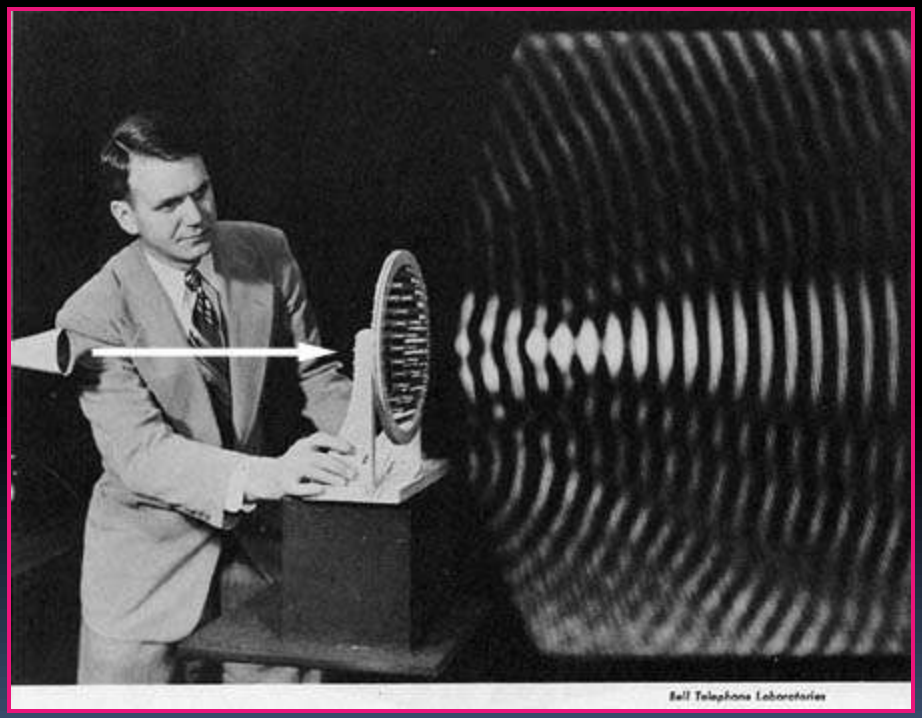
Chapter 26: Sound



26.1 The Origin of Sound

All sounds are produced by the vibrations of material objects.

Piano, violin, guitar: vibrating strings

Saxophone: vibrating reed

Flute: vibrating air around the mouthpiece

Voice: vibrating vocal cords

26.1 The Origin of Sound

People who lose their voice box will often times uses a mechanical larynx to amplify the vibrations they make into audible sound.

Video Clip

26.1 The Origin of Sound

A high pitched sound has a high frequency.

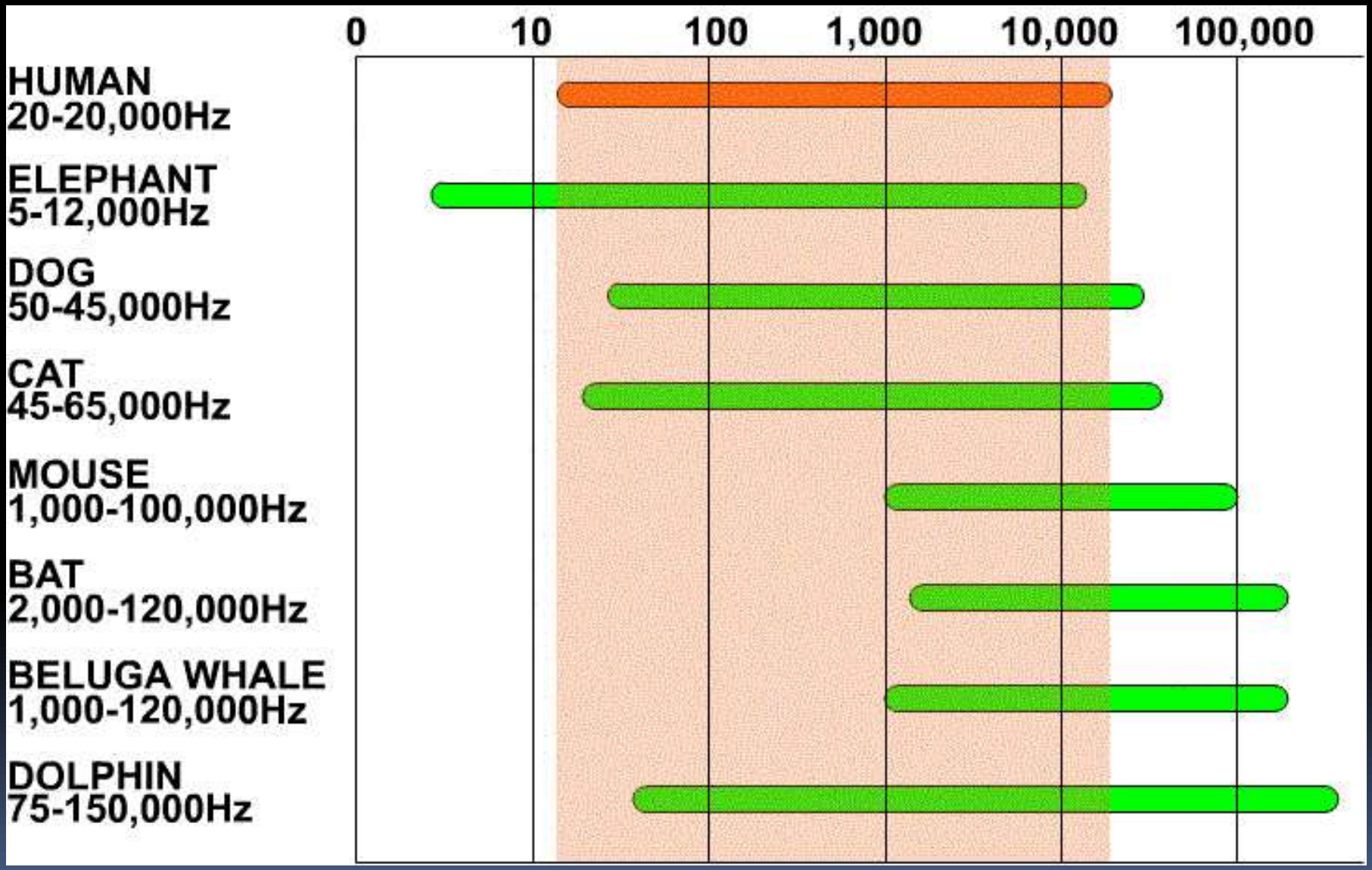
A low pitched sound has a low frequency.

26.1 The Origin of Sound

Humans have a hearing range from 20 to 20,000 Hz.

Certain animals have different hearing ranges.

26.1 The Origin of Sound



26.1 The Origin of Sound

Infrasonic: **Sound wave frequencies below 20 Hz.**

Ultrasonic: **Sound wave frequencies above 20,000 Hz.**

26.1 The Origin of Sound

As humans get older their range of hearing decreases and they cannot hear high frequencies any longer.

Cell phone company capitalize on this by creating mosquito ringtones and targeting the at teenagers.

26.1 The Origin of Sound

Let’s test your hearing range.

Keep track of what letter sound you can hear.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

l.

26.1 The Origin of Sound

a.

You're really getting on a bit
You are either old or have really messed up your hearing by turning your amp up to 11 and listening to Spinal Tap. Or both. The highest pitched ultrasonic mosquito ringtone that I can hear is 8kHz

b.

You can't remember my teens
But you can just about hear some of these tones that those youngsters are on about so you're feeling moderately smug. The highest pitched ultrasonic mosquito ringtone that I can hear is 10kHz

c.

You're in a mid life crisis
Your ears aren't what they once were and you have resorted to doing online hearing tests. The highest pitched ultrasonic mosquito ringtone that I can hear is 12kHz

26.1 The Origin of Sound

d.

You're not a hoopy frood
You thought you were really with it and in with your younger colleagues but they just laugh at you because you can't hear beyond this! The highest pitched ultrasonic mosquito ringtone that I can hear is 14.1kHz

e.

You are a thirtysomething
You're a little frustrated that you can't hear all the tones that the young 'uns can but will be more than happy if it means you don't have to listen to their damn ringtones on the bus anymore. The highest pitched ultrasonic mosquito ringtone that I can hear is 14.9kHz

f.

You are in your twenties
You can still hear reasonably well and you can play this without my old fart colleagues hearing it which makes you feel kinda good. The highest pitched ultrasonic mosquito ringtone that I can hear is 15.8kHz

26.1 The Origin of Sound

g.

You are about 20 years old
The teen repellent will no longer foil you, but you can still hear some pretty high tones. The highest pitched ultrasonic mosquito ringtone that I can hear is 16.7kHz

h.

You are the typical teenager
You can hear the frequency of the mosquito teen repellent - but probably not for much longer! The highest pitched ultrasonic mosquito ringtone that I can hear is 17.7kHz

i.

You are an easily repelled teenager
The mosquito device was made for the likes of you. You are probably begging to make the noise stop! The highest pitched ultrasonic mosquito ringtone that I can hear is 18.8kHz

26.1 The Origin of Sound

j.

You aren't even a teenager yet!

Your hearing rules! You're either quite young or you've looked after your ears.

The highest pitched ultrasonic mosquito ringtone that I can hear is 19.9kHz

k.

You are a dog

Or maybe you are a mosquito, you certainly can't be human.

The highest pitched ultrasonic mosquito ringtone that I can hear is 21.1kHz

l.

You are a liar

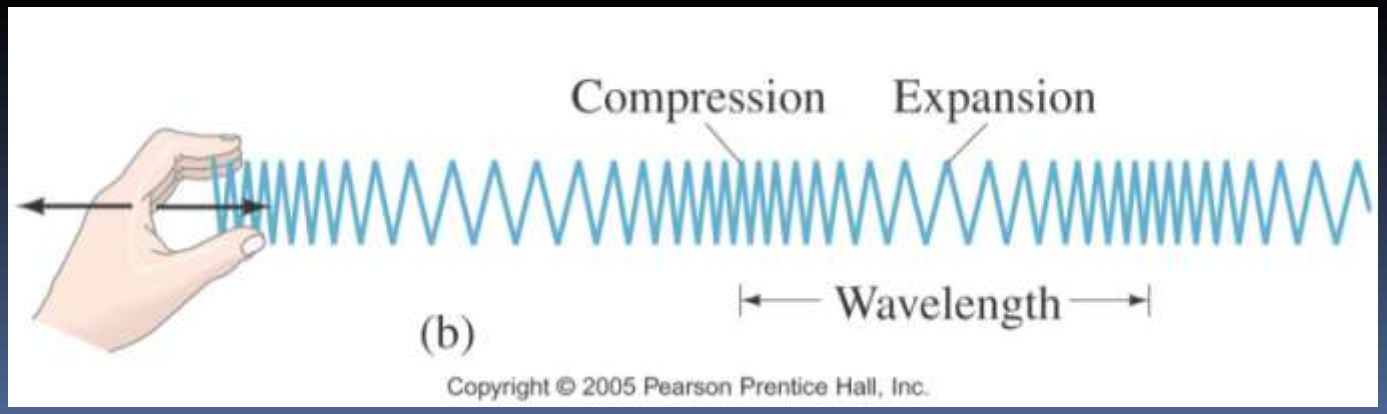
You claimed to be able to hear a tone that contained absolutely no sound!

The highest pitched ultrasonic mosquito ringtone that I can hear is 22.4kHz

26.2 Sound in Air

Sound is a longitudinal wave

Longitudinal wave – a wave when the motion of the medium is parallel to the direction in which a wave travels



26.2 Sound in Air

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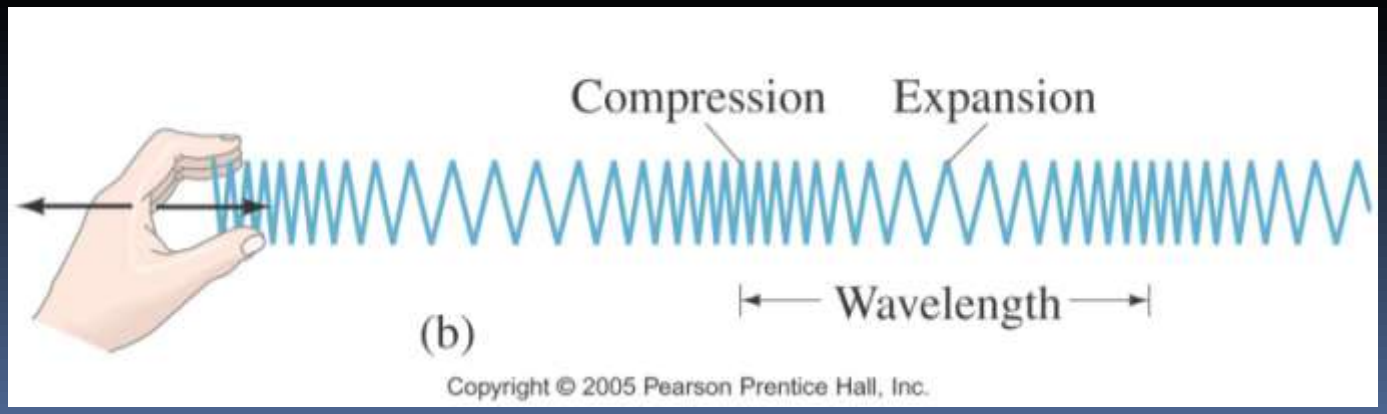
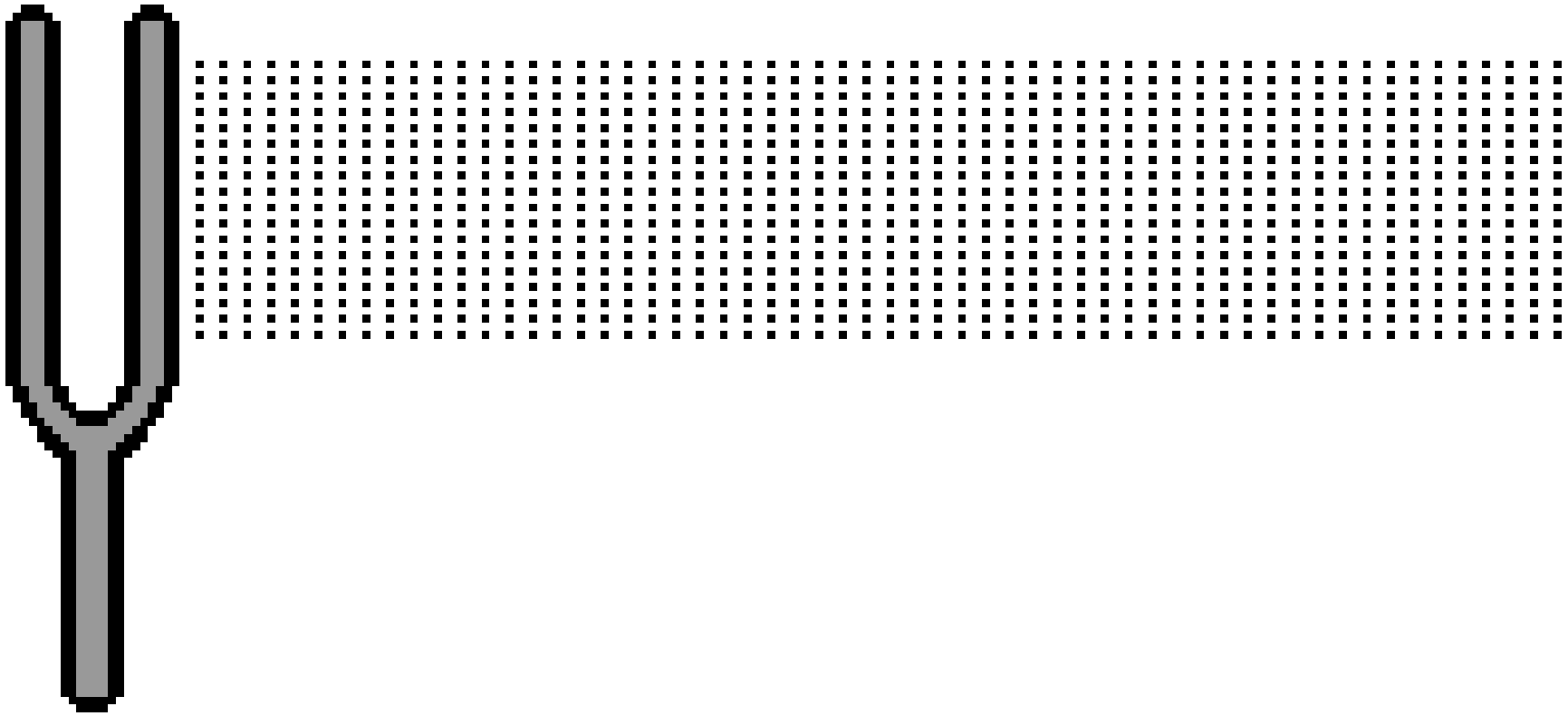


26.2 Sound in Air

As a source vibrates, a series of compressions and rarefactions is produced.



26.3 Media That Transmit Sound

Sound can travel through solids, liquids, or gases.

26.3 Media That Transmit Sound

In general, sound is transmitted faster in liquids than in gases, and still faster in solids.

TABLE 12–1 Speed of Sound in Various Materials
(20°C and 1 atm)

Material	Speed (m/s)
Air	343
Air (0°C)	331
Helium	1005
Hydrogen	1300
Water	1440
Sea water	1560
Iron and steel	≈5000
Glass	≈4500
Aluminum	≈5100
Hardwood	≈4000
Concrete	≈3000

26.3 Media That Transmit Sound

Sound cannot travel in a vacuum.

There may still be vibrations, but without a medium, there is no sound.

26.4 Speed of Sound

The speed of sound depends on the medium and the temperature.

The more elastic the medium the faster sound goes.

The hotter the medium the faster sound goes.

26.4 Speed of Sound

The speed of sound in air

$$v = 332 + .6T$$

v = speed of sound (m/s)

T = temperature (°C)

26.4 Speed of Sound

Rule of thumb:

Count how many seconds between when you see a flash of lightning and hear the thunder.

For every three seconds, the lightning stuck 1 km away.

For every 5 seconds, the lightning struck 1 mile away.

26.5 Loudness

Loudness is directly related to the amplitude of the sound wave.

Loudness is inversely related to the square of the distance from source of the sound wave.

26.5 Loudness

Intensity of sound is directly related to the loudness.

Intensity is measured on a logarithmic scale and measured in decibels (dB).

26.5 Loudness

A sound of 10 dB is 10 times more intense as a sound of 0 dB.

A sound of 20 dB is 100 times more intense as a sound of 0 dB.

A sound of 40 dB is 100 times more intense as a sound of 20 dB.

26.5 Loudness

Different sound have different intensity levels.

TABLE 12–2 Intensity of Various Sounds

Source of the Sound	Sound Level (dB)	Intensity (W/m^2)
Jet plane at 30 m	140	100
Threshold of pain	120	1
Loud rock concert	120	1
Siren at 30 m	100	1×10^{-2}
Auto interior, at 90 km/h	75	3×10^{-5}
Busy street traffic	70	1×10^{-5}
Talk, at 50 cm	65	3×10^{-6}
Quiet radio	40	1×10^{-8}
Whisper	20	1×10^{-10}
Rustle of leaves	10	1×10^{-11}
Threshold of hearing	0	1×10^{-12}

26.6 Forced Vibration

Forced vibration: The vibration of an object that is made to vibrate by another vibrating object nearby.

Sounding boards serve as a mechanism in instruments to amplify sound through force vibration.

26.8 Resonance

Resonance: what occur when the forced vibration of an object matches the object's natural frequency.

When resonance occurs, a dramatic increase in amplitude occurs.

26.8 Resonance

You can force a glass to vibrate at its natural frequency so that the amplitude gets so great that the glass breaks.

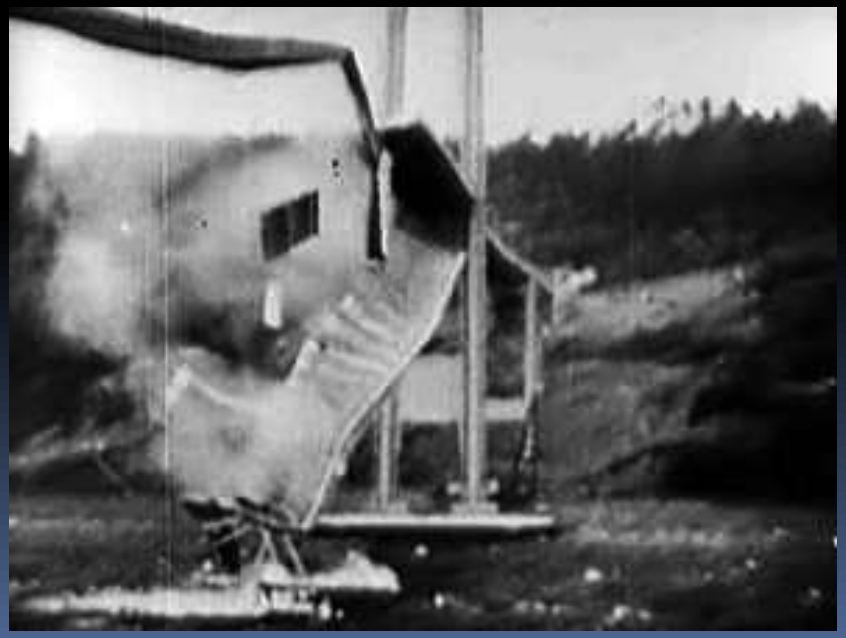
26.8 Resonance

Breaking Glass

Video

26.8 Resonance

The Tacoma Narrows Bridge broke apart in 1940 because the wind gust matched the natural frequency of the bridge.



26.8 Resonance

The Tacoma Narrows Bridge

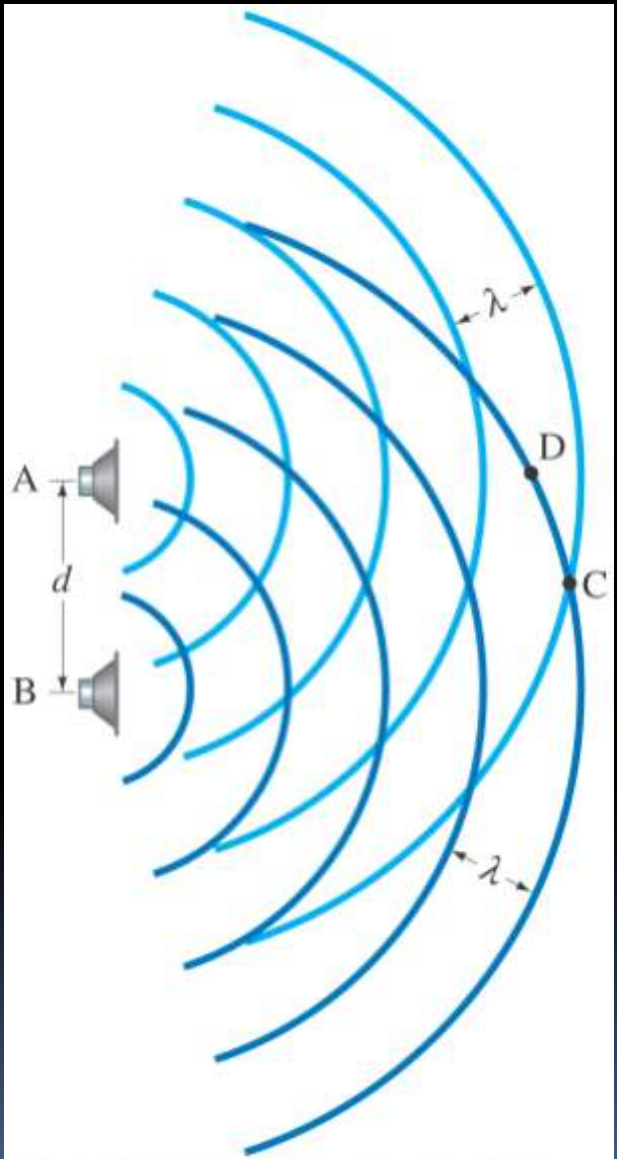
26.9 Interference

Interference: when two waves are in the same medium at the same time.

Constructive interference of sound waves results in larger amplitude.

Destructive interference of sound waves results in decrease in amplitude.

26.9 Interference



Sound waves interfere in the same way that other waves do in space.

Poorly designed theaters can create “Dead Spots” where sound is cancelled out.

26.9 Interference

Time for a Gizmo!

26.9 Interference

Time for a Another Gizmo!

26.10 Beats

Beats: the phenomenon that occurs when two sound of slightly different frequencies are heard.

Beats are used to help tune stringed instruments like guitars.

26.10 Beats

Time for a Gizmo!

26.10 Beats

Beat Frequency

$$\text{beat freq} = \left| f_1 - f_2 \right|$$

f_1 = frequency of one source

f_2 = frequency of second source