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Warm-Up | Wave Properties

Lesson Question

How are the properties of waves related?

Lesson Goals

Identify and describe the properties of transverse and longitudinal waves.

Analyze the relationship between wavelength, frequency, and wave speed.

Identify factors that affect wave speed.

Solve problems involving wavelength, frequency, and wave speed.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

crest	the highest point on a wave
rarefaction	the part of a longitudinal wave where the particles of matter are far apart
amplitude	the height of a transverse wave from the midpoint to the crest or trough
wavelength	the distance between any two equivalent points, such as from crest to crest or from trough to trough
trough	the lowest point on a wave

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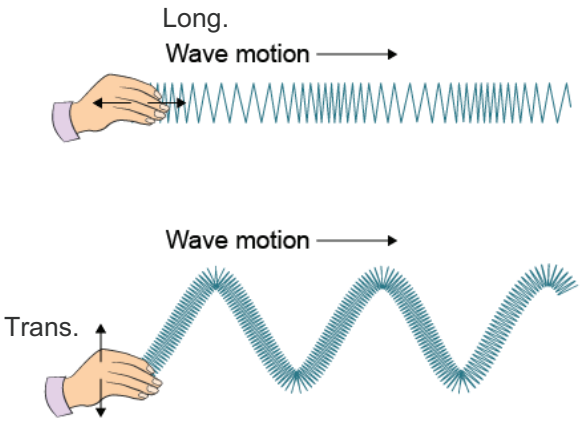
Words to Know

period	the amount of time it takes an object to complete a cycle or return to its original position
frequency	the number of oscillations per second
compression	the part of a longitudinal wave where the particles of matter are close together
hertz	the SI unit of frequency

Waves

- A wave is a disturbance that carries **energy** from one place to another.
  - Longitudinal
  - Transverse
  - **Mechanical**
  - Electromagnetic



The particles of matter are affected by the wave, but they are not carried.

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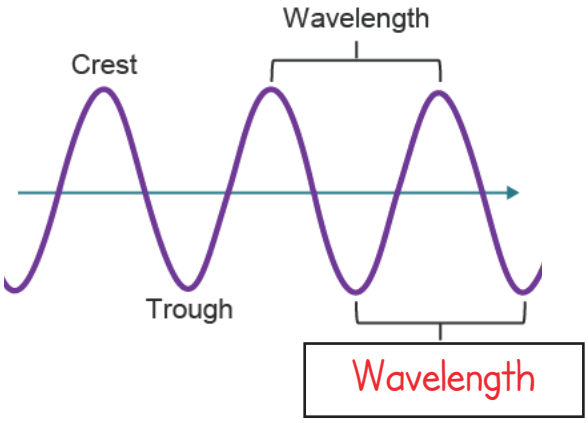
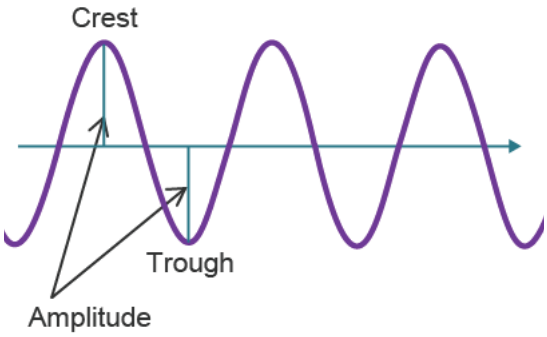
Parts of a Transverse Wave

- The highest point on a wave is known as the crest, and the lowest point on a wave is known as the trough.
- The wavelength of a wave is the distance between any two equivalent points, such as from crest to crest or from trough to trough.
    - Unit: meters, m
    - Symbol: lambda, λ



Amplitude of a Transverse Wave

- The amplitude of a transverse wave is the height from the midpoint to the crest or the trough.
    - It is directly related to the amount of energy in a wave.
    - The higher the amplitude, the higher the energy; the smaller the amplitude, the lower the energy.



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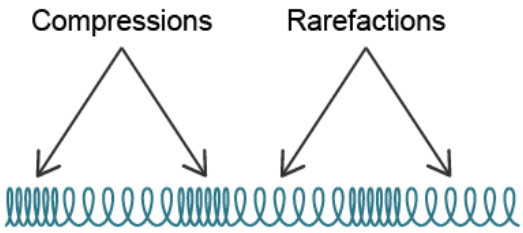
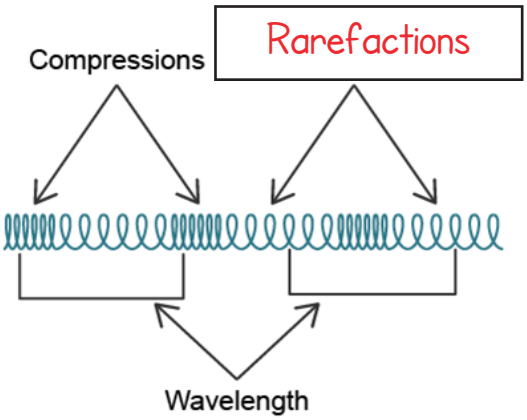
Parts of a Longitudinal Wave

- A [compression] is the part of a longitudinal wave where the particles of matter are close together.
- A [rarefaction] is the part of a longitudinal wave where the particles of matter are far apart.



Wavelength in a Longitudinal Wave

- The wavelength of a longitudinal wave is [measured] from compression to compression or from rarefaction to rarefaction.



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Amplitude of a Longitudinal Wave

- The amplitude of a longitudinal wave is related to how [close] together the particles in the medium are at the compressions of the wave.
  - The closer the particles in the compression, the [higher] the amplitude.
  - The farther apart the particles in the compression, the lower the [amplitude].

High-amplitude wave

Low-amplitude wave

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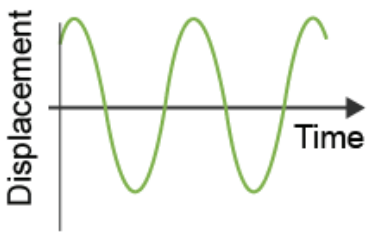
Period of a Wave

- A period is the amount of time it takes an object to complete a [cycle] or return to its original position.
  - For waves, period is the amount of time it takes one [wavelength] to pass a certain point.
  - Unit: seconds, s
  - Symbol: [*T*]



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Frequency of a Wave

- The frequency of a wave is the [number] of oscillations per second.
  - Unit: [hertz] – the SI unit of frequency
    - $\text{Hz} = \frac{1}{\text{s}}$
  - Symbol: *f*

$$\text{frequency} = \frac{\text{cycles}}{\text{time}}$$

Low-frequency waves

High-frequency waves

Period versus Frequency

- Period refers to the [time] it takes for something to happen.
  - Seconds per cycle
  - Unit: seconds

$$T = \frac{1}{f}$$

- Frequency refers to how often something happens.
  - Cycles per second
  - Unit: hertz

$$f = \boxed{\frac{1}{T}}$$

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Velocity of a Wave

- The velocity of a wave is the distance a [wave] travels in a given amount of time.
  - Distance equals wavelength.
  - Period equals the [inverse] of the frequency.
- The velocity (v) of a wave is the [frequency] multiplied by the wavelength (λ).

$$v = \frac{\lambda}{T}$$

$$v = f\lambda$$

$$T = \frac{1}{f}$$

Frequency and Velocity Calculations

A channel marker in the water is bobbing up and down as waves pass by. The waves are 5 meters apart, and 6 waves pass every 3 seconds.

- What is the wave's period? $T = \frac{1}{f} = \frac{1}{\frac{6\,\text{waves}}{3\,\text{s}}} = \frac{1}{\frac{1}{0.5\,\text{s}}} =$ [0.5s]
- What is the wave's frequency? $f = \frac{1}{T} = \frac{1}{0.5\,\text{s}} =$ [2 Hz]
- What is the wave's velocity? $v = f\lambda = (2\,\text{Hz})$ [(5 m)] $= 10\,\text{Hz m} = 10\,\text{m/s}$

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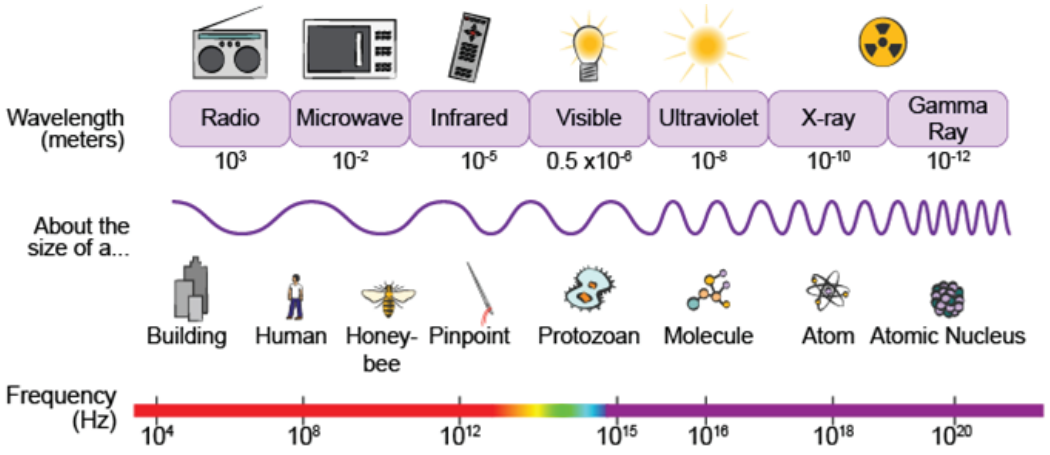
The Electromagnetic Spectrum

The electromagnetic spectrum is the range of wavelengths and frequencies of all [electromagnetic] waves. The wavelengths vary inversely with the frequency. What does that mean? The longer the wavelength, the [lower] the frequency, and the shorter the wavelength, the [higher] the frequency.



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Factors Affecting the Speed of a Wave

- Electromagnetic waves do not require a [medium] to carry energy.
- Travel at the speed of light in a vacuum, $3 \times 10^8 \text{ m/s}$
- [Mechanical] waves require a medium to carry energy.
- Travel at speeds significantly less than $3 \times 10^8 \text{ m/s}$ due to the particles that they travel through

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Factors Affecting the Speed of a Wave

EM Wave	Frequency (Hz)	Wavelength (m)	Speed (m/s)
Microwave	3×10^{11}	0.001	3×10^{8}
Optical	7.5×10^{14}	4×10^{-7}	3×10^{8}
Ultraviolet	3×10^{16}	1×10^{-8}	3×10^{8}

Ways Media Affect the Speed of Waves

- Type of medium
  - Light waves travel [faster] through gases and liquids.
  - Sound waves travel the fastest through solids and [slowest] through gases.

Medium at 21°C	Speed of Sound (m/s)
Solid steel	5,180
Ocean water	1,524
Air	344

- Temperature of medium
  - At higher temperatures, particles bump into each other more often, [increasing] the chances of energy transfer.

Temperature of Air (°C)	Speed of Sound (m/s)
20	343.6
5	334.5
–10	325.3

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Summary | Wave Properties

Lesson Question

How are the properties of waves related?

Answer

(Sample answer) The properties of a transverse wave include crests and troughs. The properties of a longitudinal wave include compressions and rarefactions. Both types of waves have wavelength, amplitude, frequency, period, and the speed of the wave.

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Review: Key Concepts

Transverse Wave	Longitudinal Wave
Crest	Compression
Trough	Rarefaction
Wavelength	
Amplitude	
Frequency $f = \frac{1}{T}$	
Period $T = \frac{1}{f}$	
Velocity	

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- The amplitude and energy of a wave are directly proportional.
- The frequency and wavelength of a wave are inversely proportional.
- The speed of a wave is calculated using the equation $v = f\lambda$.
- The speed of a wave is affected by the type of wave, the type of medium, and the temperature of the medium through which the wave travels.

Use this space to write any questions or thoughts about this lesson.

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