Sound Waves

Your ears are extraordinary organs. They pick up all the sounds around you and then translate this information into a form your brain can understand. One of the most remarkable things about this process is that it is completely **mechanical.** Your sense of smell, taste and vision all involve chemical reactions, but your hearing system is based solely on physical movement.

An object produces sound when it vibrates in matter. This could be a solid, such as earth; a liquid, such as water; or a gas, such as air. Most of the time, we hear sounds traveling through the air in our atmosphere.

When something vibrates in the atmosphere, it moves the air particles around it. Those air particles in turn move the air particles around them, carrying the pulse of the vibration through the air.

When you hit a bell, the metal vibrates -- flexes in and out. When it flexes out on one side, it pushes on the surrounding air particles on that side. These air particles then collide with the particles in front of them, which collide with the particles in front of them, and so on. This is called **compression**.

When the bell flexes away, it pulls in on the surrounding air particles. This creates a drop in pressure, which pulls in more surrounding air particles, creating another drop in pressure, which pulls in particles even farther out. This pressure decrease is called **rarefaction**.

In this way, a vibrating object sends a wave of pressure fluctuation through the atmosphere. We hear different sounds from different vibrating objects because of variations in the sound wave **frequency**. A higher wave frequency simply means that the air pressure fluctuation switches back and forth more quickly. We hear this as a higher **pitch**. When there are fewer fluctuations in a period of time, the pitch is lower. The level of air pressure in each fluctuation, the wave's **amplitude**, determines how loud the sound is.

Sound is a mechanical vibration

Sound is a regular mechanical vibration that travels through matter as a waveform. It consists of longitudinal or compression waves in matter.

Travels through matter

Although it is commonly associated in air, sound will readily travel through many materials, such as water and steel. Some insulating materials absorb much of the sound waves, preventing the waves from penetrating the material.

Does not travel in vacuum

Because sound is the vibration of matter, it does not travel through a vacuum or in outer space.

When you see movies or TV shows about battles in outer space, you should only be able to see an explosion but not hear it. The sounds are added for dramatic effect.

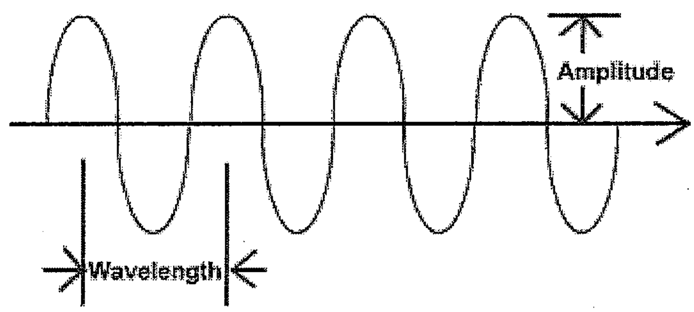
However, note that in outer space, there are actually some widely-spaced atoms and molecules floating around. But since they are so far apart, regular wave motion would not be great enough to detect.

Sound waves are different than light waves

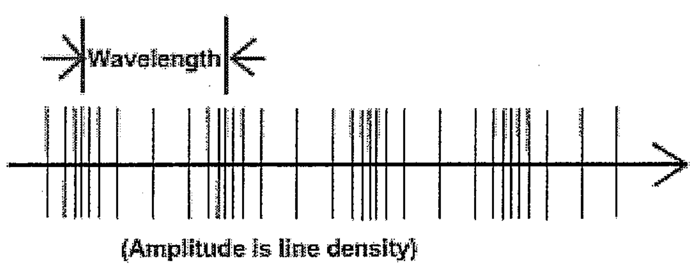
Light and radio waves are electromagnetic waves. They are completely different than sound, which is vibration of matter. Electromagnetic waves are related to electrical and magnetic fields and readily travel through space.

Sound is a longitudinal wave

The rapid back-and-forth vibration of an object creates the longitudinal or compression waves of sound. Longitudinal waves are waves that oscillate in the same path that the sound wave is moving. This is different than the up and down or transverse motion of a water wave.



Transverse wave (water wave)



Longitudinal or compression wave (sound)

The illustrations above show a comparison of a transverse wave—such as a water wave—and the compression wave of sound.

Characteristics of sound

A sound wave has the same characteristics as any other type of waveform. It has wavelength, frequency, velocity and amplitude.

Wavelength

Wavelength is the distance from one crest to another of a wave. Since sound is a compression wave, the wavelength is the distance between maximum compressions.

Speed or velocity

The sound waveform moves at approximately 344 meters/second, 1130 feet/sec. or 770 miles per hour at room temperature of 20°C (70°F).

Frequency

The frequency of sound is the rate at which the waves pass a given point. It is also the rate at which a guitar string or a loudspeaker vibrates.

The relationship between velocity, wavelength and frequency is:

velocity = wavelength x frequency

Amplitude

Since sound is a compression wave, its amplitude corresponds to how much the wave is compressed, as compared to areas of little compression. Thus, it is sometimes called pressure amplitude.

Creating and detecting sounds

Creating and detecting sounds are similar effects, but opposite. They demonstrate the duality of nature.

Creating sound

Whenever an object in air vibrates, it causes longitudinal or compression waves in the air. These waves move away from the object as sound. There are many forms of the vibration, some not so obvious.

The back and forth movement of a loudspeaker cone, guitar string or drum head result in compression waves of sound. When you speak, your vocal cords also vibrate, creating sound.

Blowing across a bottle top can also create sound. In this case, the air inside the bottle goes in a circular motion, resulting in sound waves being formed. Wind blowing through trees can also create sound this indirect way.

Sound can also be created by vibrating an object in a liquid such as water or in a solid such as iron. A train rolling on a steel railroad track will create a sound wave that travels through the tracks. They will then vibrate, creating sound in air that you can hear, while the train may be a great distance away.

Detecting sound

When a sound wave strikes an object, it can cause the object to vibrate. This leads to the method to detect sound, which requires changing that vibration into some other type of signal—usually electrical.

The main way you detect or sense sounds is through your ears. The sound waves vibrate your ear drum, which goes to the inner ear and is changed to nerve signals you can sense.

You can also feel sounds. Stand in front of a stereo or hi-fi loudspeaker on at full volume, and you can feel some of the vibrations from the music.

There are mechanical devices that detect sounds, such as the microphone. The sound vibrates a membrane, which creates an electric signal that is amplified and recorded.

Summary

Sound consists of longitudinal or compression waves that move through air or other materials. It does not travel in a vacuum. Sound has the characteristics of wavelength, frequency, speed and amplitude. Sound waves are created by the vibration of some object and are detected when they cause a detector to vibrate.

Creating Sound Waves

Sound consists of compression waves in some material—usually air. Sound waves are created by the vibration of some object or even air itself. They can be created by a back-and-forth motion of an object, by having air pass over a vibrating object, or by moving air causing the vibrations.

Questions you may have include:

- How is does a vibrating object create sound?
- What is an example of sound created by air passing by a vibrating object?
- How can air cause its own vibrations?

Vibration creates sound waves

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Back-and-forth vibration

A vibrating object will cause these compression waves in air or another medium.

A good example is a tuning fork. The metal rods in the tuning fork move back-and-forth, causing the compression wave in the air. A tuning fork could also be put in water, creating sound waves within the water.

Note that the waves created by the tuning fork on the surface of a pool of water are not sound waves. They are surface waves, which are circular instead of compression waves.

Other examples of something vibrating back-and-forth to cause sound are a guitar string, drum, loudspeaker.

Passing by vibrating object

If something vibrates as air passes through or by it, the air can be also made to vibrate as sound waves. The best example of that method come from your vocal chords.

The air causes some of the vibration and the vibration then amplifies the sound. You can see this by putting a thick blade of grass between your thumbs and blowing on it. Another example is wrapping a comb in wax paper, putting it up to your mouth and blowing on it to make the noise, similar to a kazoo.

Air causes its own vibration

When moving air passes an by object, it can start some air to vibrate and make sound. This type of sound can be heard on a windy day or when you blow across the top of a bottle.

One example is an explosion, which results in a sudden surge in air, causing the high-volume sound. Thunder and a balloon popping are other examples of this way of creating sound.

Summary

Sound can be created by a back-and-forth motion of an object, by having air pass over a vibrating object or by moving air causing the vibrations.

Name:____Date:________________Period:_______

Sound Waves

1. What is your hearing system based solely on?

2. How is sound produced?

3. Most of the sound that we hear travels through what?

4. Explain compression.

5. Explain rarefaction.

6. Why do we hear different sounds from different objects?

7. How does sound travel?

8. What type of wave is sound?

9. Explain that type of wave?

10. What is wavelength?

11. What is frequency?

12. Give two examples of sound and how it is created.

13. How do you detect sound?

14. How does a vibrating object cause sound?

15. What is an example of sound created by air passing by a vibrating object?

16. How can air cause its own vibrations?