2024 Unit 2: What happens when energy moves from one place to another?

Content Area: **Science**
Course(s):
Time Period: **MP2**
Length: **45 instructional days**
Status: **Published**

NJSLS - Science

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.
HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Science and Engineering Practices

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations. (HS-PS2-4)
- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)
- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)

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

- Theories and laws provide explanations in science. (HS-PS2-4)
- Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)

Constructing Explanations and Designing Solutions

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

Disciplinary Core Ideas

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. (HS-PS1-3)

PS2.B: Types of Interactions

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS1-3)
- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4)

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1)
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-3)

PS3.B: Definitions of Energy

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1)
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
- The availability of energy limits what can occur in any system. (HS-PS3-1)

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3)

ETS1.A: Defining and Delimiting an Engineering Problem

- 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. (HS-PS3-3)

PS4.A: Wave Properties

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

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-3, HS-PS2-4)

Systems and System Models

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)

Influence of Science, Engineering and Technology on Society and the Natural World

- Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)

Rationale and Transfer Goals

The purpose of this unit is to have students gain an understanding of how energy is moved from one location/object to another. Students will review the concept of energy conservation and wave motion before understanding the link between the two. Students will also investigate the unique behaviors of waves that allow different phenomena to be observed. By studying energy and waves, students should be able to answer the question of what happens when energy moves from one place to another.

Enduring Understandings

- All matter is made up of atoms.
- Atoms have a positively charged nucleus and are surrounded by negatively charged electrons.
- An electric force is a universal force that exists between any two charged objects.
- Work is the transfer of energy into or out of a system and is equal to the change of energy within the system.
- The wavelength and frequency of a wave are dependent upon the speed a wave travels.
- The speed a wave can travel depends upon the medium it is passing through.
- Waves undergo superposition when two or more waves meet. Superposition causes constructive or destructive interference.

Essential Questions

- Why do you get shocked when you get out of your car in the winter?
- Superstorm Sandy devastated the New Jersey Shore and demonstrated to the public how vulnerable our infrastructure is. Using your understanding of energy, design a low-technology system that would ensure the availability of energy to residents if catastrophic damage to the grid occurs again.
- How does a wave behave differently from an object?
- What does music have to do with physics?

Content - What will students know?

- A positively charged nucleus is composed of both protons and neutrons, surrounded by negatively charged electrons.
- The difference in the number of protons and electrons in an atom will determine the electric charge of an atom.
- The molecular level structure of a material is important in the effect on a macroscopic object.
- Work that enters or leaves a system is equal to the change of energy within the system.
- Energy can be converted into other forms, but it cannot be created or destroyed.
- One change in energy can cause a chain reaction in other systems.
- Changing the flow of energy from one system to another will cause changes within each system over time.
- As the frequency of a wave increases the wavelength of a wave decreases.

Skills - What will students be able to do?

- Use the periodic table to predict patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.
- Describe why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substance.
- Identify and communicate the evidence for why molecular level structure is important in how the structure and properties of matter determine the function of a material.
- Solve equations using the work-energy equation to show that positive/negative work will change the energy within the system.
- Design a simple roller coaster and show the changes in kinetic and potential energy it undergoes throughout the ride.
- Investigate scenarios in which a small change in energy leads to a bigger chain reaction.
- Use the wave formula to determine the wave speed, frequency, or wavelength of a particular wave.

Activities - How will we teach the content and skills?

- Create an activity based around an interactive periodic table [link] that will allow students to determine how two atoms will interact with one another due to their respective electric fields.
- Using the PhET simulation [link], show how an imbalance of protons and electrons will cause a net charge and how these net charges react to other objects with a net charge.
- Using a simulation such as this one from PhET [link] students describe how outer-level electrons can cause two solid objects to not pass through one another.
- Develop an activity that shows how positive work will increase the energy within a system while negative work will remove energy from a system. [link]
- Utilize the phet energy skate park simulation to show changes in potential energy lead to changes in kinetic energy. [link]
- Complete an activity using elastic potential energy to determine how small changes in displacement can lead to bigger changes in the kinetic energy of objects. [link]
- Use PhET's wave on a string simulation and view the inverse relationship between frequency and wavelength. [link]

Evidence/Assessments - How will we know what students have learned?

- **Assessments can be reviewed for each course in this folder.**

- Students will be able to answer the unit question, what happens when energy moves from one place to another?
- Students will be able to use the work-energy equation to determine a number of different variables.
- Students will be able to predict the velocity of an object if it dropped from a certain height.
- Students will be able to use the mass and velocity of an object to determine the energy required to move it.

- Students will be able to conceptually explain why a small change in energy can lead to a larger change in a system.
- Students will be able to use the wave formula to solve problems.
- Students will be able to determine whether any two atoms in close proximity to each other will attract and repel.
- Students will be able to answer a question that explains the transfer of electrons between two objects and explain the net charge on each object after the transfer.
- Physics Quarter 2 Benchmark on LinkIT website.

Spiraling for Mastery

Content or Skill for this Unit	Spiral Focus from Previous Unit	Instructional Activity
• Each pure substance has characterisc physical and chemical properes that can be used to idenfy it. • The total number of each type of atom is conserved, and thus the mass does not change. • As an object falls, the potential energy will linearly decrease as the kinetic energy linearly increases. • Energy cannot be created or destroyed. It only moves between one place and another, between objects and/or fields, or between systems. • Being able to label the parts of a wave.	• Some chemical reactions release energy, others store energy • When the moon energy of an object changes, there is inevitably some other change in energy at the same time. • Develop models to describe the atomic composition of simple molecules and extended structures. • Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.	• Review of the structure of the atom and the properties of the atom. • Review of Newton's Laws of the Motion. • Review the types of reactions that can occur between electric charges and magnetic poles. • A review of kinetic and potential energy and what they represent. • Review conservation laws and how a closed or open makes a difference. • Review the parts of a wave and how to determine if a change in the wave has occurred.

Key Resources

OpenSTAX College Physics [Link]

WebAssign Homework [Link]

PhET Simulaons [Link]

Physics [Link]

Physlet [Link]

NASA Website [Link]

Career Readiness, Life Literacies, & Key Skills

9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4	Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8).
9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an intended audience (e.g., S-ID.B.6b, HS-LS2-4).
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).

Interdisciplinary Connections/Companion Standards

Science Standard	Math Connection	ELA Connection	Science NJS
Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.	Recognize and represent proportional relationships between quantities.	Close Reading of Text: Read closely to determine what the text says explicitly and make logical inferences.	MS-PS1-1, M
Graphs, charts, and images can be used to identify patterns in data.	Describe qualitatively the functional relationship between two quantities by analyzing a graph.	Diverse Media and Formats: Synthesize content presented in diverse media and formats, including visually and quantitatively, as well as in words.	MS-ESS
Planning and Carrying out Investigations: Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually.	Make sense of problems and persevere in solving them.	Participate Effectively: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners.	SEP.