Lindenwold Public Schools

Unit 4 - How Do We Use Energy to Communicate with Each Other?

45 instructional days

New Jersey Student Learning Standards Science

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 relationships and describing those relationships qualitatively.]

HS-PS4-2: Evaluate questions about the advantages of using 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.]

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. [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 phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]

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 materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

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.* [Clarification Statement: Examples could include solar cells capturing light and

converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

Science and Engineering Practices

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)

Asking Questions and Defining Problems

- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set or the suitability of a design. (HS-PS4-2)

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)

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

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)
- 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-PS4-2, HS-PS4-5)
- 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)

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)

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-PS4-1)
- 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)

Stability and Change

- Systems can be designed for greater or lesser stability. (HS-PS4-2)

Systems and System Models

- Models (e.g., physical, mathematical, and 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)

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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-PS4-2),(HS-PS4-5)
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)

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 quantities 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 do we use energy to transfer information with each other.

Enduring Understandings:

- 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.
- 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 affects the energy of an electron within an atom.

Essential Questions:

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

- How does a hard drive store information? [Phenomena]

Content/Objectives		Instructional Actions	
Content ***What students will know***	**Skills** ***What students will be able to do***	**Activities/Strategies** ***How we teach content and skills***	**Evidence (Assessments)** ***How we know students have learned***
• As the frequency of a wave increases the wavelength of a wave decreases. • 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.	• Use the wave formula to determine the wave speed, frequency, or wavelength of a particular wave. • 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	• Use PhET's wave on a string simulation and view the inverse relationship between frequency and wavelength. [link] • Review different methods of transmitting information such as binary (digital) or video recording (analog) and show the differences between the wave forms. [link] • Use PhET's photoelectric simulation in order to view how light can behave as a particle. [link] • Investigate absorption and emission spectra to observe how light and matter interact in space. [link]	• Students will be able to use the wave formula to solve problems. • 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.

• Wireless communication uses electromagnetic radiation to communicate between two or more objects.	electron during emission or absorption. • Look at how cellular phones use microwaves in order to send and receive messages.	• Use the radio waves PhET simulation to see how movement of electrons can receive or send information and how a radio wave is similar to a microwave. [link]	• Students will be able to explain how we are able to create and send an electromagnetic wave with the intent of sending information. • Physics Unit 4 Benchmark

Spiraling for Mastery		
Content or Skill for this Unit	**Spiral Focus from Previous Unit**	**Instructional Activity**
• An electron can change position within it's orbitals when it absorbs or emits light. • Being able to label the parts of a wave. • 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.	• 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.	• 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.

	• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	

Key resources:

- OpenSTAX College Physics [Link]
- WebAssign Homework [Link]
- PhET Simulations [Link]
- oPhysics [Link]
- Physlet [Link]
- NASA Website [Link]
- The Physics Classroom [Link]

21st Century Life & Careers:

9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.

9.2.12.CAP.3: Investigate how continuing education contributes to one's career and personal growth.

9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.

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 projects 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.

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.

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.

9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.

9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately.

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.

InterDisciplinary Connections/Companion Standards:

NJSLS Math

HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1, HS-PS4-3)

HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS4-1, HS-PS4-3)

HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS4-1, HS-PS4-3)

NJSLS ELA

RST.9-10.8 Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2, HS-PS4-3, HS-PS4-4)

RST.11-12.1 Write arguments focused on discipline-specific content. (HS-PS4-3, HS-PS4-4)

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. (HS-PS4-1, HS-PS4-4)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2, HS-PS4-3, HS-PS4-4)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS4-5)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS4-4)

Companion Standards for ELA in Science and Technical Subjects: Reading

Key Ideas and Details

RST.11-12.1. Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.

Integration of Knowledge and Ideas

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Companion Standards for ELA in Science and Technical Subjects: Writing

Research to Build and Present Knowledge

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 an understanding of the subject under investigation. WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.