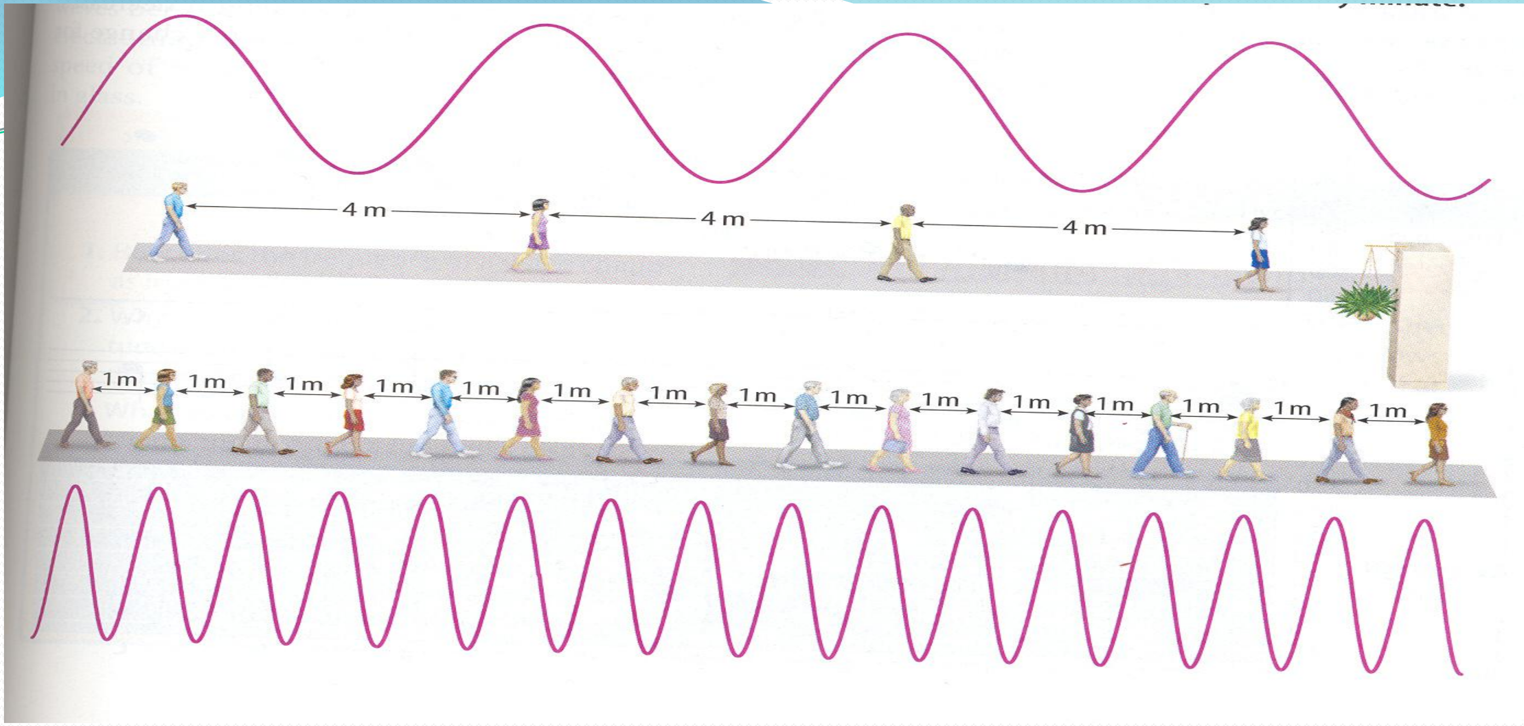
Sound Waves

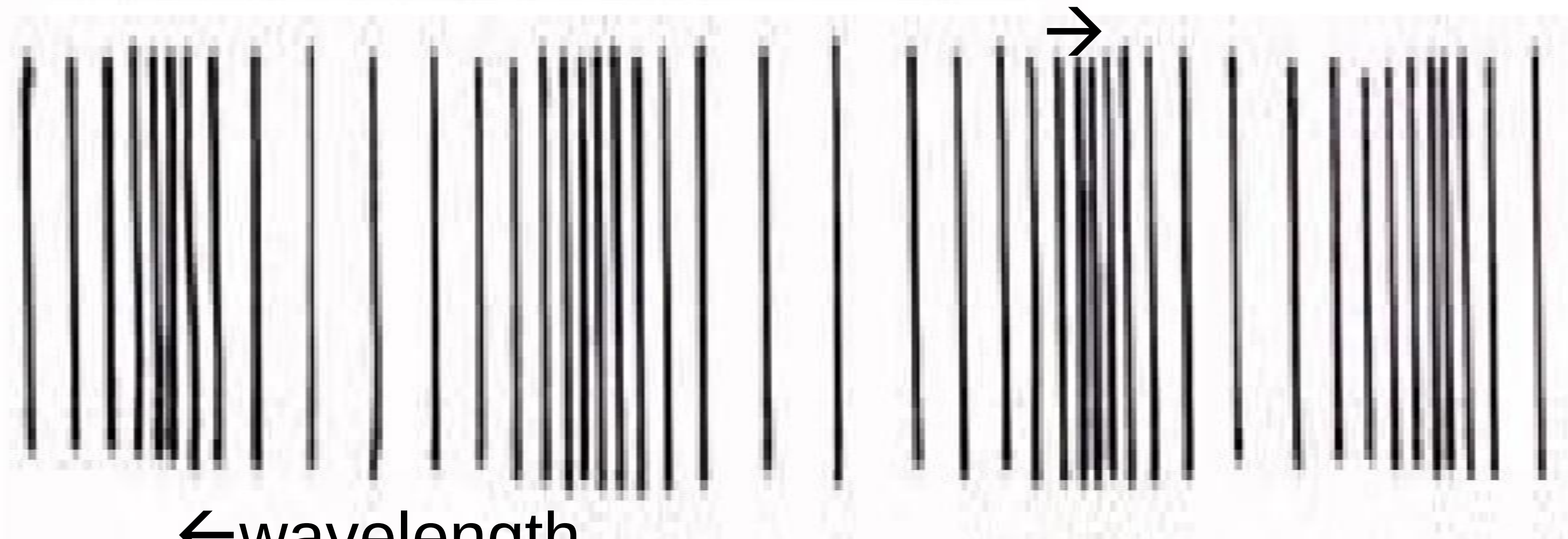
Properties of Waves

- **The basic properties of waves are amplitude, wavelength, frequency, and speed.**
- **The amplitude of a wave is the amount of energy it has. Amplitude is related to brightness and volume.**
- **The frequency of a wave is the number of complete waves that pass a given point in a certain amount of time. Frequency can also be described as the number of vibrations per second. Frequency is related to pitch.**
- **Wavelength and frequency have an inverse relationship. When one goes up, the other goes down**
- **Frequency is measured in units called hertz (Hz). A wave or vibrations that occurs every second has a frequency of 1 Hz.**



Higher frequencies result in shorter wavelengths.

In a compressional wave, the wavelength is the distance between the center of one compression and the center of the next compression or from the center of one rarefaction to the center of the next rarefaction. ←wavelength →



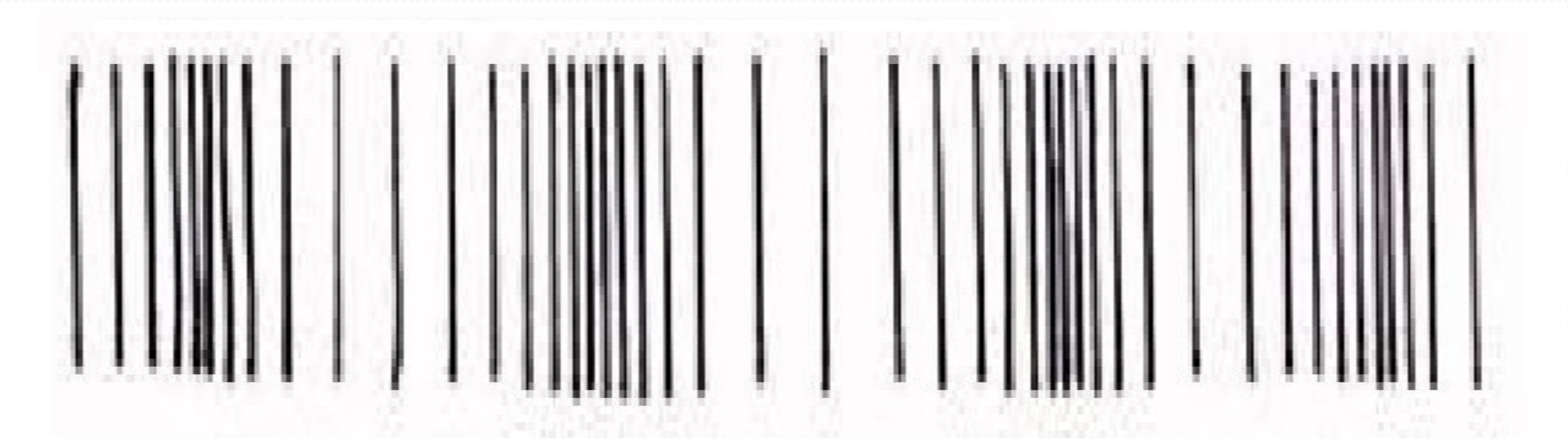
←wavelength →

A wave's amplitude is related to the energy that the wave carries.

Waves of bright light have greater amplitudes than waves that make up dim light.

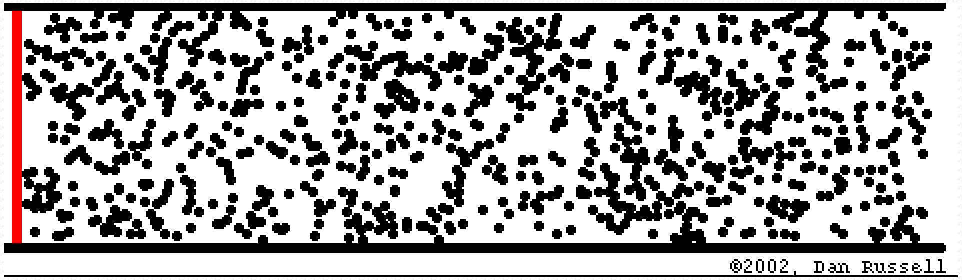
Loud sound waves have greater amplitudes than soft sound waves

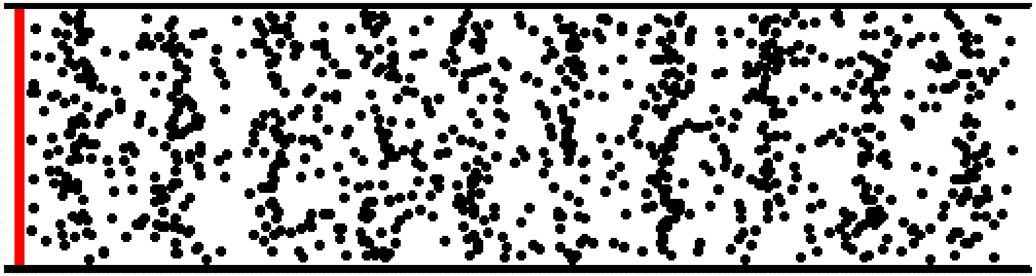
In a compressional wave, the amplitude is greater when the particles of the medium are squeezed closer together in each compression and spread farther apart in each rarefaction.



Sound Wave Basics

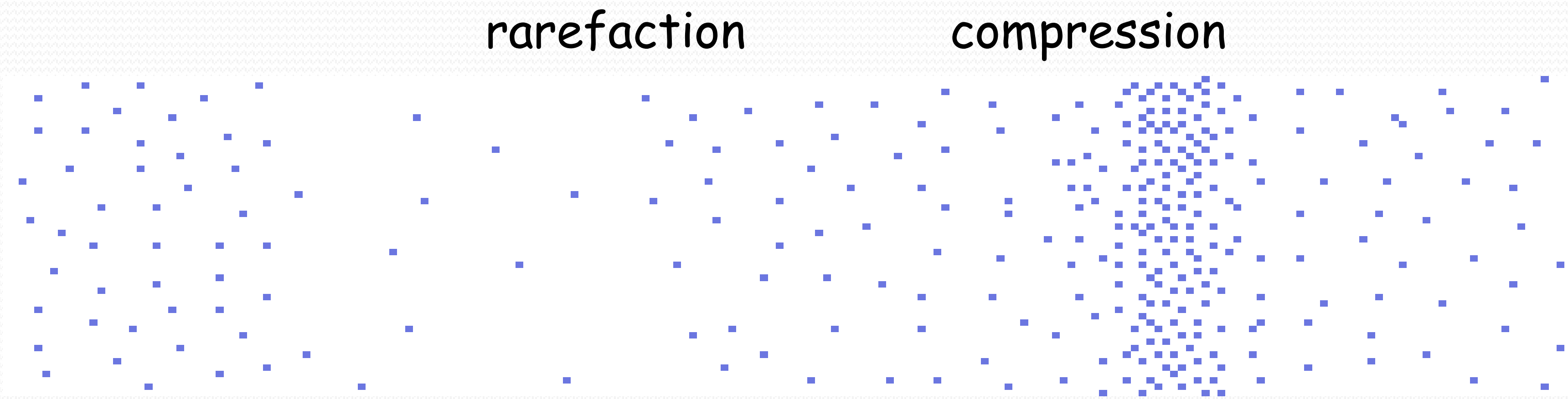
- Sound waves are longitudinal waves produced by variations in air pressure. A vibrational source pushes molecules back and forth, parallel to the direction of the wave.



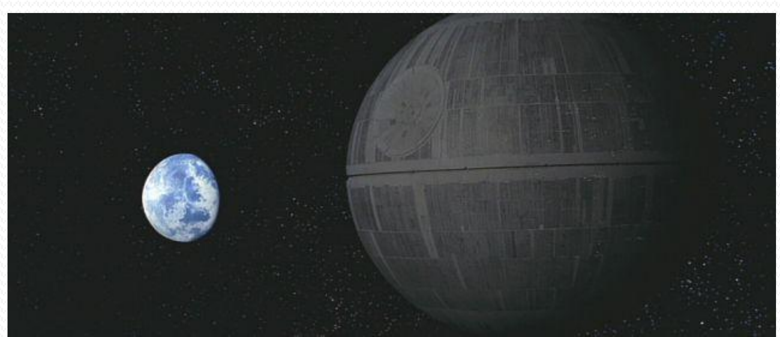


- Pick a single particle and watch the motion.

Movement of particles



- Can sound exist in a vacuum?
- In outer space, if a spaceship (or planet) explodes could you hear it?



Measuring Sound Waves

- Frequency of a sound wave is called pitch.
- Humans can hear sounds from 20 Hz to 15,000 Hz. Above 20,000 Hz, the sound waves are called ultrasonic waves.
- The amplitude (or volume) of a sound wave is the amount of pressure the sound source exerts on medium molecules.
- It is usually measured in decibels (dB) for ease of computation.

Typical Decibel levels

- 0 The softest sound a person can hear
- 10 normal breathing
- 20 whispering at 5 feet
- 30 soft whisper
- 40 quiet office, library
- 40 quiet residential area
- 50 rainfall
- 50 large office
- 60 normal conversation
- 70 freeway traffic
- 80 manual machine, tools
- 80 pop-up toaster
- 80 doorbell
- 80 ringing telephone
- 80 whistling kettle
- 85 handsaw
- 85 heavy traffic, noisy restaurant
- 90 tractor
- 90 truck, shouted conversation
- 95 electric drill
- 100 snowmobile
- 100 school dance, boom box
- 110 shouting in ear
- 110 baby crying
- 110 symphony concert
- 110 car horn
- 112 I-Pod
- 117 football game (stadium)
- 120 thunder
- 120 band concert
- 125 auto stereo (factory installed)
- 130 stock car races
- 143 bicycle horn
- 150 firecracker
- 156 cap gun
- 157 balloon pop
- 163 rifle
- 162 fireworks (at 3 feet)
- 166 handgun
- 170 shotgun

What About the Speed of Sound?

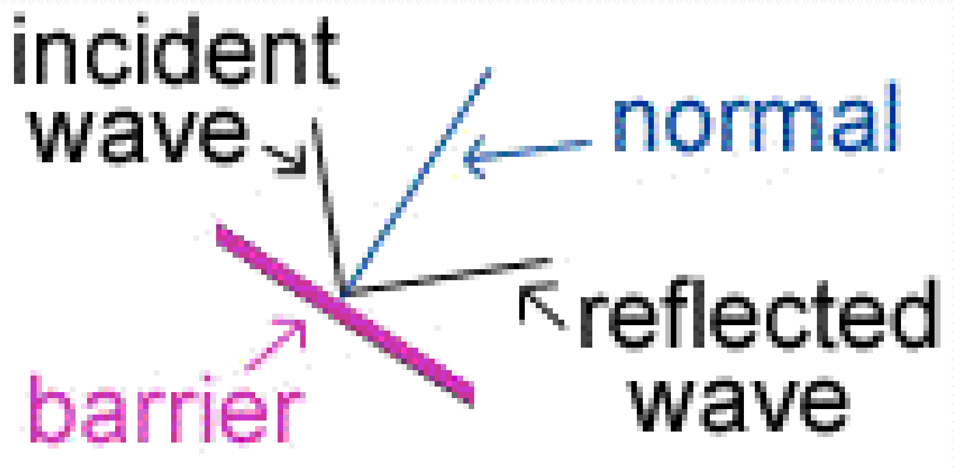
- Assumed 343 meters per second through dry air at sea level (why does this matter?)
- How many miles per hour?

$$\frac{343m}{1\sec} * \frac{3.28\,ft}{1m} * \frac{1mile}{5280\,ft} * \frac{60\sec}{1\min} * \frac{60\min}{1hr}$$

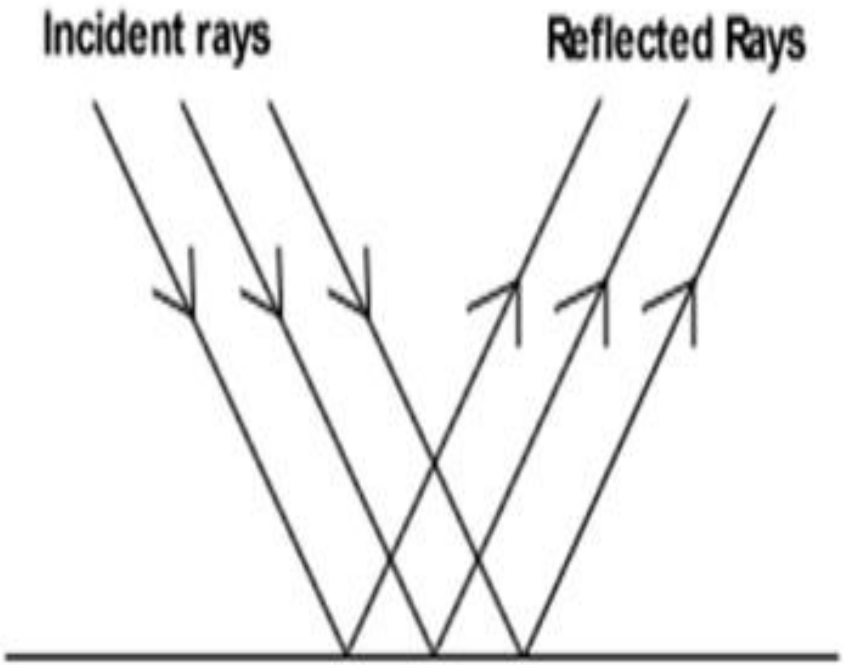
- Approximately 767 mph
- What else can change the speed of sound?
- Type of medium (solid, liquid, gas)
- Condition of medium (temperature, humidity, pressure)
- $Velocity_{solid}$ > $Velocity_{liquid}$ > $Velocity_{gases}$ Why???

Reflection and Refraction

- Just like other waves, sound waves obey the law of reflection which states the incident angle and reflection angle will be the same when reflecting off a flat surface.

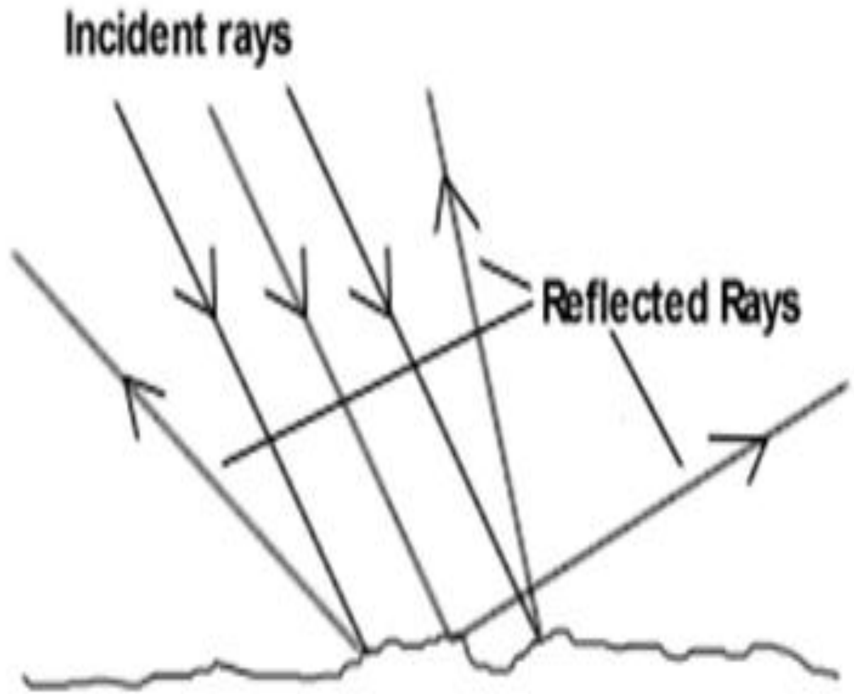


Regular Reflection



Eg. plane mirror or any other surface that produces a reflected image.

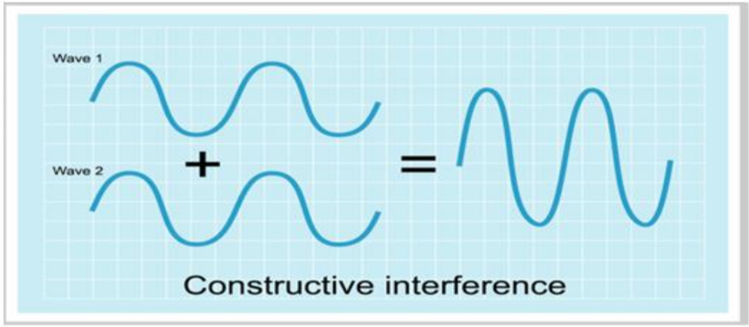
Diffuse Reflection



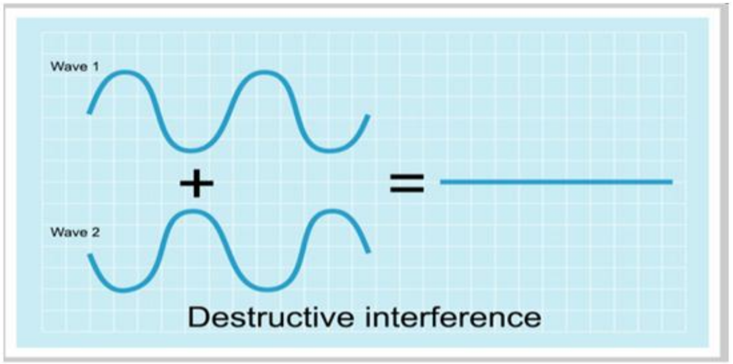
This is like any surface that we can see but does not reflect an image

Interference- when waves come into contact with each other

Constructive interference –
the crest of one wave overlaps
The crest of another wave,
making a larger wave.



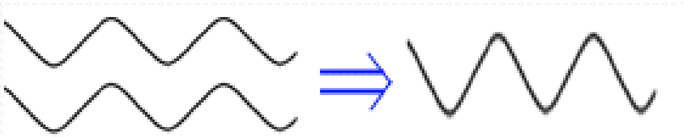
Destructive interference –
the crest of one wave overlaps
the trough of another wave,
making a smaller wave.



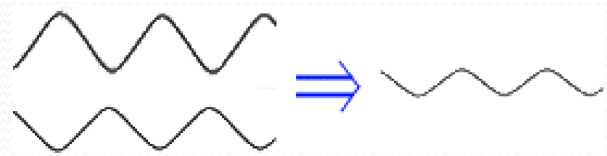
If waves with equal amplitude meet crest to trough, they cancel each other out.

Combining Waves

constructive



destructive



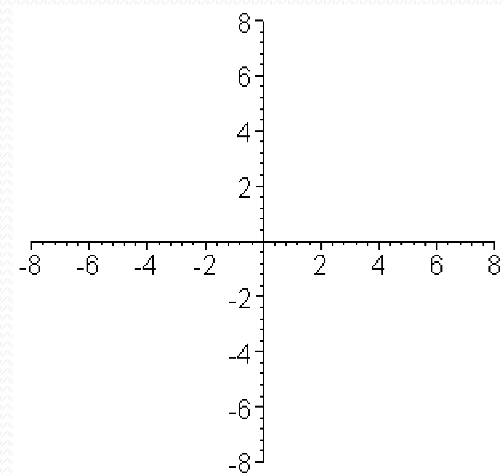
Why do the waves on the left combine to create a greater wave and the ones on the right form a lesser wave?

Simply add the amplitudes of the waves at every point to come up with the resultant wave

Sometimes, two combining sounds can create no sound. How could this happen?

Moving Sound Source

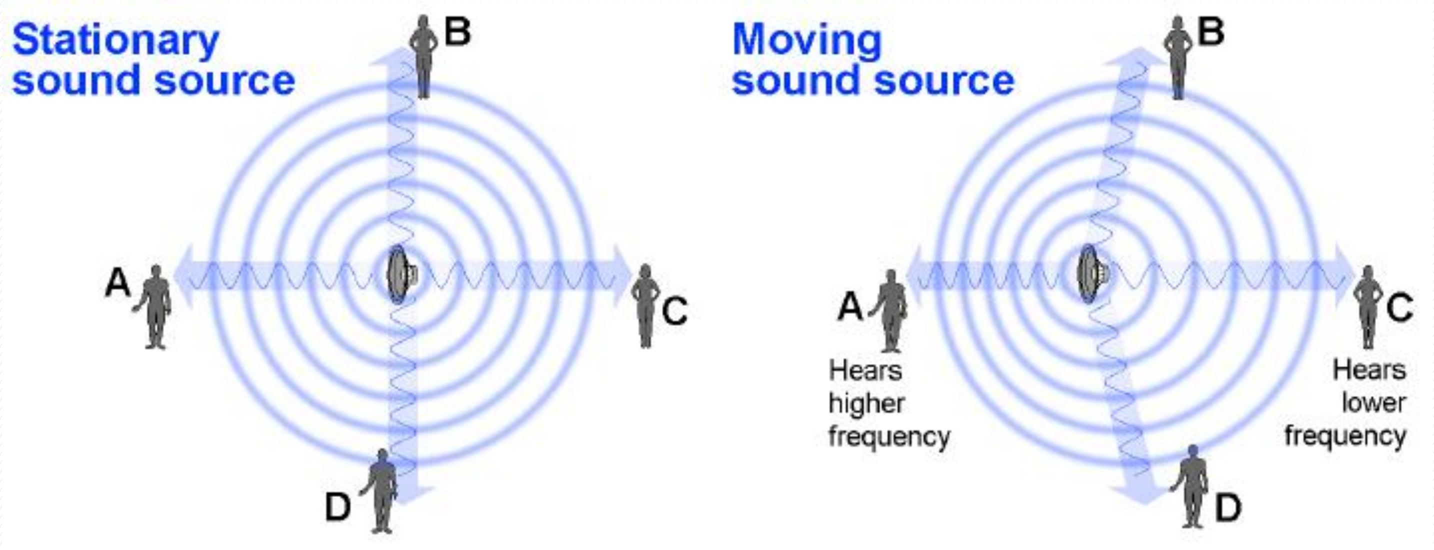
- Why does the sound of an ambulance sound different when coming towards you than when traveling away from you? These animations show a stationary source and an source moving less than the speed of sound.

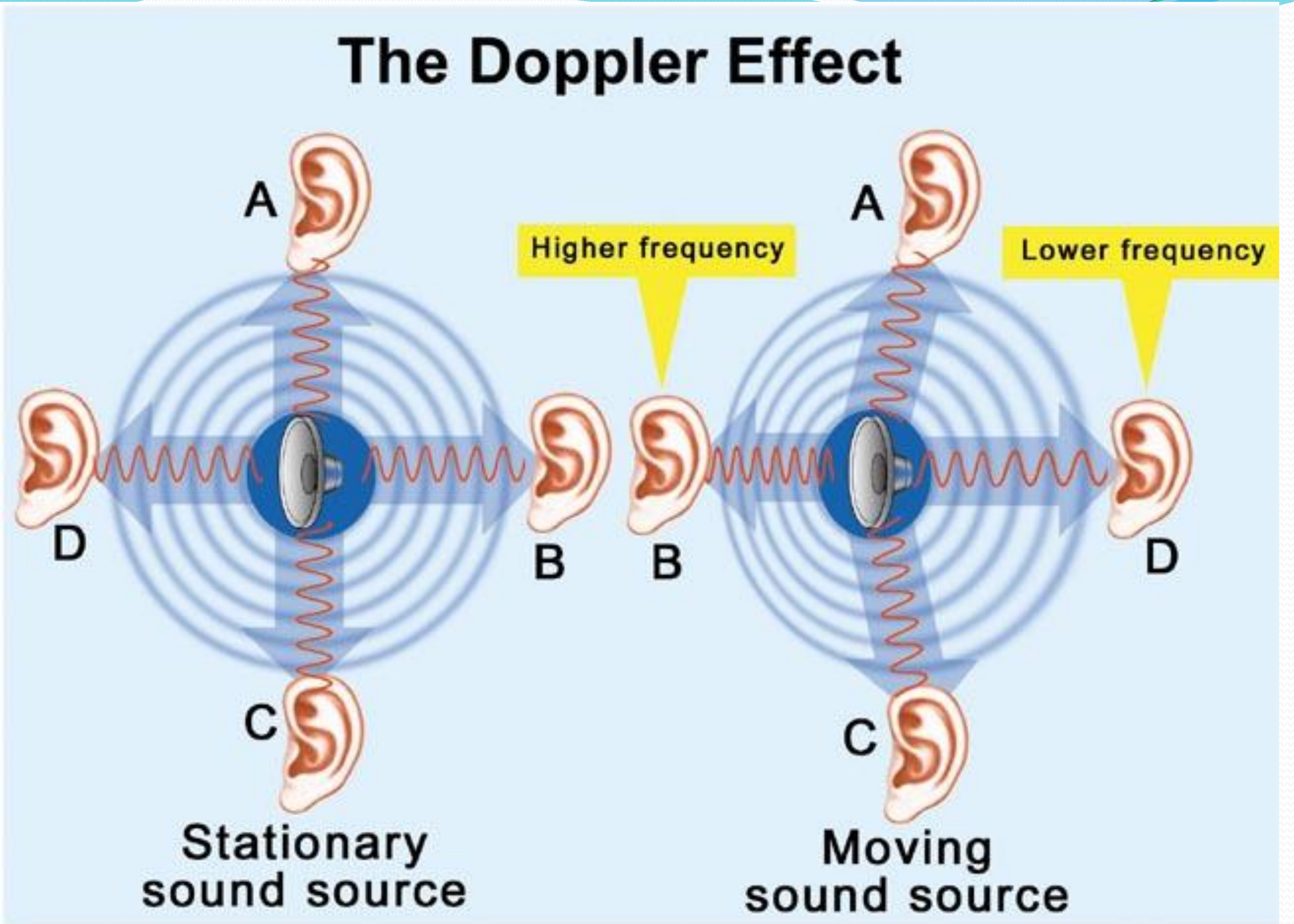


- This is called the Doppler Effect

The Doppler effect

- The shift in frequency caused by motion is called the Doppler effect.
- It occurs when a sound source is moving at speeds less than the speed of sound.




The Doppler Effect
A
D
B
C
Stationary sound source
Higher frequency
Lower frequency
A
B
D
C
Moving sound source