University High School
Performing Fine Arts Magnet

Lesson 6. Decibels

Sounds that are more intense than about 1 watt per square meter are painful to the human ear. On the other hand, *threshold intensity*, or the least intense sound that can be heard, is about 10^{-12} (0.0000000000001) watts per square meter. Since this number is ridiculous, we use *logarithms*. *A logarithm* is essentially the reverse of an exponent. The value of a logarithm is the **power** *x* to which you must raise the **base** *b* to obtain the **argument** *a*.

$$b^x = a$$
$$\log_b a = x$$

$10^3 = 1000$
$\log_{10} 1000 = 3$

$2^5 = 32$
$\log_2 32 = 5$

The logarithmic scale used for measuring sound intensity is the **decibel (dB) scale**, which uses a base of 10. This means a 10-dB increase means the sound intensity is 10 times more, a 20-dB increase means the sound intensity is 100 times more, and a 30-dB increase means the sound intensity is 1000 times more, and so forth.

Decibels are expressed by the following equation, where **sound level** *L* is a logarithm of sound intensity *I* divided by the threshold of hearing I_0:

$$L = 10 \log \frac{I}{I_0}$$

This scale puts the threshold of hearing at a very reasonable 0, and the threshold of pain at 140, making decibels much easier to work with than sound intensity expressed in acoustic watts.

Threshold of hearing	0 dB
ppp	40 dB
p	60 dB
f	80 dB
fff	100 dB
Threshold of pain	120 dB