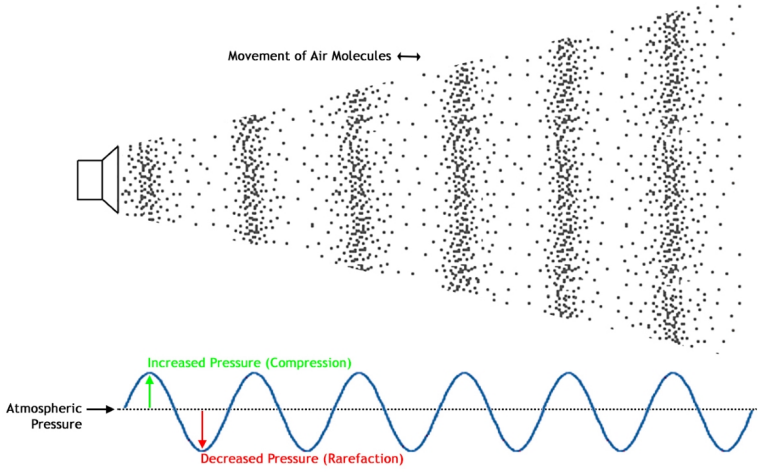
Sound

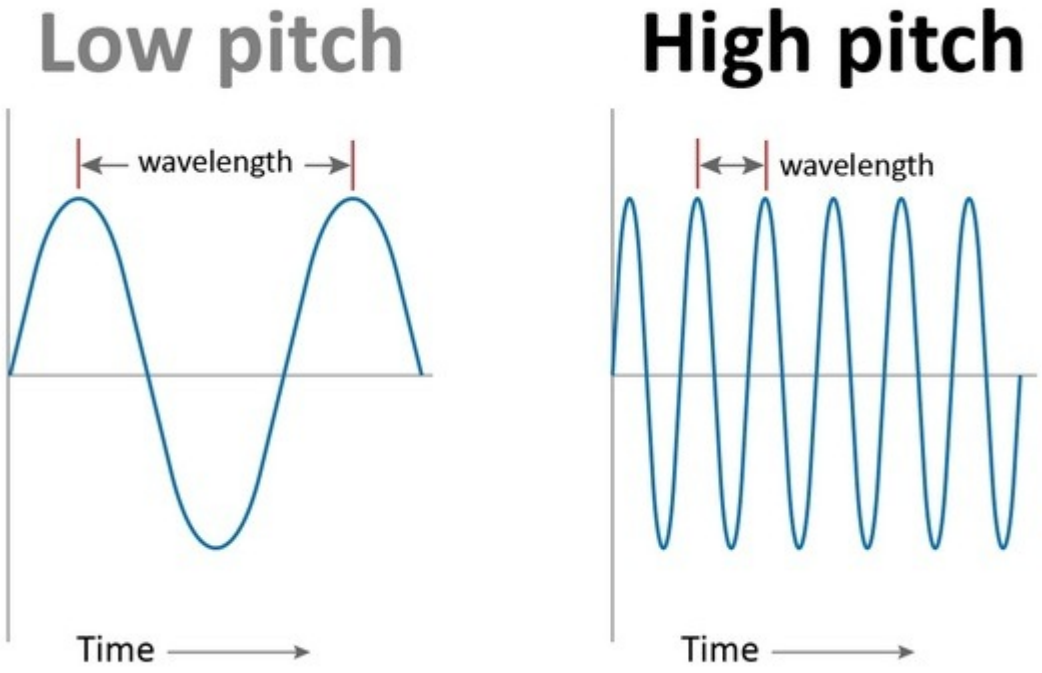
- ➔ Sound waves are longitudinal
- ➔ They can only be transmitted if particles are present
- ➔ Sound is made up of a series of compressions (particles are close together) and rarefactions (particles spread out)

Figure 1

Sound Propagation

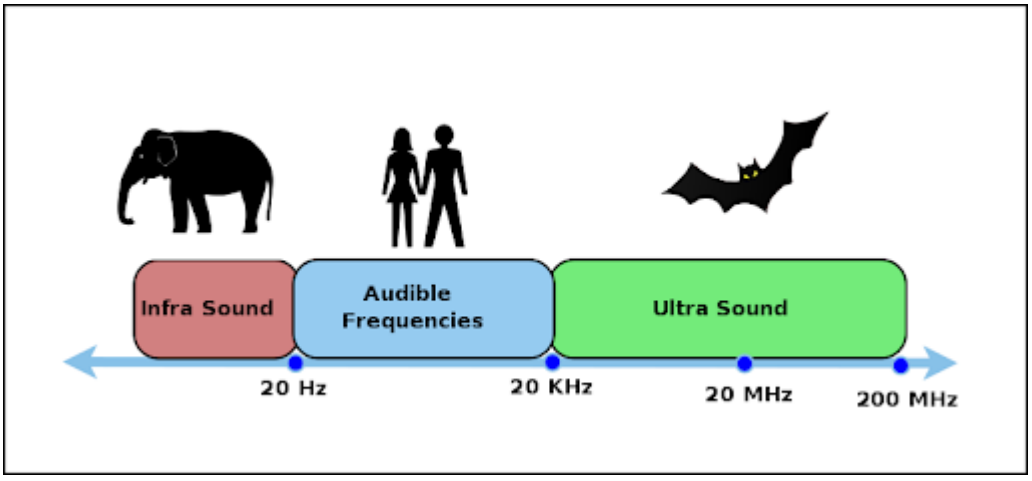


Pitch: this is the frequency of the sound wave.



Human hearing range is 20 - 20k Hz.

Sounds with frequencies below this range are infrasonic	Sounds with frequencies above this range are ultrasonic.



➔ Volume: the volume of a sound is an indication of the magnitude of the energy
- ◆ The greater the energy, the greater the amplitude of the compression, and the louder the sound
- ◆ When comparing sounds we talk about;
  - Intensity: a measure of sound energy per second within a square metre of area

$$\text{Intensity} = \frac{Power}{4\pi r^2}$$

When we talk about sound we are usually referring to Sound Intensity Level (SIL) this is measured in decibels (dB).

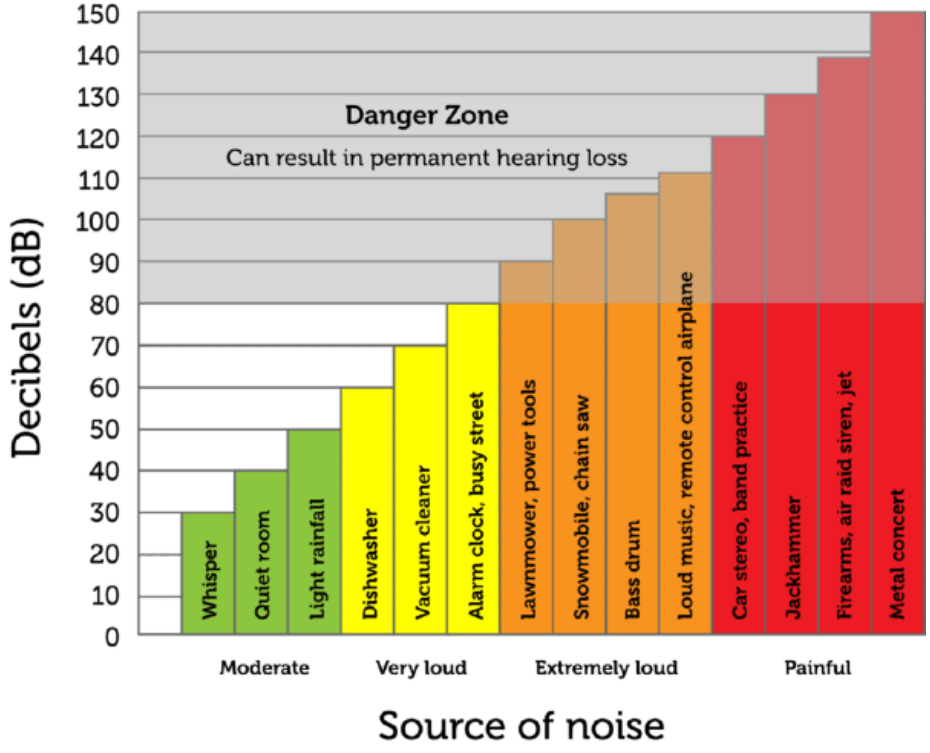
Decibels are a log scale. ie: up one number is 10x the energy. You may have come across this with the pH scale. The Richter scale is also a log scale.

$$SIL = 10log\left(\frac{I}{10^{-12}}\right)$$

Solving this for I:

$$I = 10^{\left(\frac{SIL}{10} - 12\right)}$$

SIL is measured in dB
I is measured in Watts/m^2



Source	Intensity	Intensity Level	# of Times Greater Than TOH
Threshold of Hearing (TOH)	$1*10^{-12}$ W/m^2	0 dB	10^0
Rustling Leaves	$1*10^{-11}$ W/m^2	10 dB	10^1
Whisper	$1*10^{-10}$ W/m^2	20 dB	10^2
Normal Conversation	$1*10^{-6}$ W/m^2	60 dB	10^6
Busy Street Traffic	$1*10^{-5}$ W/m^2	70 dB	10^7
Vacuum Cleaner	$1*10^{-4}$ W/m^2	80 dB	10^8
Large Orchestra	$6.3*10^{-3}$ W/m^2	98 dB	$10^{9.8}$
Walkman at Maximum Level	$1*10^{-2}$ W/m^2	100 dB	10^{10}
Front Rows of Rock Concert	$1*10^{-1}$ W/m^2	110 dB	10^{11}
Threshold of Pain	$1*10^{1}$ W/m^2	130 dB	10^{13}
Military Jet Takeoff	$1*10^{2}$ W/m^2	140 dB	10^{14}
Instant Perforation of Eardrum	$1*10^{4}$ W/m^2	160 dB	10^{16}

What is the intensity of a 40 W speaker at a distance of 3 m?

$$I = \frac{Power}{4\pi r^2} = \frac{40}{4\pi 9} = .35 \ \frac{W}{m^2}$$

What is the Sound Intensity Level?

$$SIL = 10 \log\left(\frac{.35}{10^{-12}}\right)$$

$$= 115 \text{ dB}$$

How much more intense is the sound from the speaker than a sound at the threshold of hearing?

$$\frac{.35}{10^{-12}} = 3.5 \times 10^{11}$$

$$= 350 \times 10^{9}$$

If the SIL of a speaker is 70 dB at a distance of 3 m, what is the power of the speaker?

$10^{\left(\frac{70}{10}-12\right)} = I = \frac{power}{4\pi r^2}$

$power = 4\pi(9)10^{-5}$

$= 1.13 \text{ mW}$

$10^{7-12} = \frac{power}{4\pi r^2}$

In a machine shop the SIL is 90 dB. In a library the SIL is 40 dB. How many times greater is the intensity of the sound in the machine shop?

hint: 100 000 times louder