

What is sound?

The sensation of sound is due to tiny fluctuations in air pressure, varying higher and lower than the normal ambient air pressure.

Normal ambient air pressure (1 atmosphere) is roughly 100,000 pascals [Pa], or 14.7 pounds per square inch [PSI].

The quietest audible sounds have pressure fluctuation amplitude 0.00002 Pa (20 micropascals). That is a minuscule fluctuation (five parts per billion) compared to the normal atmospheric pressure of 100,000 Pa. Common audible sounds have pressure fluctuations of around 0.01 Pa.

Dealing with tiny pressure amplitudes like 0.00002 Pa is inconvenient to write and interpret, so engineers often refer to sound levels using a logarithmic representation known as the *decibel* [dB]. The decibel expresses ordinary sound levels with a number between zero (just barely audible) and 100 (extremely loud).

Common sounds in an office or home have levels around 50 dB. Some extremely loud sounds, like jet engines and gunshots, have dangerous sound levels that exceed 100 dB.

Sound Speed

The sound pressure fluctuations—sound *waves*—move from place to place through the air at a rate known as the *speed of sound*, which is 343 meters per second at room temperature (1,125 feet per second). The speed of sound is slightly faster in warm air and slightly slower in cold air.

A couple good rules of thumb: sound travels about one foot in one millisecond (0.001 second), and about one mile in 5 seconds.

The speed of light is very close to one million times greater than the speed of sound. Light travels about one foot in a nanosecond (0.000000001 second).

Sound Frequency

The *musical pitch* of a sound is generally related to the fundamental *frequency* of the sound wave. The frequency is the repetition rate of the sound pressure fluctuation: how many fluctuations occur in one second (cycles per second, or hertz [Hz]).

Human sound perception covers the range from about 20 Hz to about 20,000 Hz. The low E string on a double bass has frequency 41.2 Hz, and the low C string on a cello has frequency 65.4 Hz, Middle C on the piano has a frequency of 261.6 Hz. Symphony orchestras typically tune to the A above middle C, which has customary frequency 440 Hz. The high E string on a violin (top space on the treble clef) has frequency 659.25 Hz.

Sound Wavelength

The distance a sound wave travels during one cycle of the pressure fluctuation is known as the *wavelength*. At room temperature, the wavelength of a 20 Hz sound is more than 17 meters (over 56 feet), while the wavelength corresponding to a 20,000 Hz sound is only 1.7 centimeters (about half an inch).

The interaction of sound waves with obstacles like walls, floors, and furniture depends strongly upon the wavelength. Because sound wavelengths vary over such a wide range, architectural design for musical acoustics is extremely challenging.

Standard Tuning Frequencies

