(2026) 04 Waves and Optics

Content Area: **Science**
Course(s): **Physics A**
Time Period: **Semester 2**
Length: **10 weeks**
Status: **Published**

Standards

	Using Mathematics and Computational Thinking
SCI.HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
	Cause and Effect
SCI.HS-PS4-2	Evaluate questions about the advantages of using a digital transmission and storage of information.
	Asking Questions and Defining Problems
SCI.HS.PS4.A	Wave Properties
SCI.HS.PS4.B	Electromagnetic Radiation
SCI.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.
	Obtaining, Evaluating, and Communicating Information
SCI.HS.PS3.D	Energy in Chemical Processes
SCI.HS.PS4.C	Information Technologies and Instrumentation
	Stability and Change

Enduring Understandings

1. Students will understand that because a wave's speed is dictated strictly by its medium, changes in wavelength and frequency at an interface govern predictable behaviors like reflection, refraction, transmission, and resonance, which can be modeled mathematically to analyze musical instruments or design optical technologies.

2. Students will understand that electromagnetic radiation must be modeled dualistically as both propagating field waves and discrete photon particles, where wavelength restrictions dictate technological imaging limits (such as why visible light cannot resolve an individual atom) and quantum interactions determine whether absorbed radiation safe-degrades into heat or dangerously ionizes living cells.

3. Students will understand that by combining waves of varying frequencies, information can be reliably digitized into pixel arrays or wave-pulse series, allowing data to be encoded, stored in computer memory, and transmitted over immense distances with minimal distortion.

4. Students will understand that foundational insights into quantum physics—specifically wave-matter interactions—enabled the engineering of modern semiconductors, microchips, and lasers, which serve as the essential baseline infrastructure for modern global communications and medical imaging systems.

Essential Questions

1. How can we mathematically model how a wave's characteristic properties (wavelength, frequency, and speed) alter when it transitions across different media boundaries?

2. How would you evaluate the physical and structural criteria required to produce acoustic resonance in instruments, and how can waves be manipulated to maximize constructive interference?

3. What is light, and how do we justify switching between a wave model of changing fields and a particle model of discrete photons to explain the variety of interactions observed?

4. How does the scale of an electromagnetic wavelength dictate our structural limits for imaging microscopic matter, and how does it determine whether radiation safely degrades into heat or destructively ionizes living cells?

5. How are waves engineered to encode, digitize, and transfer vast arrays of information (like high-resolution pixel data) across immense distances with minimal signal degradation?

6. How do modern communication technologies utilize the mathematical combination of different frequencies to ensure reliable data storage and high-fidelity signal transmission?
7. How do instruments that transmit, modulate, and detect electromagnetic waves extend our human senses to allow for advanced scientific research and medical imaging?
8. How would you formulate an argument to defend the claim that foundational discoveries in quantum physics are directly responsible for the infrastructure of modern computing and global communication networks?

Knowledge and Skills

Knowledge:

1. Analyze how the physical properties of a medium strictly dictate wave speed, evaluating how this boundary velocity change mathematically forces inverse shifts in wavelength and frequency.

2. Deconstruct how wave parameters dynamically alter at a physical interface to predict the geometric and physical mechanisms of reflection, refraction, and transmission.

3. Evaluate the boundary limitations of the wave model of light, analyzing how the threshold frequency of photoelectric materials provides definitive empirical evidence for the particle (photon) nature of electromagnetic radiation.

4. Justify why only photons exceeding a discrete kinetic energy threshold can liberate electrons from a material's surface, regardless of light intensity.

5. Analyze the mechanistic process of digitizing complex qualitative data into quantitative arrays of pixels or discrete binary values.
6. Formulate a conceptual model explaining why digitizing data allows wave-pulse series to be stored

reliably in computer memory and transmitted over vast distances with absolute noise immunity compared to analog signaling.
7. Evaluate how modern diagnostic, scanning, and communication systems exploit specific wave-matter interactions to produce, transmit, capture, and interpret data signals in scientific research and medicine.

Skills :

1. Analyze and manipulate algebraic representations of the wave equation to mathematically justify how transitions between distinct media boundaries structurally alter frequency, wavelength, and speed.

2. Critique and evaluate quantitative arguments regarding the structural, economic, and computational advantages of digital information transmission and storage over legacy analog systems.

3. Synthesize and communicate advanced technical explanations detailing the exact physics mechanisms a specific modern device (e.g., fiber optics, MRI, or solar panels) uses to capture or transmit energy and information.

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing