2024 Unit 4: How is our modern society dependent upon the motion of electrons?

Content Area: **Science**
Course(s):
Time Period: **MP4**
Length: **45 instructional days**
Status: **Published**

NJSLS - Science

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.
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 the other.
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.
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.

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-PS2-5)

Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)

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

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)

Obtaining, Evaluating, and Communicating Information

- Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4)
- Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5)

Disciplinary Core Ideas

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-5)
- 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-PS2-5)

PS3.A: Definitions of Energy

- "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (HS-PS2-5)

PS4.A: Wave Properties

- Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)
- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-5)

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. (HS-PS4-3)
- 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. (HS-PS4-4)
- Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)

PS3.D: Energy in Chemical Processes

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

PS4.C: Information Technologies and Instrumentation

- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5)
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)
- Systems can be designed to cause a desired effect. (HS-PS4-5)

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3)

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5)

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

- Modern civilization depends on major technological systems. (HS-PS4-5)

Rationale and Transfer Goals

The purpose of this unit is to first understand the mechanics behind waves and then apply them to electromagnetic radiation. Students will be able to relate changes such as frequency, amplitude, and wavelength to electromagnetic radiation and the spectrum. How information is transferred, either in analog or digital formats, will allow students to have a basic understanding of how information travels in the 21st century such as the internet. Understanding waves and electromagnetic radiation will allow students to answer the overarching question of how our modern society dependent upon the motion of electrons.

Enduring Understandings

- Electromagnetic radiation is separated into different types of radiation based on the frequency or wavelength of the wave.
- As the frequency of an electromagnetic wave increases, the energy of that wave increases.
- The emission and absorption of electromagnetic waves affect the energy of an electron within an atom.
- A change in an electric field creates a magnetic field and vice versa.
- Electric generators and electric motors are the exact opposite of one another.
- Electric circuits are controlled primarily by voltage, current, and resistance.

Essential Questions

- How do radio stations send information to your car wirelessly?
- How can electromagnetic radiation be considered a wave and a particle at the same time?
- Why do I need to wear sunscreen?
- How do we make electricity?

Content - What will students know?

- Information can be sent using analog or digital formats. Different formats are useful for different scenarios.
- Understand that light can behave as a particle or a wave depending on the situation.
- The absorption of electromagnetic radiation will increase the energy of an electron and the emission of electromagnetic emission will decrease the energy of an electron.
- Wireless communication uses electromagnetic radiation to communicate between two or more objects.
- Electric current is changed by resistance and/or voltage.
- Electric and magnetic fields are affected by changes in each.

Skills - What will students be able to do?

- Explore the differences between digital and analog information and which scenarios each format would be preferred.
- Understand Einstein's Photoelectric effect shows light behaving as a particle and the Double Slit experiment shows light behaving as a wave.
- Use the conservation of energy equation to determine the frequency or change in energy of an electron during emission or absorption.
- Look at how cellular phones use microwaves to send and receive messages.
- Solve electric circuit problems using V=IR.
- Explain how an electric generator or motor works.

Activities - How will we teach the content and skills?

- Review different methods of transforming information such as binary (digital) or video recording (analog) and show the differences between the waveforms. [link]
- Use PhET's photoelectric simulation to view how light can behave as a particle. [link]
- Invesgate absorption and emission spectra to observe how light and matter interact in space. [link]

- Use the radio waves PhET simulation to see how the movement of electrons can receive or send information and how a radio wave is similar to a microwave. [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, how does the motion of electrons affect our modern society?
- Students will be able to look at a waveform and understand whether it is digital or analog.
- Students will be able to explain the difference between the photoelectric effect and the double-slit experiment to show the duality of light.
- Students will be able to use the conservation of energy to show the energy gained or lost by an electron during emission or absorption of light.
- Students will be able to explain how we can create and send an electromagnetic wave with the intent of sending information.
- Physics Quarter 4 Benchmark on LinkIT website.

Spiraling for Mastery

Content or Skill for this Unit	Spiral Focus from Previous Unit	Instructional Activity
• An electron can change position within its orbitals when it absorbs or emits light. • The photoelectric effect is proof that light can behave like a particle through its interactions with electrons. • Digital information is sent to and from internet-connected devices using electromagnetic radiation. • Electric and magnetic forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the	• A system of objects may also contain stored (potential) energy, depending on their relative positions. • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	• Review the conservation of energy and the work energy equation. • Review the parts of a wave and how to determine if a change in the wave has occurred. • Review spectroscopy from chemistry and how different spectra are created. • Review how a pulse differs from a continuous wave. • Review of the types of reactions that can occur between electric charges and magnetic poles.

interacting objects.		

Key Resources

OpenSTAX College Physics [Link]

WebAssign Homework [Link]

PhET Simulations [Link]

Physics [Link]

Physlet [Link]

NASA Website [Link]

The Physics Classroom [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	Scie
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-
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.	
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.	