
# Waves and Sound

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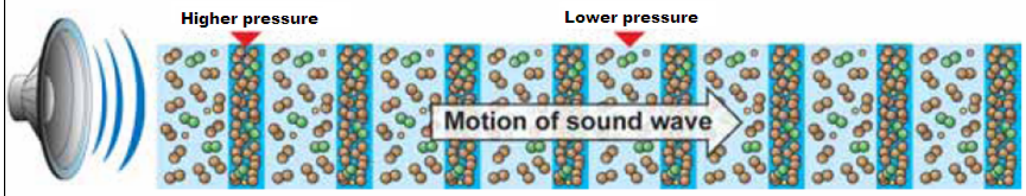
# Chapter 13 Learning Goals

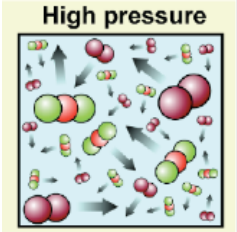
- Describe properties of sound.
- Explain how factors like temperature and pressure affect the behavior of sound waves.
- Describe how humans hear sounds.

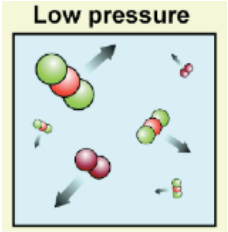
# Sound

- Sound is a traveling oscillation of atoms or pressure.
- When they are pushed by the vibrations, it creates a layer of higher pressure which results in a traveling vibration of pressure.



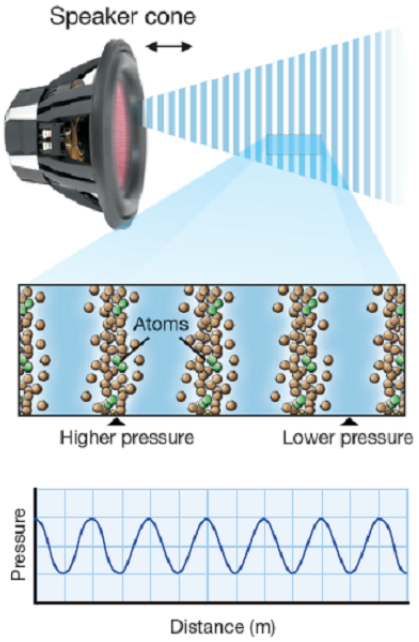
# Sound



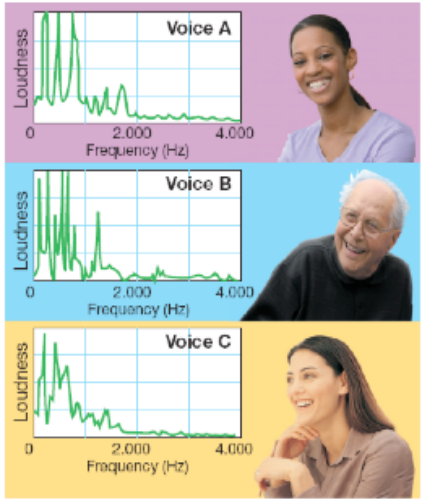

- At the same temperature and volume, higher pressure contains more molecules than lower pressure.

# Sound and Air Pressure



# The frequency of sound

- The pitch of a sound is how you hear and interpret its frequency.
- A low-frequency sound has a low pitch.
- A high-frequency sound has a high pitch.



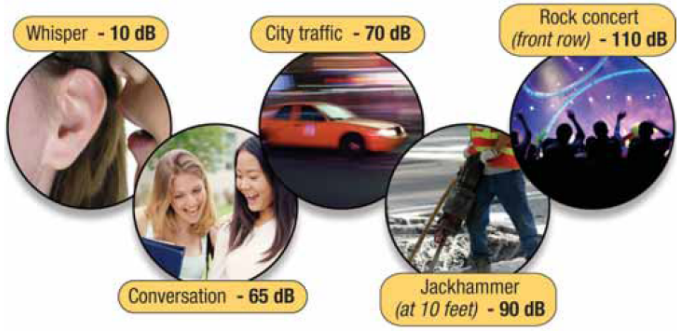

Each person is saying “Hello”.

# The frequency of sound

- Almost all the sounds you hear contain many frequencies at the same time.
- Humans can generally hear frequencies between 20 Hz and 20,000 Hz.

# Intensity and loudness of sound

- The loudness of a sound is measured in decibels (dB).
- The decibel is a unit used to express relative differences in the loudness of sounds.



cpo science making it real.

# Intensity and loudness of sound

| | |
|---|---|
| **0 dB** | Threshold of human hearing; quietest sound we can hear |
| **10–15 dB** | A quiet whisper 1 meter away |
| **30–40 dB** | Background sound level in a house |
| **45–55 dB** | The noise level in an average restaurant |
| **65 dB** | Ordinary conversation 1 meter away |
| **70 dB** | City traffic |
| **90 dB** | A jackhammer cutting up the street 3 meters away |
| **100 dB** | MP3 player turned to its maximum volume |
| **110 dB** | The front row of a rock concert |
| **120 dB** | The threshold of physical pain from loudness |

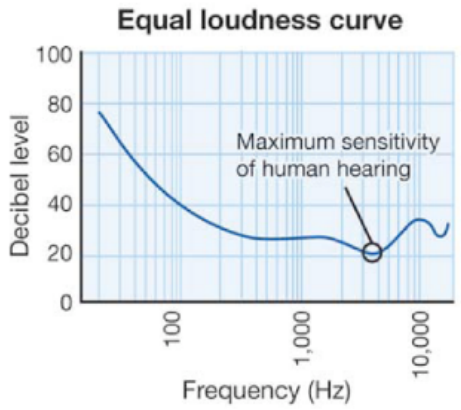
# Decibels and amplitude

| Decibels (dB) | Amplitude |
|---|---|
| 0 | 1 |
| 20 | 10 |
| 40 | 100 |
| 60 | 1,000 |
| 80 | 10,000 |
| 100 | 100,000 |
| 120 | 1,000,000 |

- The amplitude of a sound increases ten times every 20-decibels.

# Loudness

- Sounds near 2,000 Hz seem louder than sounds of other frequencies, even at the same decibel level.
- According to this curve, a 25 dB sound at 1,000 Hz sounds just as loud as an 40 dB sound at 100 Hz.



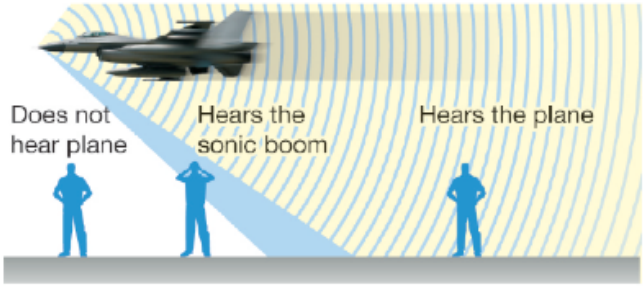
# The speed of sound

| Material | Sound Speed (m/s) |
|---|---|
| Air | 330 |
| Helium | 965 |
| Water | 1,530 |
| Wood (average) | 2,000 |
| Gold | 3,240 |
| Steel | 5,940 |

- The speed of sound in normal air is 343 meters per second (660 miles per hour).
- Sound travels through most liquids and solids faster than through air.
- Sound travels about five times faster in water, and about 18 times faster in steel.

# The speed of sound

- A supersonic jet "squishes" the sound waves so that a cone-shaped shock wave forms where the waves "pile up" ahead of the plane.
- In front of the shock wave there is total silenc

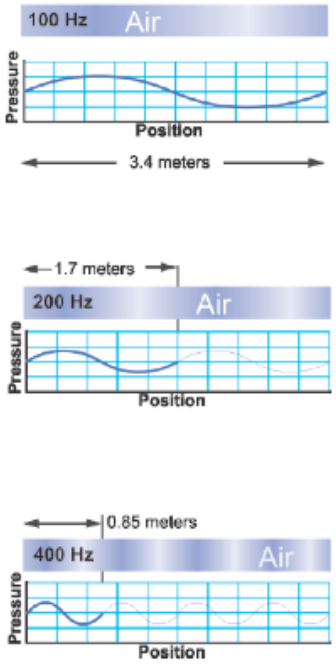


# The wavelength of sound

- **The wavelength of sound in air is similar to the size of everyday objects.**

| Frequency (Hz) | Wavelength | Typical Source |
|---|---|---|
| 20 | 17 m | rumble of thunder |
| 100 | 3.4 m | bass guitar |
| 500 | 68 cm (27”) | average male voice |
| 1,000 | 34 cm (13”) | female soprano voice |
| 2,000 | 17 cm (6.7”) | fire truck siren |
| 5,000 | 6.8 cm (2.7”) | highest note on a piano |
| 10,000 | 3.4 cm (1.3”) | whine of a jet turbine |
| 20,000 | 1.7 cm (0.67”) | highest-pitched sound you can hear |

# Wavelength of Sound

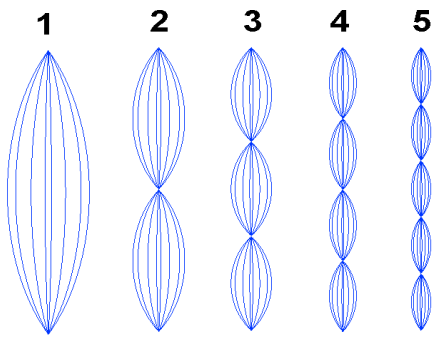


# Standing waves

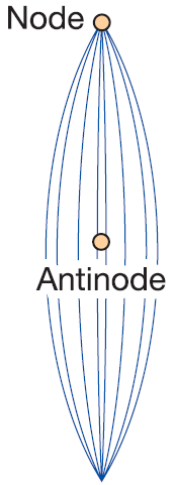
- A wave that is confined in a space is called a standing wave.
- A string with a standing wave is a kind of oscillator.

# Standing waves

- The lowest natural frequency is called the fundamental.
- A vibrating string also has other natural frequencies called harmonics.

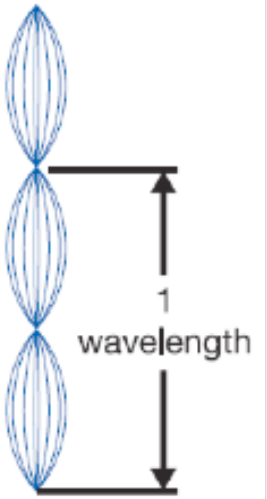


# Standing waves




- The place on a harmonic with the greatest amplitude is the antinode.
- The place where the string does not move (least amplitude) is called a node.

# Standing waves

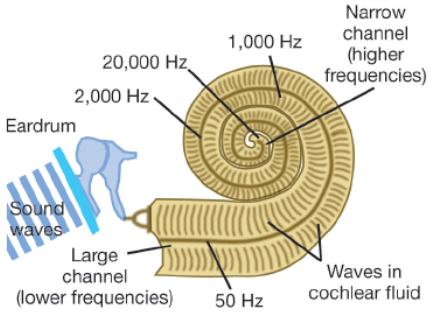



- It is easy to measure the wavelength of a standing wave on a string.
- Two harmonics equals one wave!

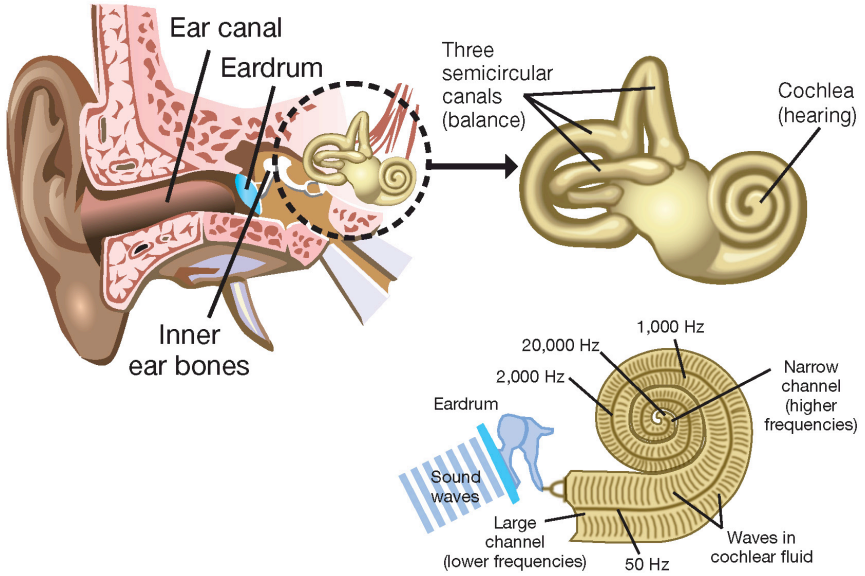
# How we hear sound

- **The parts of the ear work together:**

1. **When the eardrum vibrates, three small bones transmit the vibrations to the cochlea.**
2. **The vibrations make waves inside the cochlea, which vibrates nerves in the spiral.**
3. **Each part of the spiral is sensitive to a different frequency.**



# Human Ear Diagram



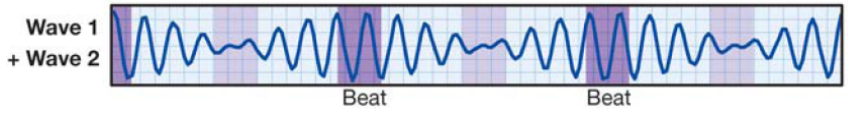
# Sound protection

Ear plug

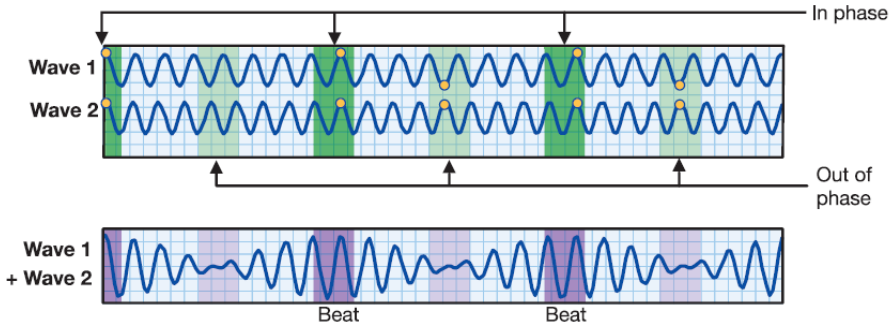
- Listening to loud sounds for a long time causes the hairs on the nerves in the cochlea to weaken or break off resulting in permanent damage.

# Beats

- When two frequencies of sound are not exactly equal in value, the loudness of the total sound seems to oscillate or beat.
- The superposition principle states that when sound waves occur at the same time they combine to make a complex wave.



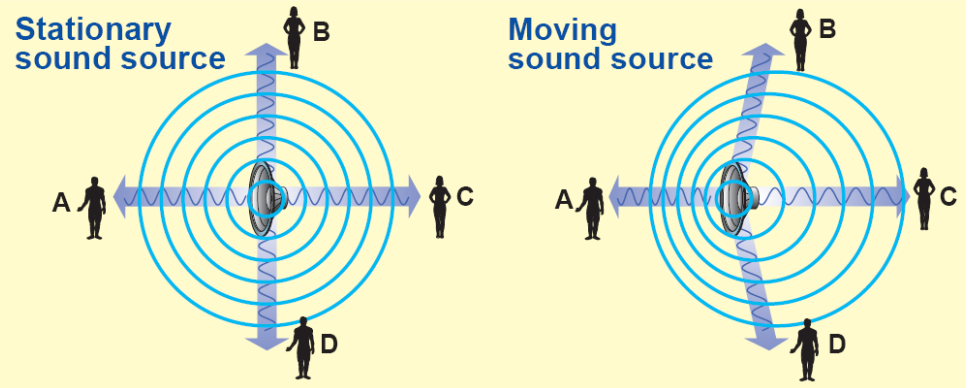
# Why We Hear Beats




# The Doppler effect

- The shift in frequency caused by motion is called the Doppler effect.
- When the object is moving, the frequency will not be the same to all listeners.
- The Doppler effect occurs at speeds below the speed of sound.

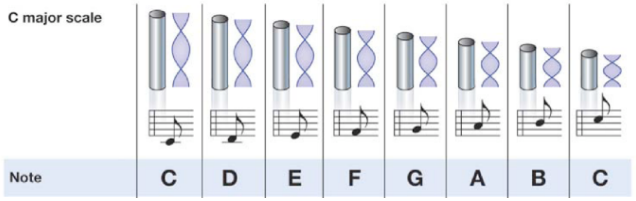
# The Doppler Effect



## Optional* Investigation 13

# Harmonic Motion

- **Key Questions:**
  - How can we observe sound as a wave?
  - How can we use the speed of sound and certain frequencies to build a basic instrument based on wavelength?



TECHNOLOGY ▸▸ CONNECTION

# Cell Phones: How they work

**The process that allows a cell phone to communicate is the same as for a radio or walkie-talkie. All of these devices use electromagnetic waves of within a specific frequency range to send information.**