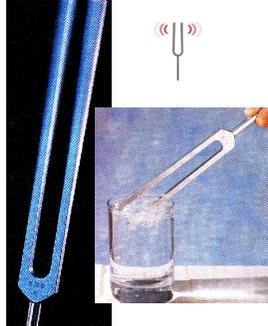


Sound Waves

Mr. Sudbury

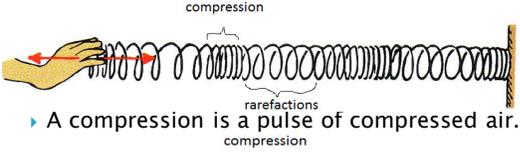
Vibrations Carry Energy

- ▶ Waves are caused by a **vibration** or a disturbance.
- ▶ Sound waves are no different.
 - Stringed instruments have vibrating strings.
 - Saxophone has vibrating reed.
 - Flute has air that vibrates past a mouthpiece.
 - Voice has vocal cords that vibrate.



Sound in Air

- ▶ Remember that sound travels as a **longitudinal wave**. (AKA compression)



- ▶ A compression is a pulse of compressed air.



Compression/Rarefaction

- ▶ When you open the door quickly, the door compresses the air and it is pushed out the window.
- ▶ When you close the door quickly, a pulse of air moves from the curtain to the door.

Media that Transmit Sound

- ▶ We hear sound travel through air, but sound waves can also travel through liquids and solids.
- ▶ Sound waves travel **fast in air**, **faster through liquids**, and **fastest through solids**.



Transmitting Sound

- ▶ Sound waves are **mechanical waves**.
- ▶ Sound **MUST** have particles to “carry” the waves. Remember that the particles do not move with the wave, they just vibrate back and forth.



- ▶ Without some form of particle (medium), you cannot hear sound.

Transmitting Sound

- Remember: You **CAN NOT** hear sound in a vacuum.

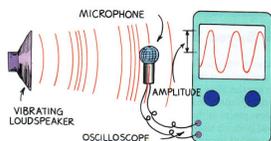


Speed of Sound

- In 0°C air, sound travels 330 m/s.
- Increases 0.60 m/s per 1°C change in air temp.
- Average “room temperature” speed is approximately 340 m/s.
- Speed of sound in a material depends on:
 - Phase: Solid, liquid, or gas
 - Elasticity of particles
 - Temperature of particles

Loudness of Sound

- The perceived loudness of a sound wave is from the amplitude of the wave.
- A machine (called an oscilloscope) can convert longitudinal waves into transverse wave we can see..



Loudness of Sound

- Loudness of sounds can be measured in decibels.
- A 10 dB increase means that the sound is 10 times louder.
- How much louder is the average factory than busy street traffic.
- Street → factory
 - $(10) \times (10) = 100$ times louder

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

Forced Vibration (Making Sound)



- Forced Vibration** – an object is made to vibrate by another vibrating object that is nearby.
- The “sounding board” in a musical instrument amplifies the sound through a forced vibration.

Creating Sound

- In each case, the vibration causes vibration in a larger area.
 - Instruments vibrate a sounding board or larger column of air.
 - Your voice vibrates due to vocal cord vibrations that vibrate the air in your throat and mouth.
- Whatever frequency is produced it the frequency of sound wave that we will hear.
- We hear frequency of a sound wave as a ***pitch***.

Pitch = frequency

- ▶ High pitch = high vibration f = shorter λ
- ▶ low pitch = low vibration f = longer λ
- ▶ Young humans can hear approximately 20 Hz to 20,000 Hz
- ▶ f below 20 Hz are **infrasonic**
- ▶ f above 20,000 Hz are **ultrasonic**
- ▶ Humans can not hear infrasonic or ultrasonic frequencies.

What Frequency?

- ▶ When vibrations occur, what determines the frequency?
- ▶ Will these two bells sound the same?



- ▶ All objects have a natural frequency that they vibrate at.
- ▶ Natural f of an object depends on size, shape, & elasticity of material.

Natural Frequency

- ▶ Different f means different pitches...



Natural Frequency

- ▶ Different f means different pitches...

- ▶ Flute
- ▶ French Horn
- ▶ Tuba



Resonance

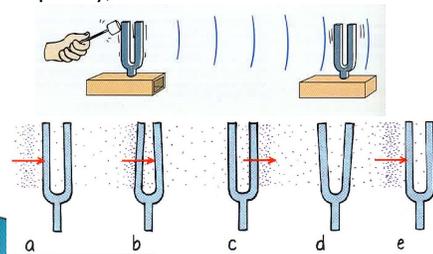
- ▶ **Resonance** is when the amplitude of a wave gets much larger (louder) because a forced vibration matches an objects natural frequency.

Example: Wind caused the Tacoma Narrows Bridge to vibrate. When it reached its natural frequency, the amplitude of the vibration increased greatly.



Resonance

- ▶ If one tuning fork is struck, it will cause another close tuning fork (of the same frequency) to vibrate.



Interference

- ▶ Constructive: (Increases amplitude)

Interference

- ▶ Destructive: Decreases Amplitude

Interference: Beats

- ▶ When two or more slightly different frequencies are sounded together, a fluctuation in the loudness of the sound is heard.
- ▶ Beats are the name for the periodic variations in loudness.

Beats

Beats

- ▶ A 262 Hz tuning fork and a 266 Hz tuning fork are struck simultaneously. What is the beat frequency?
- ▶ A 262 Hz tuning fork and a 272 Hz tuning fork are struck simultaneously. What is the beat frequency?
- ▶ Beat frequencies above 10 Hz (10 beats per second) are too rapid to be heard.

The End