

Warm-Up

Properties of Sound Waves



Lesson Question

What are the properties of sound waves?



Lesson Goals

Analyze the relationship between amplitude,

energy

intensity, and loudness.

Identify factors that affect the

intensity

of different sounds.

Analyze the relationship between pitch and frequency.

Explain the concept of

resonance



Words to Know

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

decibel	the unit of measurement for the intensity of sound
harmonic	pieces of a standing wave that are separated by a node
intensity	the amount of energy that flows through an area per unit of time
natural frequency	the frequency at which an object vibrates when struck
node	a point on a standing wave that appears to be stationary

**Words to Know**

resonance	the effect of forced vibration from an incoming wave that matches an object's natural frequency
standing wave	a wave that is produced when two waves of equal amplitude and wavelength travel in opposite directions and interfere

Sound Waves

- Sound waves are **longitudinal** waves.
 - Produced by the compression and expansion of an **elastic** medium
 - Require a medium to transfer energy
- Energy from a vibrating object is transferred through the movement of particles within the medium, creating a **mechanical** wave.
- When the vibration in the medium strikes your ear, you hear the sound.

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Intensity

- **Intensity** (I) is the amount of energy that flows through an area per unit of time.
- Sound intensity level is measured in **decibels (dB)**
 - logarithm of sound intensity
 - the way our ears perceive **sound**

$$I = \left[\frac{\text{Energy}}{\text{Time}(\text{area})} \right]$$

$$I = \frac{\text{Power}}{\text{area}}$$

Intensity and Hearing

- Vibrations from sound waves are received by **bones** in the ear.
 - Triggers electrical **impulses** in sensory nerves
 - Interpreted by the **brain** as sound

Instruction

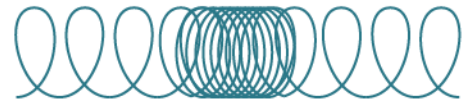
Properties of Sound Waves

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Intensity and Amplitude

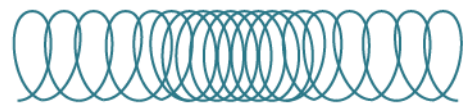
- Intensity is proportional to the **square** of the amplitude of a sound wave.



High-amplitude wave

- High-amplitude sound waves have more energy and produce

more **intense** sounds.



Low-amplitude wave

- Low-amplitude sound waves have less **energy** and produce less intense sounds.

Intensity and Distance

- Intensity is inversely proportional to the square of the distance from the source.
 - As the distance doubles, the intensity decreases to a quarter of that value.
 - As the distance is cut in half, the intensity **increases** by a factor of four.
- As the sound wave spreads out, the energy is **dispersed** over a greater area.
- The sound becomes less intense the farther it gets from the **source** of the sound.

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Intensity and Loudness

- Loudness is the subjective measurement of the **intensity** of a sound.
- Generally, loudness is **proportional** to intensity for an individual person.
- The perception of loudness may change with an individual's age or the **pitch** of the sound.

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Perception of Frequency

- Frequency is an objective measurement of how many times an object **vibrates** in a given amount of time (Hz).
 - Independent of the observer
- Pitch is a subjective perception of **frequency**.
 - Dependent on the observer

Frequency and Pitch

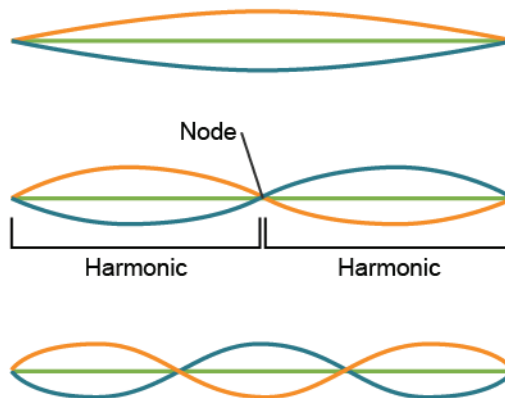
- Frequency and pitch are **directly** proportional.
- Frequency is an **inherent** property of the sound wave.
- Pitch is limited to the range of **frequencies** that an ear can detect.

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Standing Waves

- A **standing wave** is produced when two waves of equal amplitude and wavelength travel in **opposite** directions and interfere with each other.
- A **node** is a point on a standing wave that appears to be stationary.
- The pieces of the wave that are separated by a node are called **harmonics**.



Natural Frequency

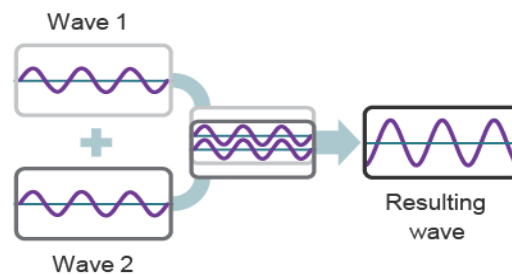
- Every object has a **natural frequency**, the frequency at which an object vibrates when struck.
 - Occurs at one of the harmonics possible for that object

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Resonance

- Resonance is a phenomenon that occurs when the frequency of a forced vibration is the **same** as the object's natural frequency.
- Creates a wave with greater **amplitude** than either individual wave



Summary

Properties of Sound Waves

**Lesson Question**

What are the properties of sound waves?

**Answer**

(Sample answer) Sound waves have properties such as intensity and frequency. These are objective measures associated with our perception of sound, such as loudness and pitch.

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Review: Key concepts

- Intensity is the amount of **energy** that flows through an area per unit of time.
 - Proportional to the square of the amplitude of a sound wave
 - Inversely proportional to the square of the distance from the source
- Loudness is a subjective measurement of the **intensity** of the sound.
 - Usually proportional to intensity for an individual person
- Frequency is an objective measurement of how many times an object vibrates in a given amount of time.
- Pitch is a subjective perception of frequency.
 - Frequency and pitch are **directly** proportional to each other.

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- A standing wave is produced when two waves of equal amplitude and wavelength travel in **opposite** directions and interfere with each other.
- A node is a **point** on a standing wave that appears to be stationary.
- The pieces of the **wave** that are separated by a node are called harmonics.
- Every object has a natural frequency, the frequency at which an object vibrates when struck.
- Resonance is a phenomenon that occurs when the frequency of a forced **vibration** is the same as the object's natural frequency.
 - Creates a wave with greater amplitude than either individual wave



Summary

Properties of Sound Waves

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