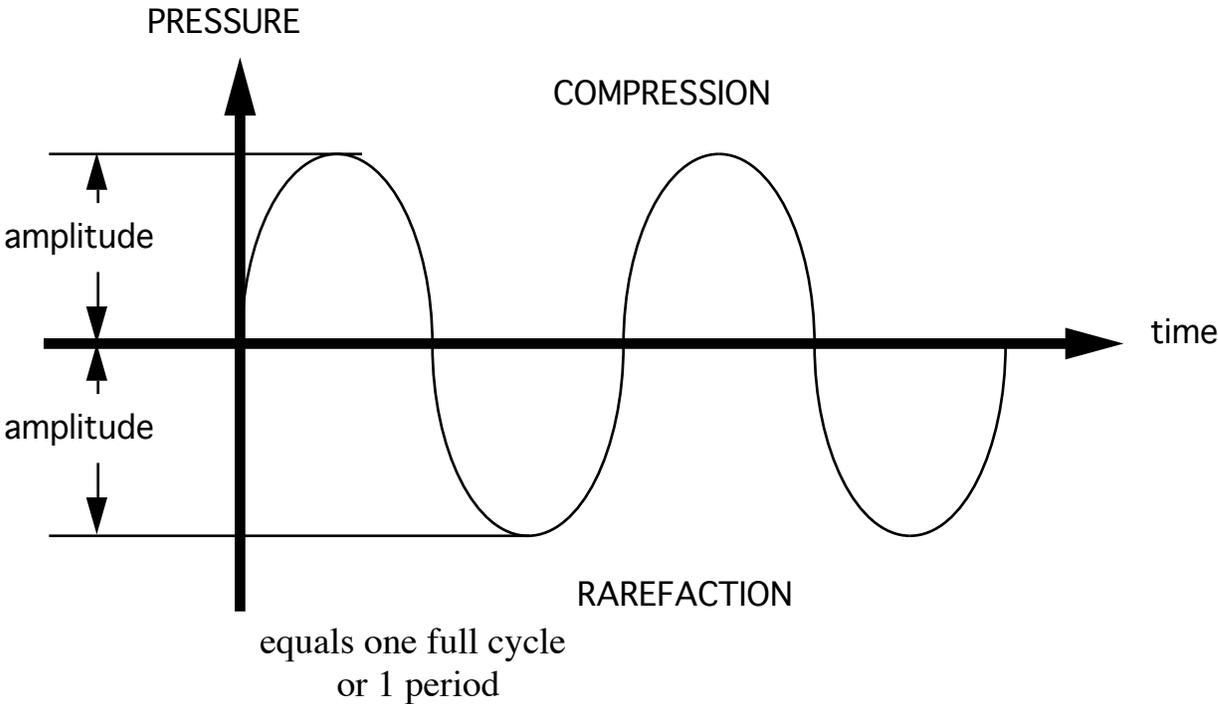


***Acoustics - the study of the physical properties of sound;  
- the study of the physics and transmission of sound.***

1. Sound is produced by a vibrating source.
2. These vibrations come in contact with air molecules that are in the immediate vicinity of the vibrating source, and create areas of higher air pressure and areas of lower air pressure in synchronization with the vibrations.
3. The area of higher air pressure is called a "compression."
4. The area of lower air pressure is called a "rarefaction."
5. These areas of compressions and rarefactions continue through the air in the form of a sound wave just like waves on the surface of water.

6. When a sound wave comes in contact with another surface, it causes that surface to vibrate in synchronization with the sound wave. This is how energy is transferred from one source to another while maintaining the characteristic vibration pattern of the original source.
7. The pattern of the pressure variations over time is called the **waveform** of that sound.
8. Waveforms are made up of a repeating pattern.
9. **Frequency** is the number of cycles of vibration that occur in one second. Therefore, the rate at which one full **cycle** of the waveform repeats itself is called the **frequency**.

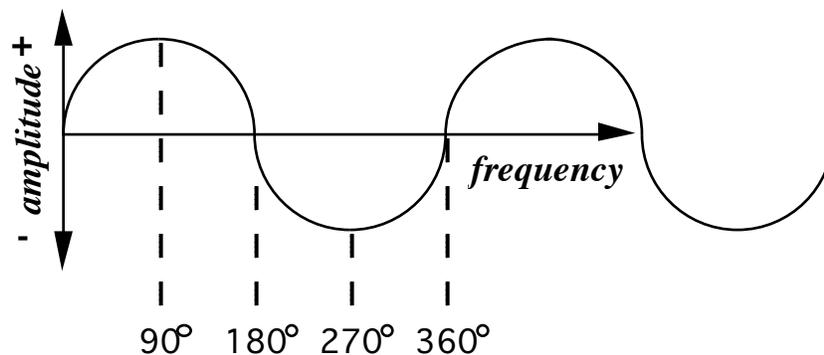
10. The amount of time that elapses during one complete cycle of vibration is called a **period**. The period of a vibration is calculated by finding the reciprocal of the frequency.



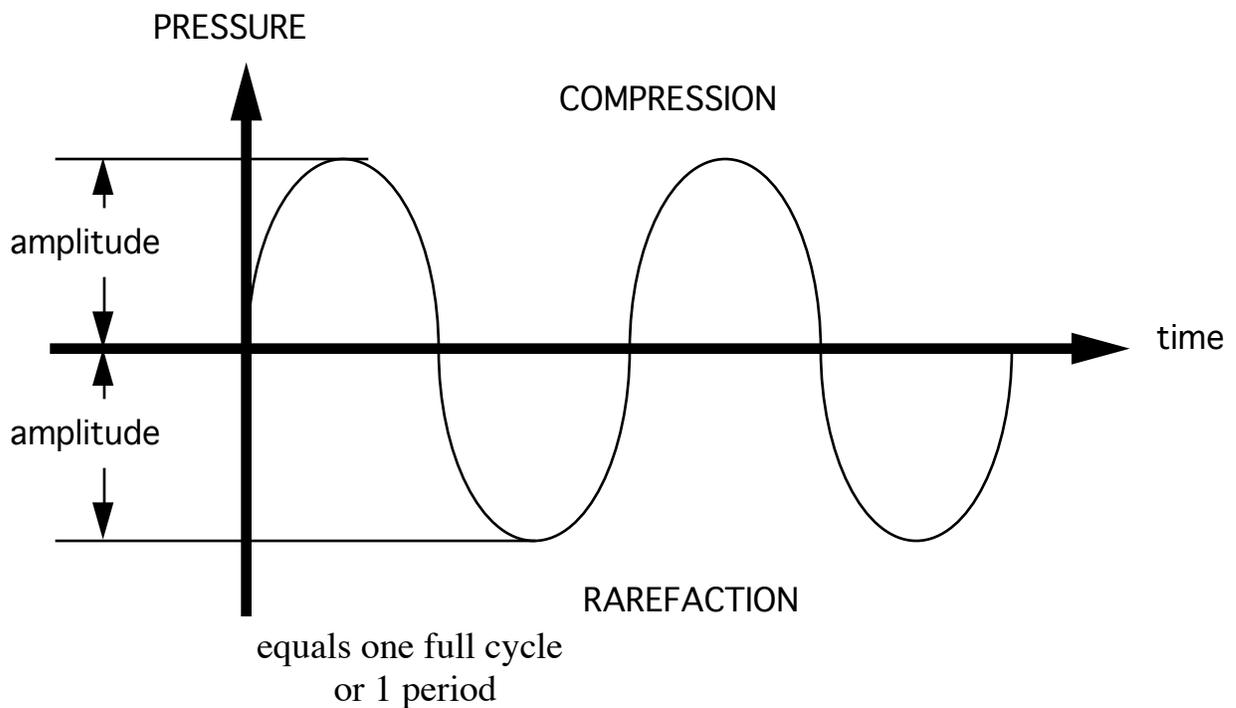
11. Frequency (the number of cycles per second) is measured in units called **Hertz**. 440 cycles per second is equivalent to 440 Hertz. Most humans are able to hear a frequency range of approximately 30 Hertz to 16,000 Hertz. The range of frequencies 20 Hertz to 20,000 Hertz is often described as **audio frequencies**.

Frequencies lower than 20 to 30 Hertz and that are inaudible to humans are described as **sub-audio** or **sub-sonic frequencies**. Frequencies higher than what humans are capable of hearing are described as **ultra-sonic frequencies**.

12. The **phase** of a sound is the point within a cycle of vibration where the sound is at a particular instant. A cycle of a wave is normally divided into 360 degrees of phase.



13. **Amplitude** is the amount of change, positive or negative, in:
- atmospheric pressure caused by the compression/rarefaction cycle of a sound wave;
  - the maximum distance that a mass travels away from the equilibrium point;
  - the extreme range/distance of a fluctuating quantity, as an alternating current, swing of a pendulum, vibrating source, waveform, etc., measured from the average or mean (point of equilibrium) to the extreme. The intensity of a sound is directly related to the amplitude of the vibration.



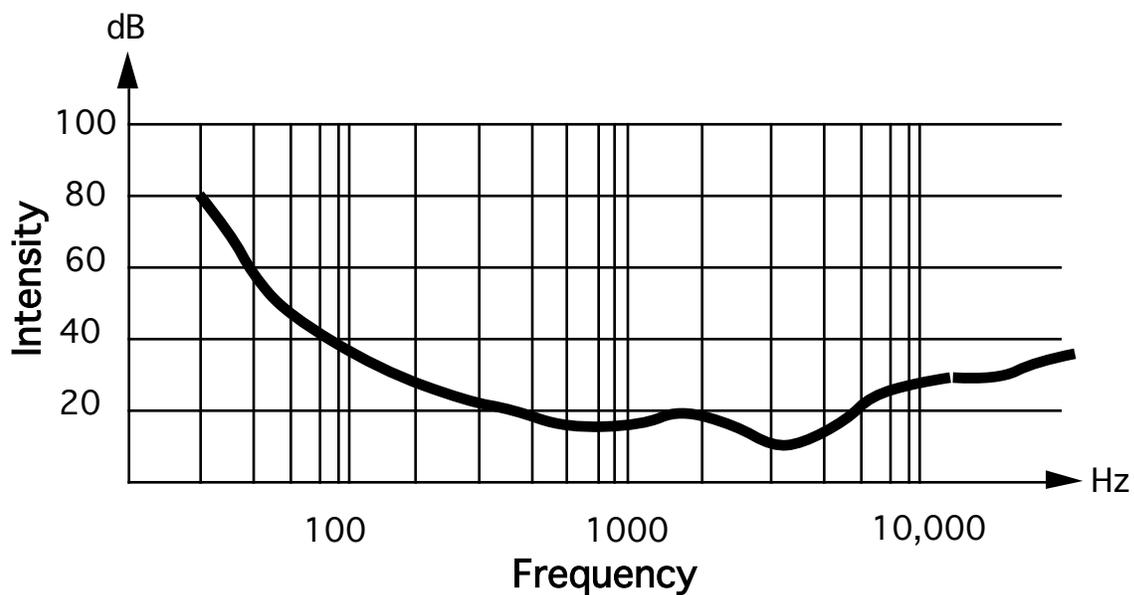
The **decibel (dB)** is used for the purpose of comparing the intensities of two sounds. In acoustics, the reference **sound pressure level (SPL)** is the threshold of audibility (0 dB SPL). A sound at the threshold of pain is considered to be 130 dB SPL. When referencing sound pressure levels, the decibel units are always positive, as there is no level below the threshold of hearing.

However, the term decibel is also used as a unit for comparing the intensity of two electrical signal levels with the largest intensity level being 0 dB - all other levels would be below and consequently a negative unit of measurement.

*Psychoacoustics - the study of the perception of sound.*

**Pitch** is our subjective response to frequency. The frequencies from 25-30 to 4000 Hz. comprise the region of greatest perceptual acuity and sensitivity to change in frequency. Pitch is perceived as a steady-state tone having either a fundamental frequency or center frequency. Although frequencies exist lower than 25 or 30 Hertz, and higher than 20,000 Hertz, those lower frequencies (if heard at all) may be heard as clicks rather than a steady-state tone (or pitch) and those frequencies higher than 20,000 Hertz would not be heard by humans (therefore not being perceived as pitch).

The sensation of **loudness** is primarily determined by the amount of acoustical energy received by the ear. In addition, research (Fletcher and Munson) has shown that the perception of a sound's loudness is also related to its frequency.



The above graph indicates that human ears are not very sensitive to low frequencies, not very sensitive to those frequencies above 10,000 Hertz, and particularly sensitive to frequencies between 3000 to 5000 Hertz. A sound of 50 Hz must have the intensity of approximately 55 dB if it is to be heard as being just as loud as a 3000 Hz sound that has an intensity of only 15 dB.