Sound waves: Intensity "How loud?"

Low Amplitude = Soft



High Amplitude = Loud

- Sound intensity is a measure of the amount of energy in sound waves.
- Intensity results from two factors:
 - ✓ the amplitude of the sound waves
 - ✓ and how far they have
 traveled from the
 source of the sound.
- The unit of intensity is the decibel (dB).

Typical sound levels

The decibel scale is *non-linear*: for every **10-decibel** *increase* in the intensity of sound, energy is **10** *times* greater.



1. Compare the *intensity* of sound you hear during a jazz band performance and a rock concert.

- Jazz band is about 100 dB
- Rock concert is about 120 dB

Sound <u>level</u> at a rock concert is 20 dB greater.

2. What is the corresponding difference in sound *energy*?

- for every 10-decibel *increase* in the intensity of sound, energy is 10 *times* greater
- 20-decibel increase means 10 · 10 times energy increase

Sound <u>energy</u> at a rock concert is 100 times greater.

How does sound travel?

<u>Vibrations are passed</u> between <u>neighboring particles</u> of a substance, so the following properties are important:

Particle arrangement: different states of matter, particular structure (crystalline or amorphous)



Temperature: higher temperature results in the increased rate of interaction between particles

Speed of sound varies from substance to substance

sound travels most slowly in gases:

✓ speed of sound in air at room temperature is 343 m/s

• it travels faster in liquids:

✓ speed of sound in water is about 1,400 m/s (about 4 times as fast as in air)

- and <u>faster still in solids</u>:
 - ✓ speed of sound in concrete is about 3,700 m/s
 - ✓ speed of sound in hardwood is about 4,000 m/s
 - \checkmark speed of sound in iron is about 5,000 m/s
 - ✓ speed of sound in *diamond* is about 12,000 m/s (about 35 times as fast as in air which is around the maximum speed of sound possible!)

Reflection, Transmission, Absorption



- Sound is reflected best from hard and/or smooth surfaces (like walls in a large hall, mountain cliffs, surface of water in a well).
- Soft and/or rough surfaces tend to absorb most of the sound.

What is Echo?



An echo is a <u>reflected</u> sound wave.

- For a human to hear the echo clearly, the delay in time between the original sound and reflected one must be at least 0.1 seconds (our ears can detect two separate sounds if they are at least this much apart).
- The repeated reflection (multiple overlapping echoes) of sound in closed quarters perceived as persistence of sound is called reverberation.



What is the minimal distance to an object that guarantees a clear echo?

- Let's consider <u>AIR</u>: sound travels at 343 m/s in air
- Time difference must be greater than 0.1 s



DISTANCE \cdot **2** = SPEED \cdot TIME

Distance to an object should be more than 17.2 m (34.3 m back and forth) **to produce a clear echo.**

Echolocation and SONAR

 Echolocation: animals such as bats and dolphins send out ultrasound waves and use their echoes to identify the locations of objects they cannot see. Animals use echolocation to find prey and avoid running into objects in the dark.





 SONAR (sound navigation ranging) is a technique that uses sound to navigate, communicate with or detect objects on or under the surface of the water. Sonars use a wide range of frequencies from infrasonic (provides longer range) to ultrasonic above a megahertz (provides high detail).