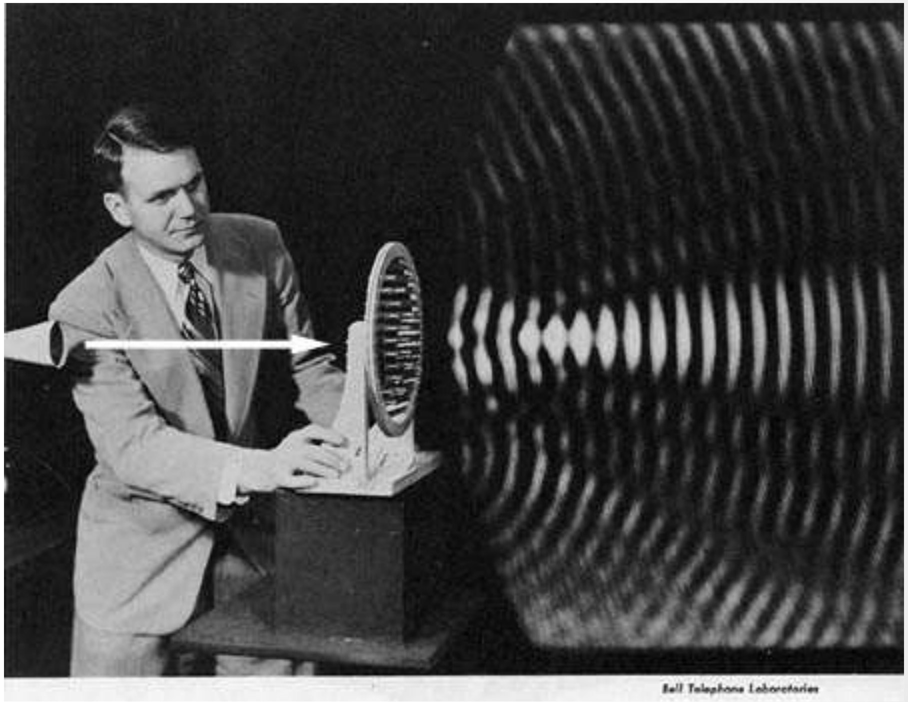
The Speed of Sound

Sound

A stimulation of the auditory nerve

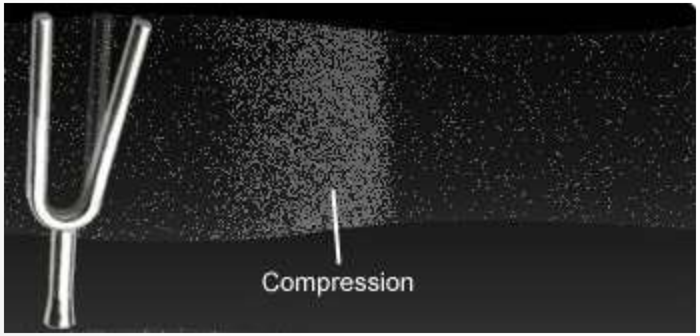
Sound waves originate from a vibrating source

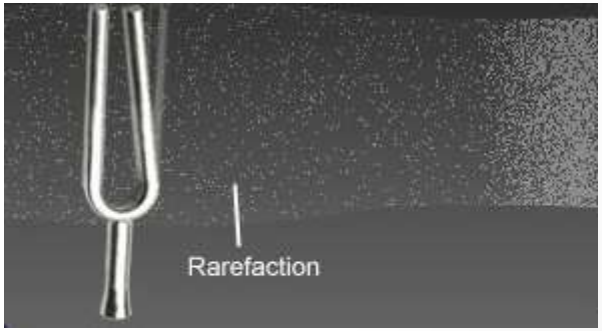
They are a longitudinal wave



Sound

When a tuning fork is struck the tines move back and forth. When the tine is out, it creates a compression, when the tine moves in, it creates a rarefaction



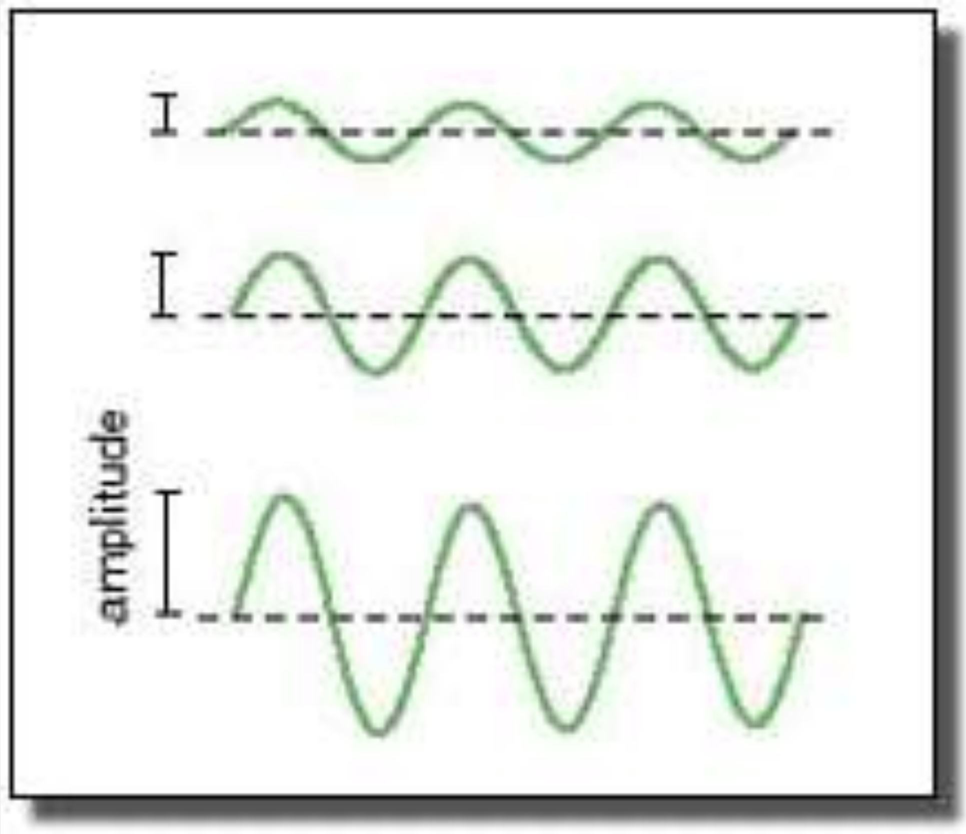


Sound

- Humans can detect sounds with frequencies from 20 Hz to 20 000 Hz
- Bats 10 Hz to 110 000 Hz
- Frogs 50 Hz to 10 000 Hz

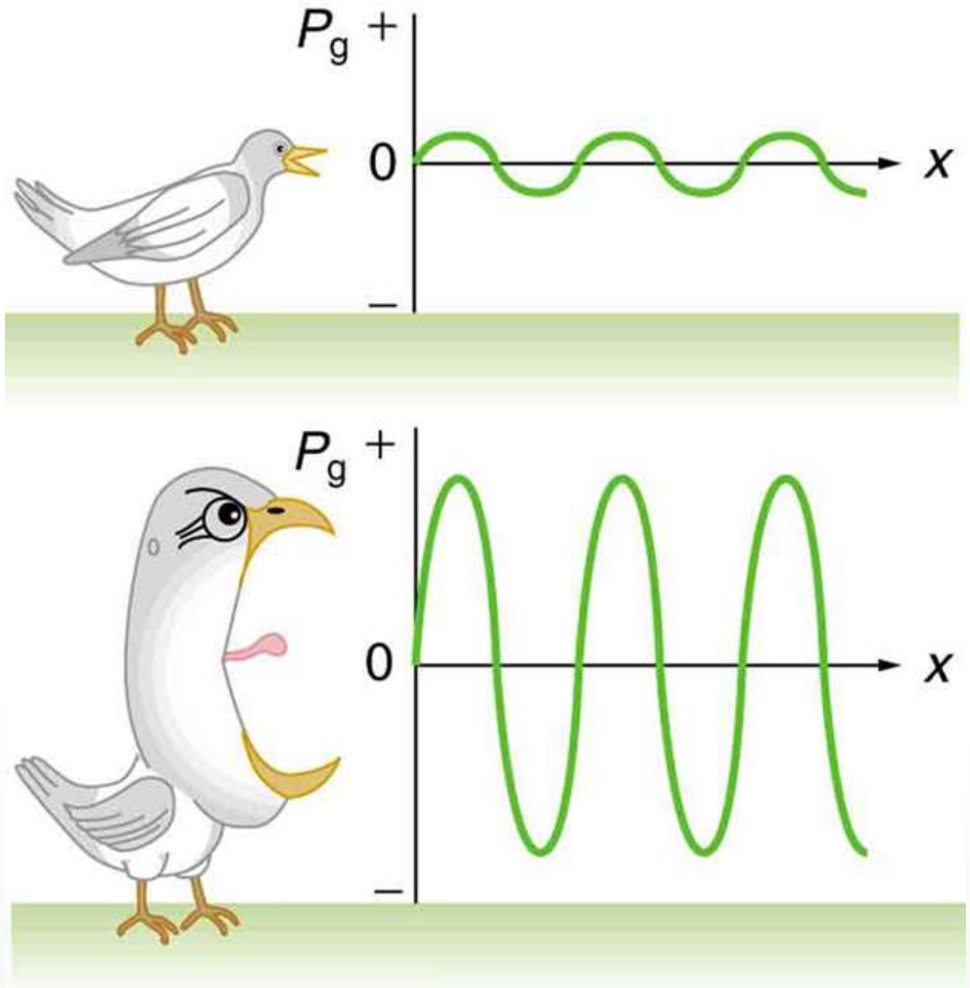
- Frequencies less than 20 Hz are infrasonic
- Frequencies greater than 20 000 Hz are ultrasonic

Sound Intensity



- Sound intensity is the energy of the sound wave
- For sound, the energy is determined by the amplitude
- The larger the amplitude, the louder the sound

Sound Intensity

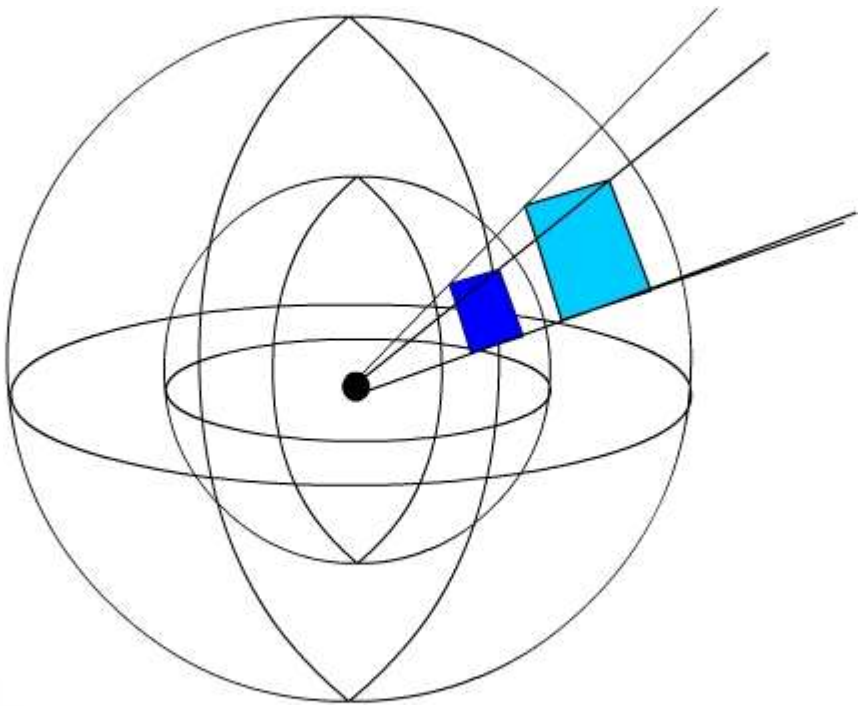


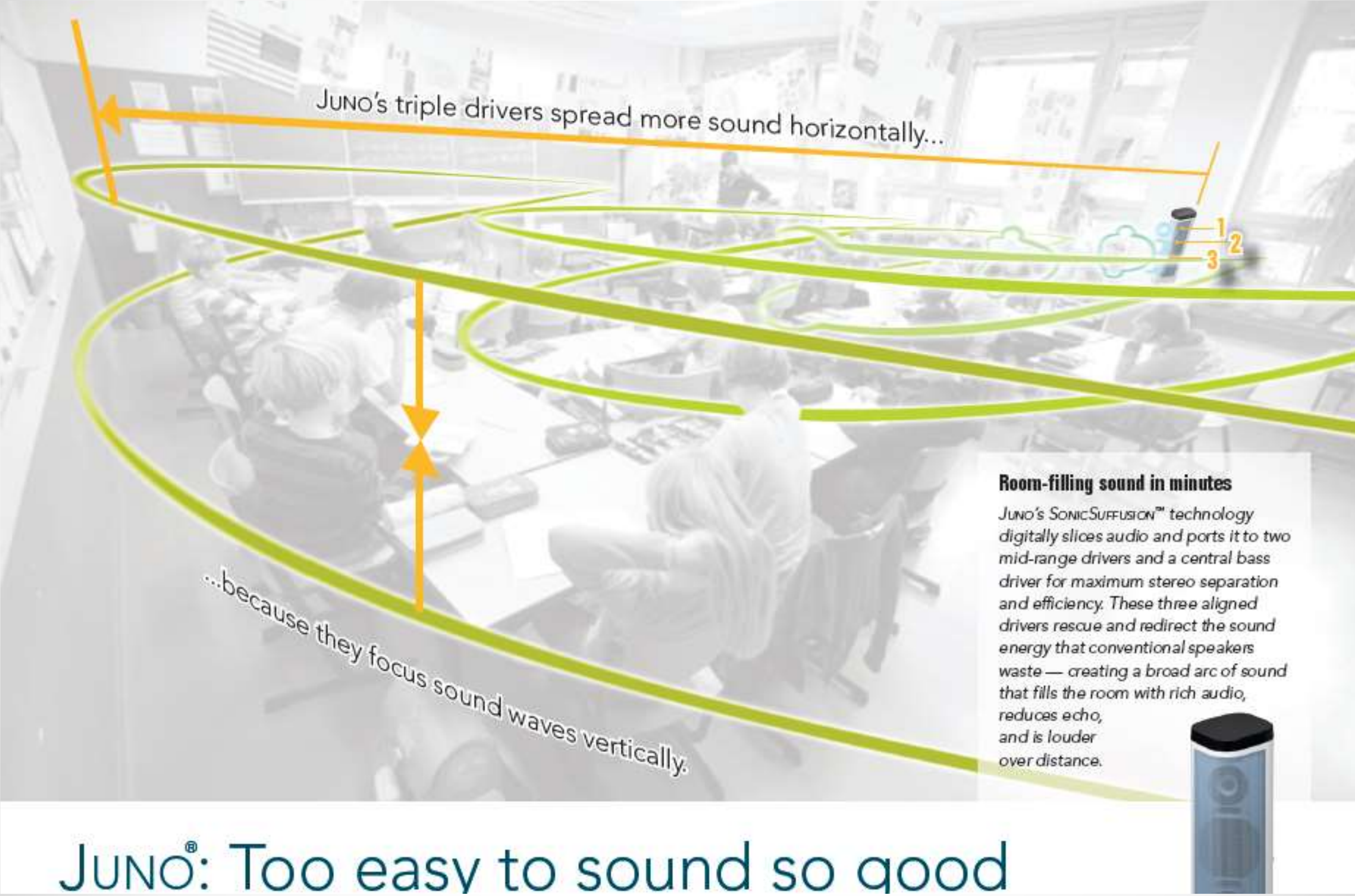
Sound Intensity

- The intensity of a sound that is received by the human ear depends on the distance between the ear and the source as well as the power of the source

- The intensity of sound decreases as the wave moves from the source to the receiver because of friction and the increased area

Sound Intensity





JUNO®: Too easy to sound so good

Juno®: Too easy to sound so good

In the past, the best way to get even sound coverage in the classroom was to cut holes in the ceiling and install numerous speakers. That's no longer necessary, thanks to FrontRow's **SonicSuffusion™ technology** built into Juno. Juno's engineers packaged three digitally-controlled drivers into a single unit that sets up in minutes — and yet evenly fills your classroom with the kind of exciting, multi-layered stereo sound you'd expect from a much larger installed system.

How Juno fills your room with sound

Juno's SonicSuffusion technology is intelligent. First, its digital crossover network keeps the two mid-range drivers and the bass module in phase and reproducing your audio at peak efficiency. Then, we exploit the physics of constructive wave propagation to rescue the sound energy that conventional and flat-panel loudspeakers waste and redirect it forward and to the sides in a 180° horizontal layer. This arc of sound spreads more evenly across the room, reduces unwanted echo, and sounds up to 25% greater in volume over distance than conventional or flat-panel speakers.

Built-in recording and more

Juno is loaded with technologies that give you better results. Like amazing one-step, voice-activated recording and sharing of screen content. And digital feedback suppression that lets you put Juno practically anywhere without the howling that plagues flat panels. It even includes the OptiVoice™ speech clarity enhancer.

As easy to try as it is to set up

Call or visit us online for a demo or a free 45-day evaluation, and hear for yourself why Juno is the new standard in school audio.

Sound Intensity

- The intensity of sound is measured in decibels (dB). The decibel scale is a logarithmic scale, meaning for every increase of 10 decibels, the loudness of sound is increased by a factor of 10
- Therefore, if a sound's intensity increased from 30 dB to 50 dB, the new sound is 100 times louder

$30-50 = 20 * 2 \times 10 \quad 10^2$

The Speed of Sound

- Sound travels through different media with different speeds
- In air, at normal atmospheric pressure and air temperature of 0°C, the speed of sound is 332 m/s
- As the air temperature increases, so does the speed

The Speed of Sound

Speed of sound in air = 332 + 0.6T

where T is air temperature in °C

The Speed of Sound

Example: What is the speed of sound in air at

a) 10°C? $\rightarrow v_s = 332 + 0.6(10)$

$= 332 + 6 \rightarrow 338\ m/s$

b) -10°C?

$v_s = 332 + 0.6(-10)$

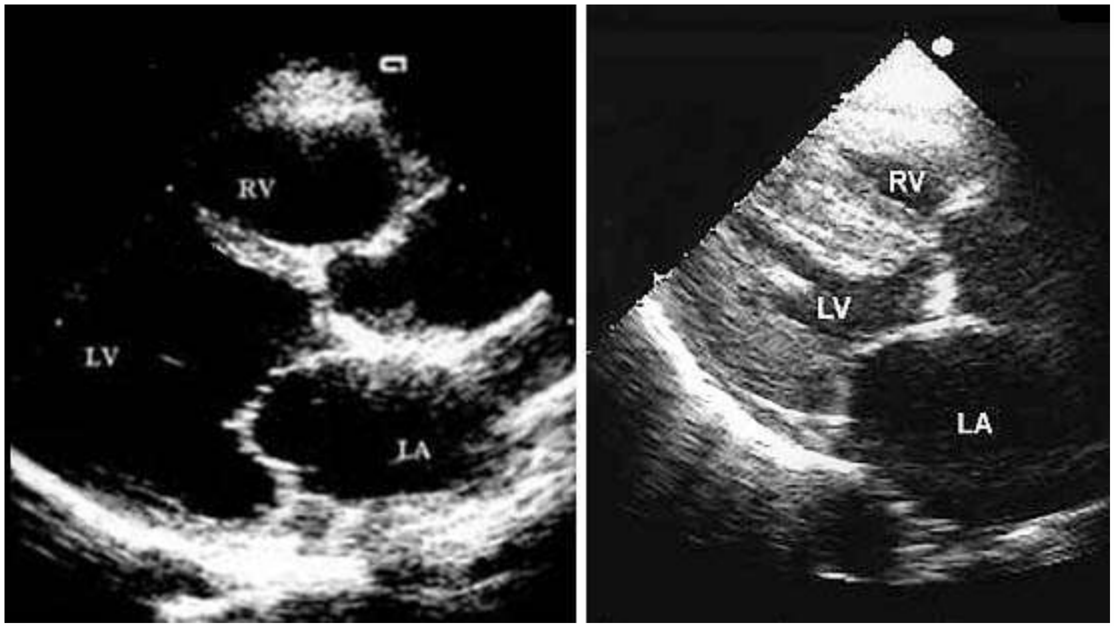
$v_s = 332 - 6$

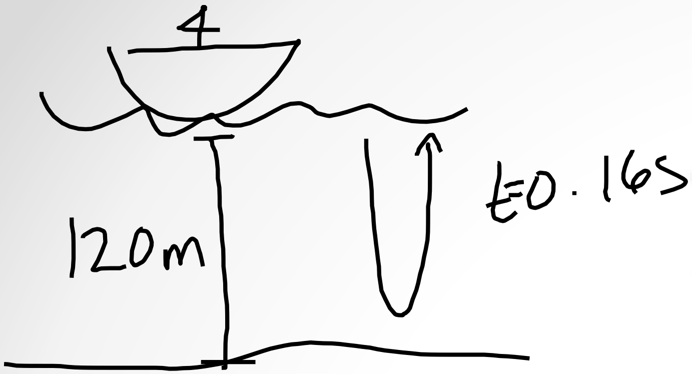
$v_s = 326\ m/s$

Echoes

- Sound waves reflect off of any hard surface.
- Echoes are the reflected sound waves returning from the solid object
- Since echoes travel to the reflecting object and back, the distance and measured time is doubled.

Echoes





Echoes

Example: A ship is anchored where the depth of the water is 120 m. An ultrasonic signal sent to the bottom of the lake returns in 0.16 s. What is the speed of sound in water?

$t = 0.16\,s$

$d = 2(120)$

$= 240\,m$

$v = ?$

$v = \frac{d}{t}$

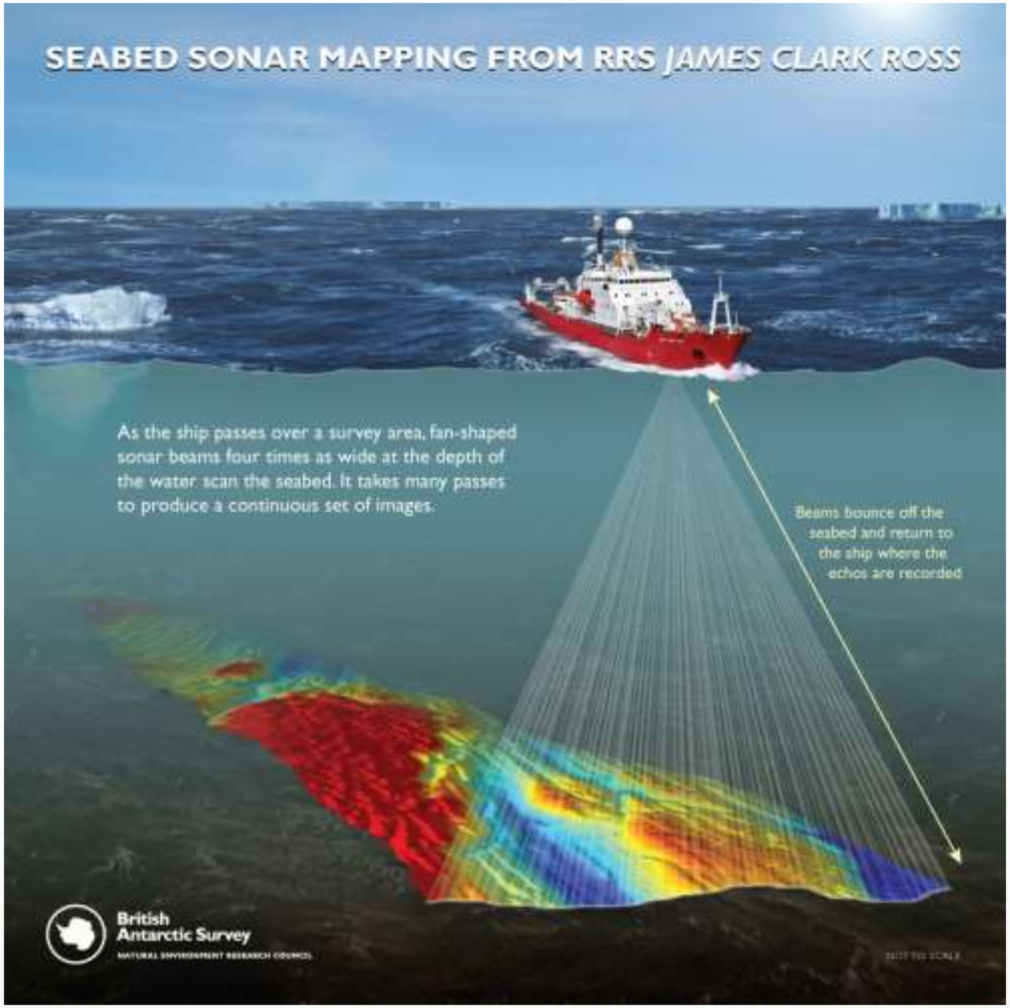
$v = \frac{240\,m}{0.16\,s}$

$v = 1500\,m/s$

SONAR

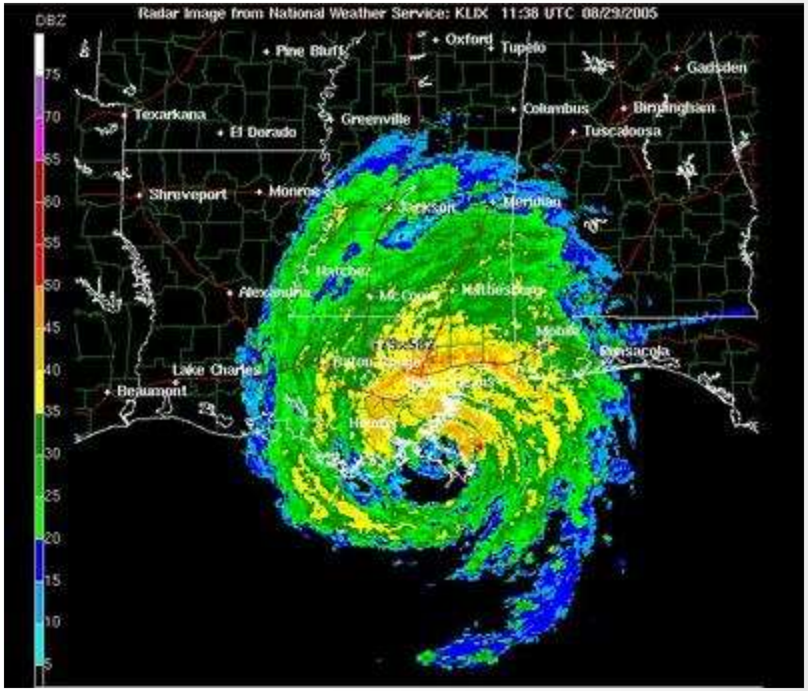
- SONAR (SOund Navigation And Ranging) uses echoes to determine the distance an object is from a transmitter.
- Sound waves are emitted from a transmitter, reflected off the object and back to the transmitter.
- The device measures the time of the sound wave's round trip and calculates the distance of the object to the transmitter

SONAR

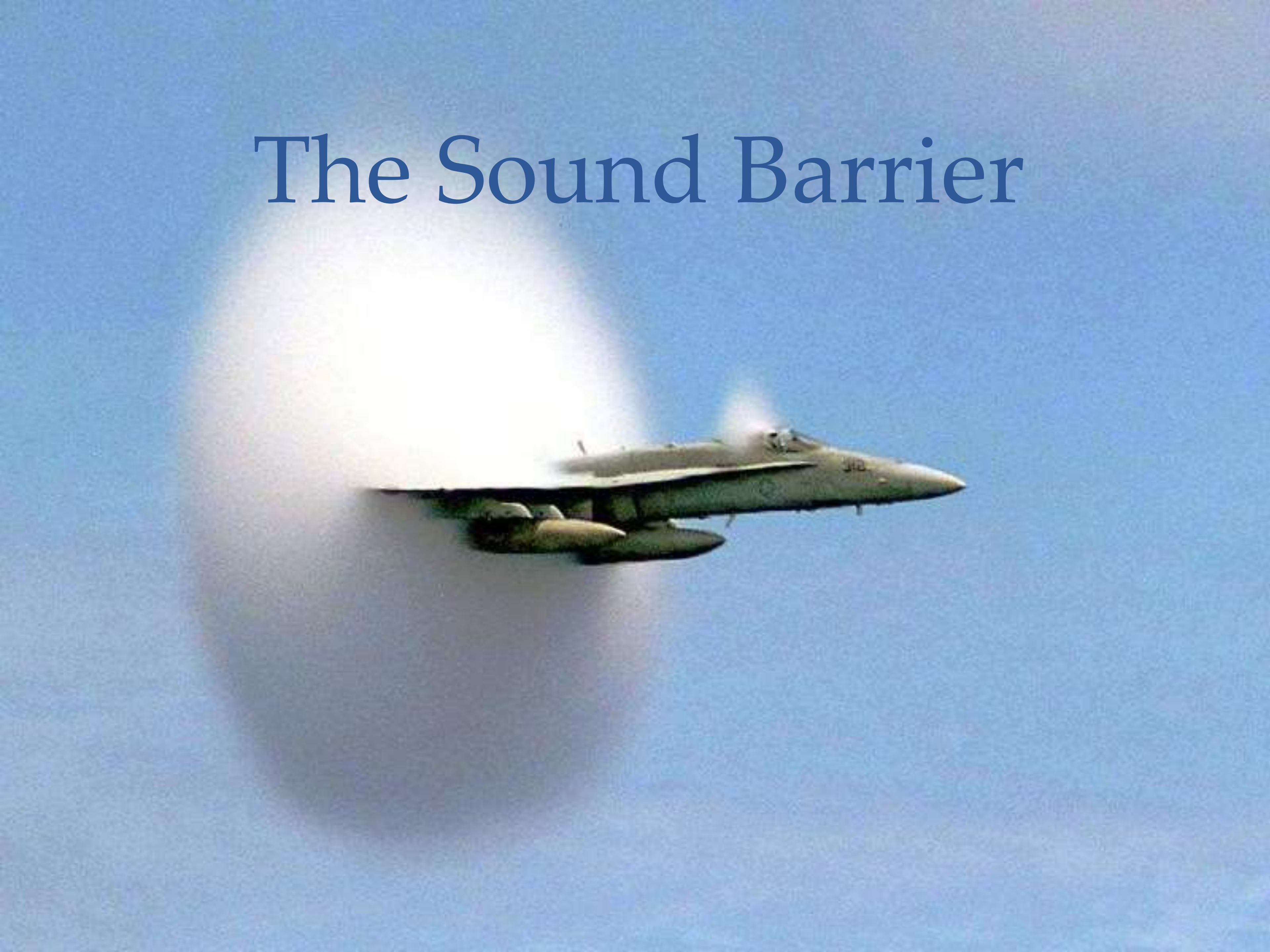

SEABED SONAR MAPPING FROM RRS JAMES CLARK ROSS
As the ship passes over a survey area, fan-shaped sonar beams four times as wide at the depth of the water scan the seabed. It takes many passes to produce a continuous set of images.
Beams bounce off the seabed and return to the ship where the echos are recorded
British Antarctic Survey

SONAR

- Common applications of SONAR are depth-finders, stud-finders, motion detectors, and used by bats and dolphins to navigate and hunt
- RADAR (RAdio Detection And Ranging) is another application of echoes but uses radio waves. It is used in speed detection and weather detection

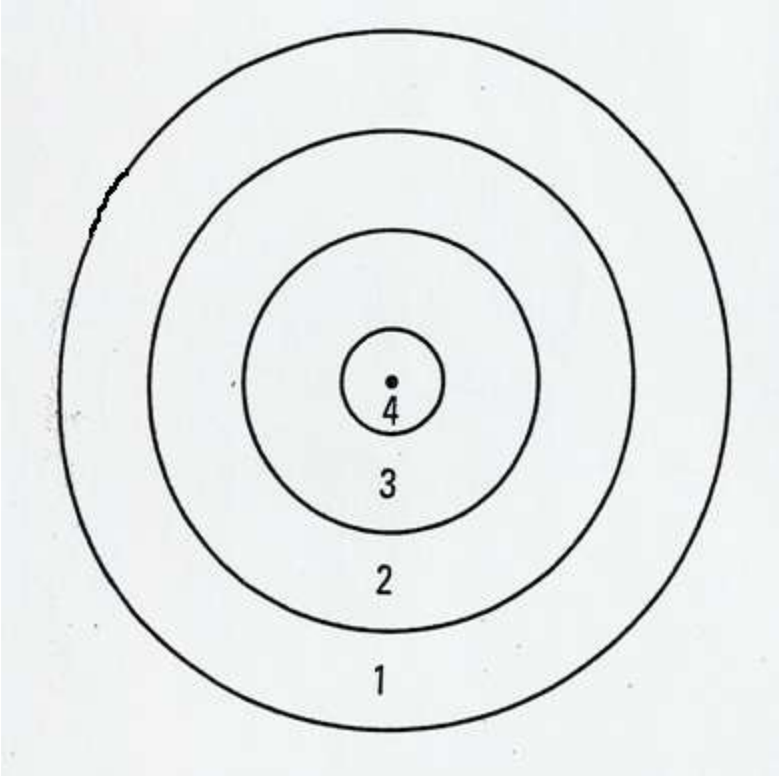


The Sound Barrier



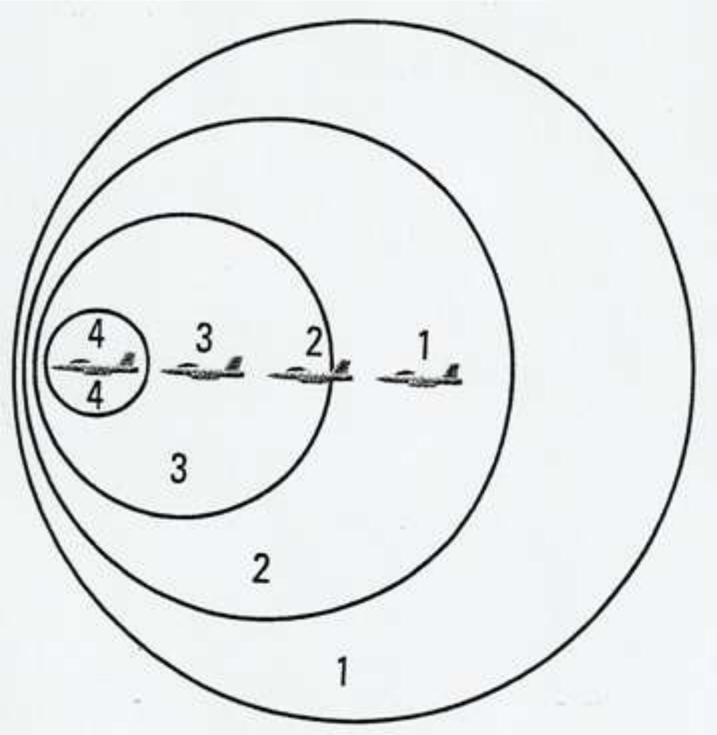
Sound Barrier

- A stationary source radiates sound waves in concentric circles.



Sound Barrier

- When an airplane is flying at the speed of sound, the waves in front of the airplane pile up producing an area of very dense air, called the sound barrier.

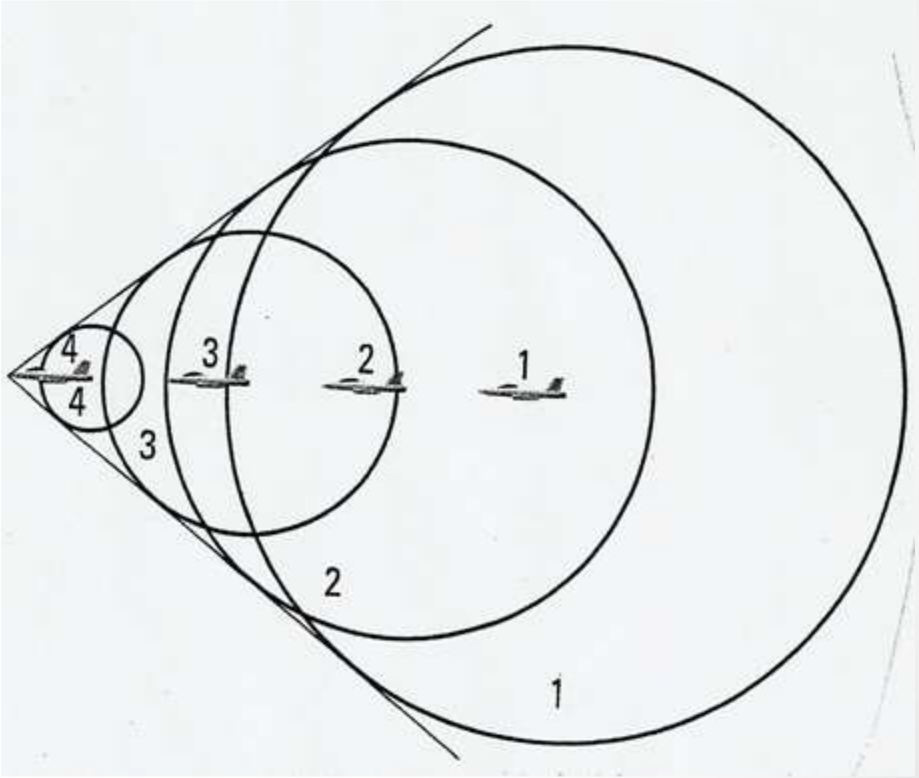


Sound Barrier

- To exceed the speed of sound, extra thrust is needed until the aircraft “breaks through” the sound barrier

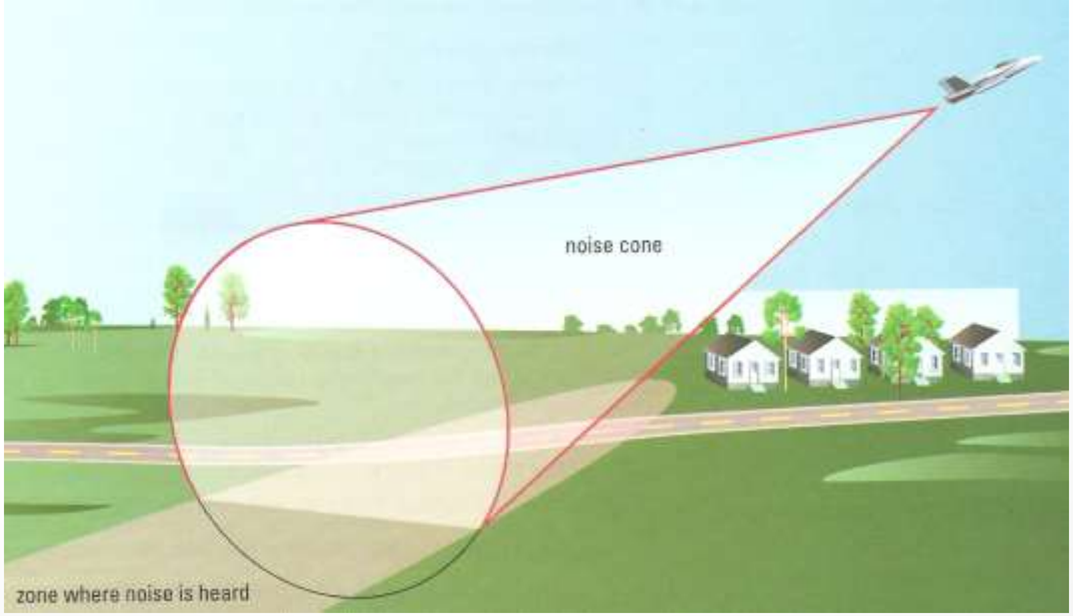
Sound Barrier

- At supersonic speeds, the spheres of sound waves are left behind the aircraft



Sound Barrier

These sound waves interfere with each other constructively, producing large compressions and rarefactions along the sides of a cone extending behind the airplane.



Sound Barrier

- The duration of the sonic boom is brief; 100 ms for most fighter jets, 500 ms for a space shuttle or Concorde jet

Sound Barrier

- The intensity and width of a sonic boom path depends on the physical characteristics of the aircraft
- In general, the greater the altitude, the lower the ground pressure
- Increased altitude also increases the boom's lateral spread

Sound Barrier

- US Air Force procedures require that whenever possible, supersonic flights be over open water, above 10 000 feet and no closer than 15 miles from shore
- Supersonic operations over land must be conducted above 30 000 feet

Sound Barrier

- Supersonic Flight, Sonic Booms

Mach Number

When objects travel many times faster than the speed of sound, it is easier to express the speed as a ratio.

$$\text{Mach Number} = \frac{\text{speed of object}}{\text{speed of sound}}$$

Therefore, 332 m/s is considered Mach 1

664 m/s is considered Mach 2

Mach Number

Example: The first plane to travel faster than Mach 1 was moving at a speed of 1229 km/h. If the air temperature was -20°C, what was the Mach number?

$V_o = 1229\ km/h$

$= 341.39\ m/s$

$T = -20°C$

$M = ?$

$$M = \frac{V_o}{V_s} = \frac{V_o}{(332 + 0.6T)}$$

$$= \frac{341.39}{332 + 0.6(-20)}$$

$$= 1.1$$