

Core Idea PS4

Waves and Their Applications in Technologies for Information Transfer

How are waves used to transfer energy and information?

- waves
- pattern
- motion
- energy transfers
- energy
- displacement
- matter
- light
- sound
- wavelike phenomena
- wave properties
- electromagnetic radiation
- system
- distance
- information
- investigate
- scale
- perception

PS4.A: WAVE PROPERTIES

What are the characteristic properties and behaviors of waves?

- wave (water, sound or a light wave)
 - A simple wave has a
 - repeating pattern
 - specific wavelength
 - specific frequency
 - specific amplitude
- wavelength
- frequency
- speed (of wave front travel)
- medium (in which the wave is traveling)
- bulk motion of matter
- code/decode
- digitized (converted into a numerical representation)
- wave pulses
- computer memory

- sound
- pressure wave
- air
- material medium
- ear
- information in sound (e.g., speech and music)
- random
- noise
- resonance
- in phase (i.e., matched peaks and valleys)
- resonate
- color
- reflect / reflection
- refract / refraction
- wave properties (are used in many applications e.g., lenses, seismic probing of Earth).

Grade Band Endpoints for PS4.A

By the end of grade 2.

- waves
- regular
- pattern
- motion
- water (waves)
- sound (waves)
- matter
- vibrate

By the end of grade 5.

- wave
- amplitude (height of the wave)
- wavelength (spacing between wave peaks)
- add / cancel (waves can add to or cancel out one another as they cross, depending on their relative phase)
- phase (i.e., relative position of peaks and troughs of the waves)
 - (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.)
- earthquake
- seismic wave
- motion

- Earth's crust.

By the end of grade 8.

- simple wave
- repeating pattern
 - with a specific wavelength
 - frequency
 - amplitude
- sound wave
- medium
- transmission
- geologist
- seismic wave
- reflection
- interface
- probe
- planet (earth)

By the end of grade 12.

- wavelength
- frequency
- wave
- speed (of travel of the wave)
- medium
- reflection
- refraction
- transmission of waves
- interface
- media
- model
- encode
- information
- digitize
- array
- pixels
- memory
- pulses
- resonance
- structure
- vibration
- resonate

PS4.B: ELECTROMAGNETIC RADIATION

What is light?

How can one explain the varied effects that involve light?

What other forms of electromagnetic radiation are there?

- electromagnetic radiation (e.g., radio, microwaves, light)
- model
- wave
- pattern
- electric field
- magnetic field
- particle
- matter
- quantum theory

By understanding wave properties and the interactions of electromagnetic radiation with matter, scientists and engineers can design systems for transferring information across long distances, storing information, and investigating nature on many scales—

some of them far beyond direct human perception.

- range
- frequency
- visible spectrum
- color
- eyes
- technology
- electromagnetic wave(s)
- vacuum
- speed
- speed of light
- medium
- wavelength
- property
- reflect
- refract (to bend a path)
- absorption
- light
- electromagnetic radiation (ultraviolet, X-rays, gamma rays)
- matter
- ionization

- atom
- X-rays
- dense
- photovoltaic material
- emission
- electron
- barcode scanner
- “electric eye” system
- solar cell
- particle model of light
- temperature
- element
- spectral line
- microscopic quantity
- nuclear transition
- gamma radiation
- radioactive isotope

Grade Band Endpoints for PS4.B

By the end of grade 2.

- object
- light
- illumination
- hot objects glow light (e.g., a fire, the sun)
- material
- dark
- surface
- light source
- mirror
- prism
- light beam (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)

By the end of grade 5.

- light
- Earth
- sun
- star
- object

- reflect
- eye
- color
- surface properties (Boundary: This phenomenon is observed, but no attempt is made to discuss what confers the color reflection and absorption properties on a surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.)
- lens
- bend
- light beam
- magnification

By the end of grade 8.

- light
- reflect
- absorption
- transmit
- object
- material
- frequency (color)
- light
- path
- transparent material (e.g., air and water, air and glass)
- bend
- lens
- prism
- wave model of light
- brightness
- color
- frequency-dependent bending of light
- sound waves
- water waves

By the end of grade 12.

- electromagnetic radiation (e.g., radio, microwaves, light)
- model
- wave
- electric field
- magnetic field
- particle
- photon

- wave model
- Quantum theory (Boundary: Quantum theory is not explained further at this grade level.)
- wavelength
- visible light
- atoms
- vacuum
- speed
- speed of light
- medium
- properties of that medium.
- matter
- thermal energy (heat)
- short wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays)
- ionize
- photovoltaic material
- emission
- electron
- element
- frequency
- nuclear transition
- microscopic quantities

PS4.C: INFORMATION TECHNOLOGIES AND INSTRUMENTATION

How are instruments that transmit and detect waves used to extend human senses?

- waves
- interaction
- matter
- design
- technology
- instrument (e.g., telescopes, microscopes)
- light waves
- radio waves
- microwaves
- infrared waves
- communications system
- digitized signal (i.e., sent as wave pulses)
- information
- signal (that can be detected by appropriately designed devices (e.g., telescopes, cell phones, wired or wireless computer networks))
- information degradation

- medical imaging devices
- wave signals (e.g., ultrasound, X-rays)
- sonar (based on sound pulses)
- measure
- depth
- sea
- system
- laser
- vacuum

Grade Band Endpoints for PS4.C

By the end of grade 2.

- human senses
- eyes
- light
- ears
- sound
- vibration
- touch
- device
- communicate (send and receive information)

By the end of grade 5.

- lens
- eyeglasses
- telescopes
- microscopes
- instrument
- light path
- bending light
- digitized information (e.g., the pixels of a picture)
- degradation
- computer
- cell phone
- code / decode information

By the end of grade 8.

- technology (e.g., radio, television, cell phones, wired and wireless computer networks)

- signal
- interaction
- matter
- communication
- digitized signals (sent as wave pulses)

By the end of grade 12.

- technology (e.g., medical imaging, communications, scanners)
- wave
- interaction
- matter
- scientific research
- tools (for producing, transmitting, and capturing signals and for storing and interpreting the information)
- quantum physics (Boundary: Details of quantum physics are not formally taught at this grade level.)
- semiconductors
- computer chips
- lasers