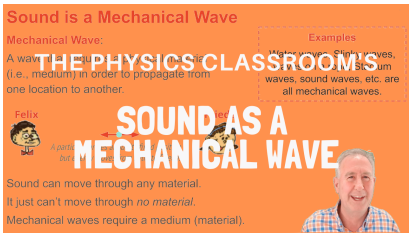
Properties of Sound Waves
Lesson Notes

Learning Outcomes

- What do the various properties of sound waves - frequency, amplitude, wavelength, and speed - describe?

Review: The Nature of a Sound Wave



- Sound waves are created by a vibrating object that create disturbances that move through a medium.
- Sound waves are mechanical waves that propagate through a medium by means of particle-to-particle interaction.
- In fluids such as air, sound waves move as longitudinal waves with a repeating pattern of compressions and rarefactions.
- Sound waves transfer energy without transporting matter.

Sound Frequency

- In general, **frequency** refers to **how often** a repeating, periodic event occurs. It indicates the number of times the event occurs per second (or minute or hour or day).
- For sound waves, **frequency** refers to how often particles of the medium vibrate back and forth about their fixed position.
- The frequency of every particle's vibration is equal to the frequency of the sound source.

Frequency

# of cycles/time

Unit:
Hertz (Hz)
or cycles/second

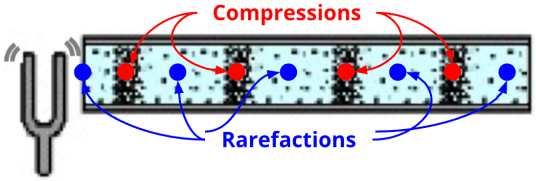
Pitch and Human Hearing

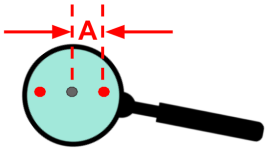
- A sound's frequency is perceived as *pitch*.
- A high-pitched sound is a high-frequency sound wave and a low-pitched sound is a low-frequency sound wave.
- Humans hear sounds with frequencies as low as 20 Hz and as high as 20 000 Hz.

Range of Human Hearing

Amplitude, Energy and Loudness

Sounds travel through fluids like air as a longitudinal wave; particles of air vibrate about a fixed position.





Longitudinal Wave Type

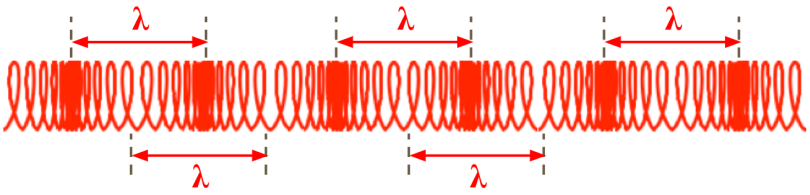
Particles vibrate || to wave motion.

Amplitude (A): maximum displacement of a particle from rest

High amplitude sound waves transport more energy and are perceived as more intense, louder sounds.

Wavelength (λ)

- In general, wavelength refers to the length of the wave … the length of the repeating unit observed within the pattern.
- For longitudinal waves, the wavelength is the distance from a compression to the next adjacent compression.



- High frequency sounds are short-wavelength waves.
- And low frequency sounds are long-wavelength waves.

The Speed of Sound

- The **speed of sound** (**v**) is the distance traveled per unit of time.
- The speed of sound depends upon **the properties of the medium** through which it travels.

$$V_{solid} > V_{liquid} > V_{gas}$$

- For sound waves traveling through air:

$$V_{sound\ in\ air} = 331.6\ m/s + (0.60\ m/s/°C) \cdot T$$

where **T** = celsius temperature

- Variations in frequency, wavelength, or amplitude will **NOT** affect the speed of a sound wave.

Frequency, Wavelength, and Speed

For any type of wave, there is a mathematical relationship between **wave speed** (**v**), **frequency** (**f**), and **wavelength** (**λ**):

$$v = f \cdot \lambda$$

- For sound waves traveling through a uniform medium, the speed is fixed. Changes in **f** or **λ** will not change the **v**.
- A doubling of the **f** will decrease the **λ** by a factor of 2.
- A tripling of the **f** will decrease the **λ** by a factor of 3.
- A halving of the **f** will increase the **λ** by a factor of 2.