thinking</i> to determine that acceleration of the car/object. Students will be given various graphs in which they can qualitatively and quantitatively <i>construct explanations</i> for the motion of the object. Option 1 2-3 Application of motion: Students will use a variety of sources to make an argument with evidence about speed, acceleration or motion as it applies to the real world. In their argument students could consider cost, safety, reliability, aesthetics as well as social, cultural and environmental impacts (Ideas: high speed rail, no speed limits...) Option 1: High Speed Rail Evaluation	

ADDITIONAL UNIT RESOURCES

VIDEOS SIMULATIONS LABS PROJECTS READINGS	Possible Unit Plan/Instructional Sequence Possible Essential Standards
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UNIT 3 Forces

(4 wks)

Unit Description: “Forces” Unit 3 will focus on forces and motion, including vector and scalar quantities while practicing using the kinematic equations. Newton’s three laws of motion describe how the motion of objects is dependent on inertial mass and net force. Students will describe quantitatively and qualitatively, *how* objects move. Through planned investigations, practice problems, and guided inquiry students will study Newton’s three laws of motion. They will plan and carry out their own investigations and summarize their findings in a lab report. Students will read a variety of informational text and participate in small and large group discussions on the content, as well as write a summary reflection of their experience.

Essential Question:

- What causes the motion of an object?
- How do you know if an object is accelerating?

Key Learning Objectives:

Students will be able to:

- Use appropriate academic content language in written evaluation and discussions.
- Plan and carry out investigations involving forces and kinematics.
- Develop and use graphical models to explain or predict data. (force, acceleration, mass)
- Use mathematics and computational thinking to identify and quantify variables associated with forces (velocity, acceleration, displacement, force, and mass).
- Obtain, evaluate and communicate information based on Newton’s three laws.
- Apply Newton's 3 laws to various scenarios.
- Draw and label free body diagrams to predict motion of objects.

Unit Standards:

HS-PS2-1: Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

PS2A: Forces and Motion Newton’s second law accurately predicts changes in the macroscopic objects.

Science and Engineering Practices

- Engaging in argument from evidence
- Developing and using models
- Planning and carrying out investigations
- Analyzing and Interpreting data
- Using mathematics and computational thinking
- Asking questions and defining problems
- Constructing explanations and designing solutions
- Obtaining, evaluating and communicating information

Crosscutting Concept

- Systems and system models
- Cause and Effect: Mechanisms and Explanations
- Patterns
- Scale/Proportion and Quantity

Key Unit PERFORMANCE TASKS:

3-1 Newton's Second Law Lab: Students will plan and carry out an investigation to determine the relationship between acceleration, mass of the object and net force acting on an object. Students will collect and analyze data and submit a formal lab report of their data.

- [Option 1: Catapults](#)

What else is needed? FBD activity?

ADDITIONAL UNIT RESOURCES

VIDEOS
SIMULATIONS
LABS
PROJECTS
WORKSHEETS & ACTIVITIES
READINGS & WEBSITES

Possible Unit Plan/Instructional Sequence

[Possible Essential Standards](#)

UNIT 4 Gravity and Circular Motion

(3 wks)

Unit Description: "Gravity and Circular Motion" In Unit 4 students will investigate Newton's Universal Law of Gravitation, Kepler's Laws, and circular motion. Newton's laws of motion and kinematic principles are applied to describe and explain the motion of objects moving in circles. Emphasis will be on identifying and explaining what creates and affects the force of gravity between objects, explaining the motion of orbiting objects and solving for net force on an object experiencing circular motion.

Essential Question:

- What causes objects to orbit?

Key Learning Objectives

Students will be able to:

- Explain how gravity affects or controls the motion of the solar system.
- Identify the variables that affect the strength of gravity between two objects(mass, distance).
- Mathematically solve for the gravitational force between two objects.
- Relate gravitational force to mass and distance.
- Identify Kepler's three laws and state their importance to orbits.
- Draw force diagrams of objects experiencing circular motion and determine net force.
- Conduct research on a topic involving space then create a propaganda flier to communicate information about the topic.
- Use mathematical representations of an object moving in a circle (centripetal force, tangential velocity, period, frequency, radius, mass, centripetal acceleration)

Unit Standards:

Performance Expectations:

HS-ESS-1-4: Use mathematical or computational representation to predict the motion of orbiting objects in the solar system.

ESS1.B Earth and the Solar System Kepler's Law describes common features of the motion of orbiting objects including their elliptical paths around the sun. Orbits may change due to gravitational effects from or collisions with other objects in the solar system.

HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass and its acceleration.

PS2.A: Forces and Motion Newton's second law accurately predicts changes in the motion of macroscopic objects.

HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.[Clarification statement: Emphasis is on the quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment boundary: Assessment is limited to systems with two objects]

PS2.B: Types of Interactions Newton's law of Universal Gravitation and Coulomb's Law provide the mathematical models to describe and predict the effects of gravitation and electrostatic forces between distant objects.

PS2.B: Types of Interactions Forces at a distance are explained by fields (gravitational, electric, magnetic) permeating space that can transfer energy through space.

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

ETS1.A: Defining and Delimiting Engineering Problems Criteria and constraints also include satisfying any requirements sets by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ETS1.A: Defining and Delimiting Engineering Problems Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

Science and Engineering Practices

- Engaging in argument from evidence
- Developing and using models
- Planning and carrying out investigations
- Analyzing and Interpreting data
- Using mathematics and computational thinking
- Asking questions and defining problems
- Constructing explanations and designing solutions
- Obtaining, evaluating and communicating information

Crosscutting Concept

- Systems and system models
- Cause and Effect: Mechanisms and Explanations
- Patterns
- Scale, Proportion and Quantity
- Stability and Change

Key Unit PERFORMANCE TASKS:

4-1 Gravitational Force: In this activity, students will model and predict how mass and distance affect the force of gravitation between two objects. Students will collect and analyze data, supporting their understanding using free body diagrams as models and computational thinking to generate quantitative data.

- [Option 1: Phet Gravity Force Lab Simulation](#)

4-2 Gravity and Orbits: In this activity students will use a simulation or hands-on activity to identify Kepler's three laws and state their importance to orbits. They will draw force diagrams of objects experiencing circular motion and determine net force quantitatively and/or qualitatively. They will explain how gravity affects or control the motion of the solar system.

- [Option 1: Phet Simulation Gravity and Orbits](#)

4-3 Propaganda Project: Students will conduct research on a specific topic such as Space Exploration to see if countries should continue to invest their valuable resources into major global challenges such space exploration. They will research costs, time, resources, safety, as well as the needs and wants of society. They will design and construct a propaganda poster that will communicate their stance on this topic. Students will present fliers. Students must research at least two primary sources for global challenge examples and must cite the source.

ADDITIONAL UNIT RESOURCES

VIDEOS
SIMULATIONS
LABS
PROJECTS
WORKSHEETS & ACTIVITIES
READINGS & WEBSITES

Possible Unit Plan/Learning Sequence

[Possible Essential Standards](#)

UNIT 5 Energy

(4 wks)

Unit Description: "Energy" Unit 4 will focus on the identification and quantification of different forms of energy. The law of conservation of energy will be used to qualitatively and quantitatively study energy transformation, specifically focusing on gravitational potential and kinetic energy.

Essential Question:

- What is energy and how does it interact with matter?

Key Learning Objectives

Students will be able to:

- Create and use models to explain how energy transfers within a system.
- Define and describe the various types of energy (gravitational potential energy, kinetic energy, thermal energy, total mechanical energy)
- Mathematically identify and solve for variables with energy and energy conservation. (kinetic and gravitational potential energy, mechanical energy)
- Design, build and refine a device that transfers energy.
- Plan and carry out an investigation that relates concepts from motion and forces to energy.
- Students will analyze and interpret energy diagrams in order to predict what might have caused the energy transformations.

Unit Standards:

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

PS3.A: Definitions of Energy Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within than system. That there is a single quantity called energy is due to the fact that a systems total energy is conserved. Even as, within the system, energy in continually transferred from one object to another and between its various possible forms.

PS3.B: Conservation of Energy and Energy Transfer Conservation of energy means that the total change in energy in any system is always equal to the total energy transferred into or out of the system.

PS3.B: Conservation of Energy and Energy Transfer Energy cannot be created or destroyed but it can be transported from one place to another and transferred between systems.

PS3.B: Conservation of Energy and Energy Transfer Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. Relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

PS3.B: Conservation of Energy and Energy Transfer The availability of energy limits what can occur in any system.

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

PS3.A: Definitions of Energy Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved. Even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

PS3.A: Definitions of Energy At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

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

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

PS3.A: Definitions of Energy At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

PS3.D: Energy in Chemical Processes Although energy cannot be destroyed, it can be converted to less useful form – for example, to thermal energy in the surrounding environment.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

ETS1.C: Optimizing the Design Solution Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices

- Engaging in argument from evidence
- Developing and using models
- Planning and carrying out investigations
- Analyzing and Interpreting data
- Using mathematics and computational thinking
- Asking questions and defining problems
- Constructing explanations and designing solutions
- Obtaining, evaluating and communicating information

Crosscutting Concept

- Systems and system models
- Cause and Effect: Mechanisms and Explanations
- Patterns
- Scale, Proportion and Quantity
- Stability and Change
- Energy and matter: flows, cycles and conservation

Key Unit Assignments:

5-1 Energy Analysis: In order to demonstrate energy conservation, students will generate qualitative energy conservation equations by completing an energy bar chart analysis of a given system. They will then solve for mathematical variables associated with various types of energy. Students will complete their energy worksheet.

- [Option 1](#)

5-2 Energy Lab: Students will design and perform an experiment to look at energy transformations (specifically with KE and PE) within a given system. Students will mathematically solve for variables associated with KE and PE and provide models to show the transfer of energy within the system.

- [Option 1: Roller Coaster Cars](#)

5-3 Engineering and Energy Transfer: Students will engineer a product that allows them to study energy transfer, specifically looking at PE and KE. Options could include a Rube Goldberg, mouse trap cars, [roller coasters](#), nerf guns, catapults. (The link offers a car design task.) Students will argue the effectiveness of their product.

- [Option 1: Car Design](#)
- [Option 2: Bobsled design](#)

ADDITIONAL UNIT RESOURCES

VIDEOS
SIMULATIONS
LABS
PROJECTS
WORKSHEETS & ACTIVITIES
READINGS & WEBSITES

Possible Unit Plan/Learning Sequence

[Possible Essential Standards](#)

UNIT 6 Momentum

(3 wks)

Unit Description: “Momentum” Unit 5 students will investigate the impulse-momentum change theorem and the law of conservation of momentum. Students will analyze momentum. Quantitative analysis of momentum and momentum conservation will apply to elastic and inelastic collisions. Students will apply their understanding of the relationship between change in momentum, force and time of impact to engineer a device that minimizes force.

Essential Questions:

- What is the difference between inertia and momentum?
- What is momentum and how is it conserved?

Learning Objectives:

Students will be able to:

- Use mathematical thinking to apply **conservation of momentum** to **elastic** and **inelastic** collisions.
- Calculate the **momentum** of an object (mass x velocity)
- Design, build and test a device to decrease the **force** of impact during a collision by applying their understanding of impulse.
- Analyze and interpret data from collisions in order to determine **impulse**.
- Report data findings both orally and in writings

Unit Standards:

HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

PS2.A: Forces and Motion Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved.

PS2.A: Forces and Motion If a system interacts with objects outside of itself, the total momentum of the system can change; however, any such change is balanced by changes in momentum of objects outside of the system.

HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

PS2.A: Forces and Motion If a system interacts with objects outside of itself, the total momentum of the system can change; however, any such change is balanced by changes in momentum of objects outside of the system.

HS-ETS1-2: Design a solution to a complex real world problem by breaking it down into smaller more manageable problems that can be solved through engineering.

ETS1.A: Defining and Delimiting Engineering Problems Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

ETS1.C: Optimizing the Design Solution Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.

Science and Engineering Practices • Using mathematics and computational thinking. • Analyzing and interpreting data. • Planning and carrying out investigations. • Constructing explanations and designing solutions. • Asking questions and defining problems.	Crosscutting Concepts: • Structure and function • Systems and system models • Patterns • Energy and matter: flows, cycles and conservation • Stability and change • Cause and effect: mechanism and explanation • Scale, Proportion and quantity
Key Unit PERFORMANCE TASKS: 6-1 Collision Cart Simulation: Students can use the online interactive tools (or collision carts) to participate in an activity where students will gather evidence that can be used to support a claim that total system momentum is or is not conserved in elastic or inelastic collisions. Students will be given word problems to mathematically solve for variables associated with conservation of momentum and will then check the answers using an additional simulation. 6-2 Crash Lab: Students will design, build and refine a device to minimize the force experienced during a collision. Using predetermined materials and size constraints, students engineer this device. Using force sensors and dynamic carts and low friction tracks, students will collect data to analyze the effectiveness and compare to the force experienced during a collision without their device present.	

ADDITIONAL UNIT RESOURCES

VIDEOS SIMULATIONS LABS PROJECTS WORKSHEETS & ACTIVITIES READINGS & WEBSITES	Possible Unit Plan/Learning Sequence Possible Essential Standards
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UNIT 7 Thermodynamics

(3 wks)

Unit Description: "Thermodynamics" Unit 6 will focus on types of heat transfer, building on models previously developed in "Energy unit". Students will be able to qualitatively and quantitatively describe energy transfer as heat. Mechanisms through which heat transfers within the Earth's interior are explained.

Essential Questions:

- What is thermal energy?
- How does thermal energy transfer?

Learning Objectives:

Students will be able to:

- Differentiate between convection, conduction and radiation.
- Design and develop models to describe the cycling of matter by convection.
- Design a solution to a real world problem by creating a solar oven that can transform solar energy into thermal energy.
- Explain how heat transfers (Q) from one object to a next within a system and that this heat can be used to do work (W).
- Describe how objects can undergo a phase change through heat transfer (solid → liquid → gas).

Unit Standards:

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

PS3.B: Conservation of Energy and Energy Transfer Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

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

PS3.A: Definitions of Energy At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light and thermal energy.

PS3.B: Conservation of Energy and Energy Transfer Uncontrolled systems always evolve toward more stable states, that is, toward more uniform energy distribution (e.g. water flows downhill, objects hotter than their surrounding environment cool down).

PS3.D: Energy in Chemical Processes Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

HS-ESS2-3: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

ESS2.A: Earth Materials and Systems Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of the physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

ETS1.C: Optimizing the Design Solution Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

PS1.A: Structure and properties of Matter The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

PS1.A: Structure and properties of Matter Attraction and repulsion between electric charges at the atomic scale explain the structure, properties and transformation of matter, as well as the contact forces between material objects.

Science and Engineering Practices

- Engaging in argument from evidence
- Obtaining, evaluating and communicating information
- Developing and using models
- Asking and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking

Crosscutting Concepts:

- Structure and function
- Systems and system models
- Patterns
- Energy and matter: flows, cycles and conservation
- Stability and change
- Cause and effect: mechanism and explanation

Key Unit PERFORMANCE TASKS:

7-1: Heat Transfer: Students will design, build and refine a device that transfers thermal energy (into or out of a system). Students will generate diagrams (such as LOL) to model the energy flow within the system. Students will present their findings and analyze and compare results with other groups within the class to determine which device is the most efficient at heat transfer.

- [Option 1: Solar Oven](#)

7-2: Earth's Convection Currents: Students will utilize the Internet and research and cite at least two primary sources to *create a model* to describe the cycle of matter within the earth by thermal convection. Students will work in groups and/or pairs and use the articles to create a list of content-based questions and share with at least two other partner groups.

- [Option 1: Convection Currents](#)

OPTIONAL: [Unit Assessment](#)

ADDITIONAL UNIT RESOURCES

VIDEOS
SIMULATIONS
LABS
PROJECTS
READINGS

[Possible Unit Plan/Learning Sequence](#)

[Possible Essential Standards](#)

UNIT 8 Waves

(5 wks)

Unit Description: "Waves" In unit 7, students will be able to identify between the wave and particle model for electromagnetic radiation. They will participate in a hands-on lab, conduct online research, and summarize and report out findings. Unit 7 will provide students with the basic understanding of wave types as well as wave properties, with emphasis on the application of sound and electromagnetic waves in society. Electromagnetic radiation may be useful to understanding using either a wave or particle model. Radio frequency identification poses advantages and disadvantages to the storage and transmission of information in society.

Essential Questions:

- How can we describe waves that help us predict its behavior?
- How do waves affect or play a role in technology?
- What are the purposes of waves?

Learning Objectives:

Students will be able to:

- Compare and contrast types of waves. (longitudinal, transverse, mechanical, electromagnetic, sound, light)
- Mathematically solve for variables associated with waves (frequency, period, wavelength, speed).
- Evaluate claims about digital storage and transmission.
- Draw conclusions about the dangers of electromagnetic waves.
- Plan and conduct an experiment to
 - o study the relationship between frequency and wavelength
 - o explain how medium effect wave speed
- Differentiate between the wave and particle model and assess when to use each.
- Describe the outcome of constructive and destructive interference.
- Identify and explain red shift (doppler effect) as evidence of the Big Bang theory
- Qualitatively describe and provide examples of diffraction, refraction, dispersion, and reflection.
- Conduct short-term research and summarize findings in writing.
- Complete a standardized lab report
- Use academic language appropriately

Unit Standards:

HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment boundary: Assessment is limited to algebraic relationship and describing those relationships qualitatively.]

PS4.A: Wave Properties The wavelength and frequency of a wave are related to one another by the speed of travel of the waves, which depends on the type of wave and the medium through which it is passing. (PS4-1)

HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information. [Clarification statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily and copied and shared rapidly. Disadvantages could include issues of easy deletion, security and theft.]

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

HS-PS4-3: Evaluate the claims, evidence and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than another. [Clarification Statement; Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomena could include resonance, interference, diffraction and photoelectric effect.] [Assessment boundary: assessment does not include using quantum theory..]

PS4.A: Wave Properties Waves can add or cancel one another as they cross, depending on their relative phase, but they emerge unaffected by each other.

PS4.B: Electromagnetic Radiation Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (PS4-3)

HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published material could include trade books, magazines, web resources, videos and other passages that may reflect bias.] {Assessment Boundary: assessment is limited to qualitative descriptions]

PS4.B: Electromagnetic Radiation When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (PS4-4)

HS-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the energy transfer mechanism that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the way that the sun's radiation varies due to the sudden solar flares ('space weather'), the 11-year sunspot cycle and noncyclic variations over centuries.] [Assessment Boundary: Assessment does not include the details of the atomic and sub-atomic processes involved with the sun's nuclear fusion]

ESS1.A: The Universe and Its Stars The big bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.

SCIENCE and ENGINEERING PRACTICES

- Asking questions and defining problems.
- Using mathematics and computational thinking.
- Engaging in argument from evidence.
- Constructing explanations and designing solutions.
- Obtaining, evaluating and communicating information.
- Developing and using models.

CROSSCUTTING CONCEPTS

- Cause and effect
- Stability and Change
- System and System models
- Energy and matter

Key Unit PERFORMANCE TASKS:

8-1 Wave Properties: Students will identify the anatomy of a transverse and longitudinal wave then *plan and carry out an investigation* to determine the relationship between frequency and wavelength. Students will *generate graphs* to support that frequency and wavelength are inversely proportion by keeping wave speed constant. They will also *explain* how wave speed depends on the medium.

- [Option: Groovy sounds and Slinky Lab](#)
- [Option: Slinky Lab](#)

8-2 Electromagnetic Effects on the Human Body: Students will work in collaborative teams to research information about different frequencies of electromagnetic waves to determine wavelength, usage in society, and effects on the human body (dangerous vs not dangerous) then share their findings. Students should then make a claim about which wavelength/frequency is the most useful and/or the most dangerous to humans.

- [Option 1](#)

8-3 EM Model Analysis: Teachers will provide students with informational resources. Students will look at various scenarios (phenomena of light including: refraction, reflection, diffraction, dispersion, polarization, interference). Images that promote the wave and particle model of scenarios will be provided. Students will then evaluate stated claims and either support or refutes the claim using evidence and reasoning. Students will be able to identify which model is more useful than another for various phenomena. Students will then write up their findings and cite evidence to support or refute the claim.

8-4 RFID Activity: Students will research the advantages and disadvantages of storing and transmitting personal information via Radio-Frequency identification chip. They will form an opinion about RFID use in a population and participate in a class discussion.

- [Option 1](#)

8-5 Doppler Effect: Students will research how sound and light waves display the doppler effect. They will then make an argument for how the Doppler effect might be used as evidence for the expansion of our Universe and the Big Bang theory.

- [Option 1](#)

[Possible END of UNIT Assessment](#)

ADDITIONAL UNIT RESOURCES

[VIDEOS](#)
[SIMULATIONS](#)
[LABS](#)
[PROJECTS](#)
[READINGS & WEBSITES](#)
[WORKSHEETS](#)

[Possible Unit Plan](#)
[Possible Essential Standards](#)

UNIT 9 Electricity and Magnetism

(5 wks)

Unit Description: “Electricity and Magnetism” Unit 8 discusses the flow of charge through electric circuits. Students will start off defining the fundamental unit of charge and relate electrical force to other variables, thus using Coulomb’s law to predict the force acting on a charged particle. The variables which cause and hinder the rate of charge flow (Ohm’s Law) are explained and the mathematical application of electrical principles to series, parallel and combination circuits is presented. Through research while carrying out an engineering task, students will understand the principles that allow for the function of solar cells and DC motors.

Essential Questions:

- How can we model electrical and magnetic fields?
- What is electricity and what causes it?
- How does electrical energy convert into other forms of energy?

Key Learning Objectives:

- Identify and explain the fundamental unit of charge.
- Use field lines to explain and predict the magnitude of force and direction of an electric or magnetic field (related to Coulomb’s law).
- Compare and contrast series and parallel circuits.
- Quantitatively and qualitatively describe variables associated with Ohm’s law.
- Predict current by manipulating voltage and resistance.
- Describe how a magnet can induce a current.
- Describe how an electrical current can generate a magnetic field.
- Compare and contrast conductors, insulators, and semiconductors.
- Explain how solar energy can be converted into other forms of usable energy.
- Design, build and refine a device to convert solar into mechanical energy.

Unit Standards:

HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms: [Clarification Statement; Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: assessment is limited to main group elements, Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

PS1.A: Structure and Properties of Matter Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (PS1-1)

HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification statement: Emphasis is on the quantitative and conceptual descriptions of gravitational and electric fields.]

[Assessment boundary: Assessment is limited to systems with two objects]

PS2.B: Types of Interactions Newton's law of Universal Gravitation and Coulomb's Law provide the mathematical models to describe and predict the effects of gravitation and electrostatic forces between distant objects. (PS2-4, PS2-5)

PS2.B: Types of Interactions Forces at a distance are explained by fields (gravitational, electric, magnetic) permeating space that can transfer energy through space. (PS2-4, PS2-5)

HS-PS2-5: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

PS2.B: Types of Interactions Forces at a distance are explained by fields permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (PS2-4, PS2-5)

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PS3.A: Definitions of Energy "Electrical energy" may mean energy stored in a battery or energy stored in electrical currents. (PS3-2, PS3-3)

HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

PS1.A: Structure and Properties of Matter The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (PS1-2, PS1-3)

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

PS3.A: Definitions of Energy At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, light, sound, and thermal energy. (HS-PS3-2, HS-PS3-3)

HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

PS3.C: Relationship Between Energy and Forces When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

PS3.D: Energy Solar cells are human made devices that likewise capture the sun's energy and produce electrical energy. (Secondary to HS-PS4-5)

PS4.B Electromagnetic Radiation Photoelectrical materials emit electrons when they absorb light of a high enough frequency. (PS4-5)

HS-ESS3-2: Evaluate competing design solutions for developing, managing and utilizing energy and mineral resources based on cost-benefit ratios.

ESS3.A: Natural Resources All forms of energy production and other resource extraction have associated economic, social, environmental and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (ESS3-2)

HS-ETS1-3: Evaluate a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

ETS1.B: Developing Possible Solutions When evaluating solutions it is important to take into account a range of constraints including costs, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (ETS1-2, ETS1-3)

SEP

- Asking questions and defining problems.
- Using mathematics and computational thinking.
- Engaging in argument from evidence.
- Constructing explanations and designing solutions.
- Obtaining, evaluating and communicating information.
- Developing and using models.
- Planning and carrying out investigations
- Analyzing and interpreting data

CCC

- Cause and effect
- Stability and Change
- System and System models
- Energy and matter
- Structure and function
- Patterns

Key Unit PERFORMANCE TASKS:

9-1 Electrostatics Activity: Students will record their observations and use their understanding of static charges to explain how charge transfers to different objects and how charges interact (forces) through electric fields. Students develop models (field lines) as evidence for their explanations.

- [Option 1: Electrostatics Rotating Stations](#)

9-2 Conductivity of Different Materials Lab: Students will plan and carry out an investigate and complete a circuit using various materials of different conductive properties. They analyze and argue how the resistance of different materials affect the current (qualitatively and/or quantitatively).

- [Option 1](#)

9-3 Solar Energy: Using solar cells and commonly available materials, a group of 3 or 4 students will design, build and refine a device that converts solar energy into mechanical energy. Students will develop a model to explain how solar cells convert light into electrical energy and how a motor works to convert electrical energy into mechanical energy.

- [Option 1: Solar Car](#)

9-4 Building a Generator: Students will use available tools to analyze DC motors that have been disassembled and explain how the components of a motor function to generate a current. Students will design and build a device that converts mechanical energy into electrical energy. They will measure the current output as well as the ability to power light bulbs. Students will complete a lab report.

- [Option 1](#)

ADDITIONAL UNIT RESOURCES

VIDEOS
SIMULATIONS
LABS
PROJECTS
READINGS

[Possible Unit Plan](#)

[Possible Essential Standards](#)