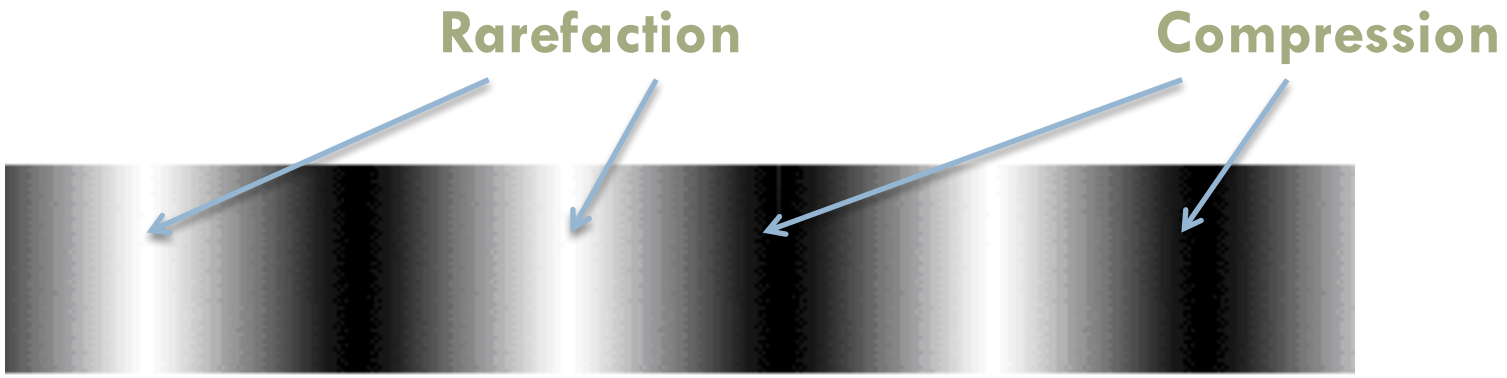
SOUND

Sound

- All sounds originate in the vibrations of material objects.
  - Human voice, trumpet, flute, guitar
- Sound is a longitudinal wave.
- A pulse of compressed air is called a **compression.**
- A pulse of low-pressure air is called a **rarefaction.**



Sound

- The frequency at which an object vibrates is the frequency of the sound wave it produces.
- The frequency of a sound wave is the pitch.
- The range of frequencies most people can hear is between 20 and 16,000 Hz.
  - Below 20 Hz – infrasonic
  - Above 16,000 Hz – ultrasonic
- The ability to hear high frequencies deceases with age. By age 70, most people can't hear above 8000 Hz.

Speed of Sound in Different Media

- Sound travels in solids, liquids, and gases.
- The speed of sound differs in different materials.
- In general, sound is transmitted faster in liquids than in gases, and still faster in solids.
- Sound cannot travel in a vacuum.
- The speed of sound in dry air is about 343 m/s.

Air (0°) – 331 m/s
Air (20°) – 343 m/s
Water (25°) – 1493 m/s
Iron (25°) – 5130 m/s

Speed of sound in air:
$v = 331 + 0.6\,(T\ °C)$

Sound Wave Energy

- Typical sound waves have very little energy
  - If 50,000 people yelled for 90 minutes, the amount of sound energy produced would only be enough to heat up one cup of coffee.
- As sound travels through media, it loses energy to heat.
  - High frequency waves are converted to heat faster, so these waves die out sooner.
  - If you need a sound wave to travel far, it should be a low frequency wave.

Natural Frequency

- When an object is disturbed, it vibrates at its own special set of frequencies, which make a certain sound.
- The **natural frequency** of an object depends on the elasticity and shape of the object.
  - When an object vibrates at its natural frequency, it uses the least amount of energy.

FIGURE 26.8 ▲
The natural frequency of the smaller bell is higher than that of the big bell, and it rings at a higher pitch.

Resonance

- **Resonance –**
  - Occurs when an object is vibrated at its natural frequency.
  - The result is a vibration of greater AMPLITUDE.

FIGURE 26.10 ▲
Pumping a swing in rhythm with its natural frequency produces larger amplitudes.

FIGURE 26.12 ▲
In 1940, four months after being completed, the Tacoma Narrows Bridge in the state of Washington was destroyed by a 40-mile-per-hour wind.

Loudness

- Loudness is a psychological sensation sensed in the brain, and it differs for different people.
- Loudness varies as the logarithm of intensity (wave energy).
  - (ex: An increase from 10 dB to 20 dB means the sound is 10 times louder).
- The unit of intensity for sound is the decibel (dB), named after Alexander Graham Bell.

Table 26.1 Sound Levels

Source of Sound	Level (dB)
Jet engine, at 30 m	140
Threshold of pain	120
Loud rock music	115
Old subway train	100
Average factory	90
Busy street traffic	70
Normal speech	60
Library	40
Close whisper	20
Normal breathing	10
Hearing threshold	0