

### Relative intensity is measured in decibels

Just as the frequency of a sound wave determines its pitch, the intensity of a wave approximately determines its perceived loudness. However, loudness is not directly proportional to intensity. The reason is that the sensation of loudness is approximately logarithmic in the human ear.

*Relative intensity* is the ratio of the intensity of a given sound wave to the intensity at the threshold of hearing. Because of the logarithmic dependence of perceived loudness on intensity, using a number equal to 10 times the logarithm of the relative intensity provides a good indicator for human perceptions of loudness. This measure of loudness is referred to as the *decibel level*. The decibel level is dimensionless because it is proportional to the logarithm of a ratio. A dimensionless unit called the **decibel** (dB) is used for values on this scale.

The conversion of intensity to decibel level is shown in **Table 2**. Notice in **Table 2** that when the intensity is multiplied by 10, 10 dB are added to the decibel level. A given difference in decibels corresponds to a fixed difference in perceived loudness. Although much more intensity ( $0.9 \text{ W/m}^2$ ) is added between 110 and 120 dB than between 10 and 20 dB ( $9 \times 10^{-11} \text{ W/m}^2$ ), in each case the perceived loudness increases by the same amount.

**Table 2** Conversion of Intensity to Decibel Level

Intensity ( $\text{W/m}^2$ )	Decibel level (dB)	Examples
$1.0 \times 10^{-12}$	0	threshold of hearing
$1.0 \times 10^{-11}$	10	rustling leaves
$1.0 \times 10^{-10}$	20	quiet whisper
$1.0 \times 10^{-9}$	30	whisper
$1.0 \times 10^{-8}$	40	mosquito buzzing
$1.0 \times 10^{-7}$	50	normal conversation
$1.0 \times 10^{-6}$	60	air conditioning at 6 m
$1.0 \times 10^{-5}$	70	vacuum cleaner
$1.0 \times 10^{-4}$	80	busy traffic, alarm clock
$1.0 \times 10^{-3}$	90	lawn mower
$1.0 \times 10^{-2}$	100	subway, power motor
$1.0 \times 10^{-1}$	110	auto horn at 1 m
$1.0 \times 10^0$	120	threshold of pain
$1.0 \times 10^1$	130	thunderclap, machine gun
$1.0 \times 10^3$	150	nearby jet airplane

### decibel

a dimensionless unit that describes the ratio of two intensities of sound; the threshold of hearing is commonly used as the reference intensity

### Did you know?

The original unit of decibel level is the *bel*, named in honor of Alexander Graham Bell, the inventor of the telephone. The decibel is equivalent to 0.1 bel.

### extension

#### Integrating Health

Visit [go.hrw.com](http://go.hrw.com) for the activity "Why Your Ears Pop."



**Keyword** HF6SNDX