

## Poll: Is 3 dB, 6 dB or 10 dB SPL double the sound pressure?

*This is not a trick question. This is not about the subjective perceived loudness of hearing and not how to add sound sources. SPL is the abbreviation for "Sound Pressure Level". The term loudspeaker and amplification is not specifically raised with the previous survey. It's all about sound pressure the most important sound value.*

*There is only one correct answer: **Twice the sound pressure is an SPL of +6 dB.***

*We should go on reading, if we want to know more and want to understand all this stuff.*

## • Sound (music) and noise (bang) •

**Subjectively perceived loudness (volume), objectively measured sound pressure (voltage), and theoretically calculated sound intensity (acoustic power)**

You will find here the dependence of sound levels in dB, the respective factors, and evaluation of measurements and personal perceptions.

## **More often it's not about music, but about noise and noise level**

It's not easy to understand the relationship between these terms: There is the subjectively and artificially perceived concept of loudness, the objectively measurable audio voltage from a microphone which is proportional to the sound pressure (a sound field size) and last, but not least there is the calculated sound intensity (acoustic strength) or acoustic power (a sound energy size).

**How many decibels (dB) is twice (double, half) or three times as loud? Loudness/Volume – What is the dependence of the level in decibels?**

What does the common phrase "sound level" mean? Is it the volume level, the loudness level, the sound pressure level – thus proportional to the voltage level, the sound intensity level, the sound power level – or does it mean the A-weighted or C-weighted sound level? This is about the level dynamics of the amplitudes.

It's often necessary to estimate how much a sound level changes. Our ears interpret a wide range of sound amplitudes, volume or loudness as change in level and

change in loudness. The decibel is a very convenient unit for measuring signal levels in electronic circuits or sound pressure levels in air. However, changes in the loudness of sounds as perceived by our ears do not conform exactly to the corresponding changes in sound pressure level. Loudness is the quality of a sound that is the primary psychological correlation of physical strength (amplitude). Loudness, a subjective feeling, is often confused with objective measures of sound pressure level SPL such as decibels.

Definitions:

Sound level or noise level is a physical quantity measured with measuring instruments.

Loudness is a psycho-physical sensation perceived by the human auditory perception or the human ear/brain mechanism. That is not the same.

We are told by psycho-acousticians that a level 10 dB greater usually means "double the loudness" or "twice as loud".

A decibel is one-tenth of a bel, which is the logarithm of the ratio of any two energy-like quantities or two field-like quantities.

Ratio doubling means:

- a power level of +3 dB, or a sound intensity level of +3 dB
- an electric voltage level of +6 dB, or a sound pressure level of +6 dB
- a loudness level of about +10 dB
- 10 dB more SPL means 10 times increase in amplifier (electric) power.

In the newsgroups these often misunderstood statements are explained rather less accurately. Decibels can also mean dB SPL or dBA, while a level change is always in dB. The perceived loudness of the sound depends on several factors: the amplitude, the sound pressure level, the frequency, and the time behaviour of the sound. A typical question on the internet: "Is 3 dB or 6 dB double the loudness?" The answer is: "It is neither 3 dB, nor 6 dB – it is closer to 10 dB".

## Decibel levels and perceived volume change

**A person feels and judges sound events by exposure time, spectral composition, temporal structure, sound level, information content and subjective mental attitude.** Three physically measurable parameters can be identified and separated from each other in musical material and can be described as the pitch (or fundamental frequency  $f$ ), the tone duration (or time interval  $\Delta t$ ), and the volume (or amplitude  $y_0$ ).

Sometimes, even the timbre or the acoustic spectrum representing the number and relative strength of overtones is regarded as one of the parameters. However, "timbre" can only count as a parameter in a figurative sense, because it does not consist of a variable with a discrete value. Never forget the change of volume caused by the distance between the source of sound and the listener.

**A typical question:** "How many more times "intense" would the 18 dB sound seem compared to the 6 dB sound?" The level difference is 18 dB minus 6 dB = 12 dB. The calculator answers: 12 dB level difference equals a sound intensity factor of 15.85 or a sound pressure factor of 3.98, or a loudness factor of 2.3. Do we know what intensity means? Do we really need this intensity?

Doubled loudness (volume) is how many dB? Really loudness?

**Avoid using the psychoacoustical terms loudness perception and volume.**

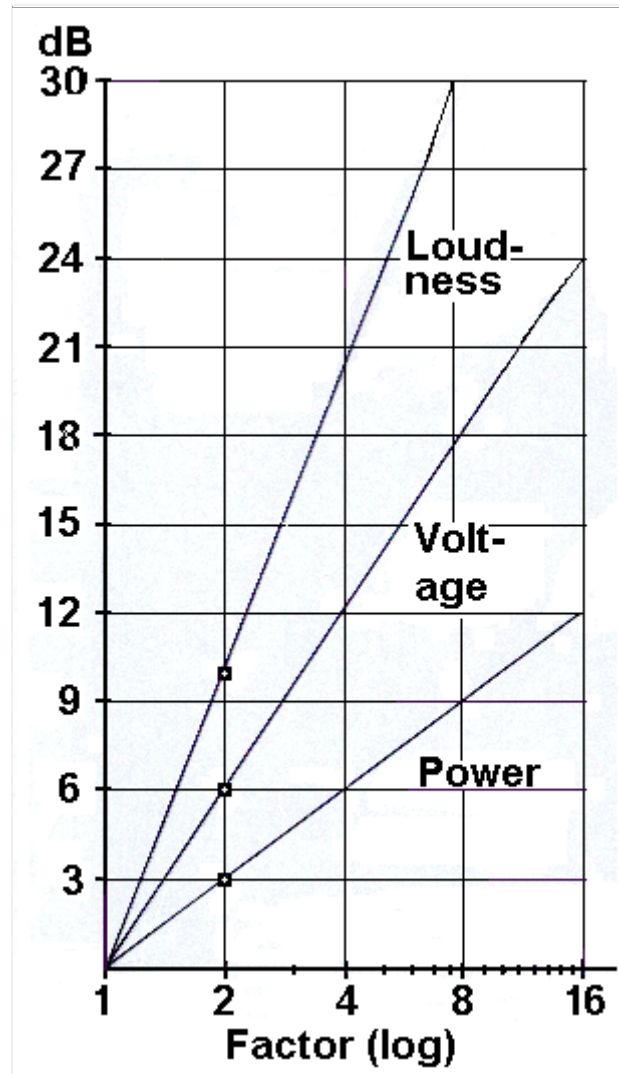
**This subjective sound-sensation is not clearly measurable without ambiguity.**

**The term "loudness" or "volume" is a problem because it belongs to psycho-acoustics and this personal feeling is not correct definable.**

**Loudness as a psychological correlate of physical strength (amplitude) is also affected by parameters other than sound pressure, including frequency, bandwidth, spectral composition, information content, time structure, and the duration of exposure of the sound signal. The same sound will not create the same loudness perception by all individuals (people).**

As psycho-acoustic parameters to describe the "loudness" there is the "loudness level" with the unit phon and the "loudness" with the unit sone.

**Levels in decibels (dB) and their different factors**



Double or twice the loudness = factor 2 means about 10 dB more sensed loudness level (psycho acoustic)

Double or twice the voltage = factor 2 means **6 dB** more measured voltage level (sound pressure level) •

Double or twice the power = factor 2 means 3 dB more calculated power level (sound intensity level)

While every 6 dB SPL represents a doubling of amplitude, a non-exact rule-of-thumb is that every 10 dB increase is a doubling of perceived loudness - psycho-acousticians tell us.

**Don't use the term "doubling of decibels, or doubling of dB".** Always the factor is doubled.

## Sound level change and loudness ratio

To use the calculator, simply enter a value.

The calculator works in both directions of the  $\leftrightarrow$  sign.

<b>Level change <math>\Delta L_{\text{loud}}</math> (psychoacoustics)</b> <input type="text" value="10.0"/> dB	$\leftrightarrow$	<b>Ratio <math>x</math> for loudness (volume)</b> <input type="text" value="2"/> times
$\Delta L = 10 \cdot \log_2 x = 33.22 \cdot \log(x)$		$x = 10^{\frac{\Delta L}{33.22}} = 2^{\frac{\Delta L}{10}}$
<b>• Level change <math>\Delta L_p</math> (field quantity)</b> <input type="text" value="10.0"/> dB	$\leftrightarrow$	<b>• Ratio <math>y</math> for sound pressure (voltage)</b> <input type="text" value="3.162278"/> times
$\Delta L = 20 \cdot \log_{10} y$		$y = 10^{\frac{\Delta L}{20}}$
<b>Level change <math>\Delta L_1</math> (energy quantity)</b> <input type="text" value="10.0"/> dB	$\leftrightarrow$	<b>Ratio <math>z</math> for acoustic intensity (power)</b> <input type="text" value="10"/> times
$\Delta L = 10 \cdot \log_{10} z$		$z = 10^{\frac{\Delta L}{10}}$

The ratio (factor) is in mathematics part of a product. A ratio is  $x$  times the increase of a basic value. **Loudness or volume are not the same as intensity.** Aha, that is a light bulb moment.

The sound wave's **amplitude** (RMS) is the fluctuation in sound pressure as the wave passes by.

<b>Ratio <math>x</math> for loudness (volume)</b> <input type="text" value="2"/> times (sensation)	$\leftrightarrow$	<b>Level change <math>\Delta L_{\text{loud}}</math> (psychoacoustics)</b> <input type="text" value="10.0"/> dB
$x = 10^{\frac{\Delta L}{33.22}} = 2^{\frac{\Delta L}{10}}$		$\Delta L = 10 \cdot \log_2 x = 33.22 \cdot \log(x)$
<b>• Ratio <math>y</math> for sound pressure (voltage)</b> <input type="text" value="2"/> times (field size)	$\leftrightarrow$	<b>• Level change <math>\Delta L_p</math> (field value)</b> <input type="text" value="6.0206"/> dB
$y = 10^{\frac{\Delta L}{20}}$		$\Delta L = 20 \cdot \log_{10} y$
<b>Ratio <math>z</math> for acoustic intensity (power)</b> <input type="text" value="2"/> times (energy size)	$\leftrightarrow$	<b>Level change <math>\Delta L_1</math> (energy value)</b> <input type="text" value="3.0103"/> dB
$z = 10^{\frac{\Delta L}{10}}$		$\Delta L = 10 \cdot \log_{10} z$

"Loudness" cannot be the same as "intensity" and "sound intensity" is not the same as "sound pressure".

Distinguish clearly between loudness, sound pressure, and (sound) intensity. And what is amplitude?

When talking about sound as heard by our ears or by microphones, take care to speak in terms of **sound pressure** as sound field quantity. The sound energy measurements such as sound intensity and sound power have not much use here and are mostly misleading. Air pressure fluctuations considered desirable such as speech or music are pleasant to the ear, while undesirable ambient sound such as traffic noise is annoying.

## Twice, two fold, and doubling sound . .

### Which sound?

**Doubling of the volume** (loudness) should be **sensed** as a level difference of **+10 dB** – acousticians say.

**Doubling the sound pressure** (voltage) corresponds to a **measured** level change of **+6 dB** •

**Doubling of sound intensity** (acoustic energy) belongs to a **calculated** level change of **+3 dB**.

**+10 dB** is the level of **twice the perceived volume** or twice as loud (loudness) in psychoacoustics – mostly **sensed**.

**+6 dB** is the level of **twice the (RMS) value** of voltage respectively sound pressure – mostly **measured** •

**+3 dB** is the level of **twice the energy** or power respectively intensity – mostly **calculated**.

For voltage and sound pressure in acoustics the measured **RMS value** (root mean square) is usually specified.

For sinusoidal AC signals, the **peak value**  $V_0$  or  $p_0$  is denoted by the term **amplitude**.  $V_{\text{RMS}} = |V_0| / \sqrt{2}$ .

The doubling of the factor (twice the factor) means:

for the loudness level: +10 dB,

for the sound pressure level: **+6 dB** SPL and for the electric voltage level: +6 dB,

for the sound intensity level: +3 dB and for the power (energy) level: +3 dB ... and 10 dB SPL more means, the amplifier needs 10 times more power.

20 dB gain change should give about the **ratio of 4** (four times) for sensed volume and loudness,

20 dB gain change gives the **ratio of 10** for measured voltage and sound pressure and

20 dB gain change gives the **ratio of 100** for calculated sound power and acoustic intensity.

Decibel (dB) can also mean dB SPL or dBA; but a level change is always in decibels dB.

The sensed volume or the loudness of a sound depends on several factors: the **amplitude**, the sound pressure level, the frequency, and the time behaviour of the sound.

A typical question on the internet: "Are 3 dBs or 6 dBs double the **loudness** (or twice as loud)?"

Answer: "It's neither 3 dB, nor 6 dB – it's closer to 10 dB more."

## The human perception of loudness

# Sound Level Comparison Chart and the Ratio

Table of sound level dependence and the change of the respective ratios of subjective volume (loudness), objective sound pressure (voltage), and sound intensity (acoustic power).

**How many decibels (dB) level change is double, half, or four times as loud?**

How many dB appear twice as loud (two times)? Here are all the different ratios.

Ratio means "how many times" or "how much" ... Doubling of loudness.

Level change	Volume Loudness	Voltage Sound pressure	Acoustic Power Sound Intensity
+60 dB	64	1000	1000000
+50 dB	32	316	100000
+40 dB	16	100	10000
+30 dB	8	31.6	1000
+20 dB	4	10	100
<b>+10 dB</b>	2.0 = double	3.16 = $\sqrt{10}$	<b>10</b>
+6 dB	1.52 times	2.0 = double	4.0
+3 dB	1.23 times	1.414 times = $\sqrt{2}$	2.0 = double
---- ±0 dB ----	---- 1.0 -----	---- 1.0 -----	---- 1.0 -----
-3 dB	0.816 times	0.707 times	0.5 = half
-6 dB	0.660 times	0.5 = half	0.25
<b>-10 dB</b>	0.5 = half	0.316	0.1

-20 dB	1/4 = 0.25	0.100	0.01
-30 dB	0.125	0.0316	0.001
-40 dB	0.0625	0.0100	0.0001
-50 dB	0.0312	0.0032	0.00001
-60 dB	0.0156	0.001	0.000001
<b>Log. size</b>	<b>Psycho size</b>	<b>Field size</b>	<b>Energy size</b>
<b>dB change</b>	<b>Loudness multipl.</b>	<b>Amplitude multiplier</b>	<b>Power multiplier</b>

<b>Ratio / Factor</b>	<b>Change in Sound Loudness Level</b>	<b>Change in Sound Pressure Level</b>	<b>Change in Sound Power Level</b>
40	+53.22 dB	+32.04 dB	+16.02 dB
30	+49.07 dB	+29.54 dB	+14.77 dB
20	+43.22 dB	+26.02 dB	+13.01 dB
15	+39.07 dB	+23.52 dB	+11.76 dB
10	+33.22 dB	+20 dB	+10 dB
5	+23.22 dB	+13.98 dB	+6.99 dB
4	+20 dB	+12.04 dB	+6.02 dB
3	+15.58 dB	+9.54 dB	+4.77 dB
2	+10 dB	+6.02 dB	+3.01 dB
----- 1 -----	----- ±0 dB -----	----- ±0 dB -----	----- ±0 dB -----
1/2 = 0.5	-10 dB	-6.02 dB	-3.01 dB
1/3 = 0.3333	-15.58 dB	-9.54 dB	-4.77 dB
1/4 = 0.25	-20 dB	-12.04 dB	-6.02 dB
1/5 = 0.2	-23.22 dB	-13.98 dB	-6.99 dB
1/10 = 0.1	-33.22 dB	-20 dB	-10 dB
1/15 = 0.0667	-39.07 dB	-23.52 dB	-11.76 dB
1/20 = 0.05	-43.22 dB	-26.02 dB	-13.01 dB
1/30 = 0,033	-49.07 dB	-29.54 dB	-14.77 dB
1/40 = 0,025	-53.22 dB	-32.04 dB	-16.02 dB

The loudness ratio 4 (four times the loudness) changes the sound loudness level by 20 dB.

The sound pressure ratio 4 (four times the pressure) changes the sound pressure level by 12.04 dB.

The sound power ratio 4 (four times the intensity) changes the sound power level by 6.02 dB.

The loudness ratio 3 (three times the loudness) changes the sound loudness level by 15.58 dB.

The sound pressure ratio 3 (three times the pressure) changes the sound pressure level by 9.54 dB.

The sound power ratio 3 (three times the intensity) changes the sound power level by 4.77 dB.

The loudness ratio 2 (two times (twice) the loudness) changes the sound loudness level by 10 dB.

The sound pressure ratio 2 (two times the pressure) changes the sound pressure level by 6.02 dB.

The sound power ratio 2 (two times the intensity) changes the sound power level by 3.01 dB.

Loudness is a subjective feeling that is often confused with objective SPL measurements in



decibels. With sound level we usually mean a logarithmic ratio of measurable sound pressures.

The number of **sones** to a **phon** was chosen so that a doubling of the number of sones sounds to

the human ear like a doubling of the loudness, which also corresponds to increasing the sound

pressure level by (+)10 dB, or increasing the sound pressure by a ratio  $3.16 = \text{root of } 10$ .


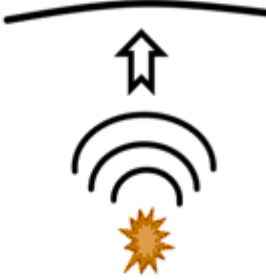

"What are sones and phons?":

<http://www.sengpielaudio.com/calculatorSonephon.htm>

## **Sound loudness - Sound pressure - Sound intensity**

**The factors and their levels in decibels (dB).**

**Loudness perception - sound pressure effect - sound intensity cause**

Change of Level	Loudness Perception	Sound Pressure Effect	Sound Intensity Cause
			
Decibels	Loudness Gain Factor	Voltage Gain Factor	Power Gain Factor
+ 20 dB	4.000	10.000	100.000
+ 10 dB	2.000 •	3.160	10.000
+ 6 dB	1.516	2.000 •	4.000
+ 3 dB	1.232	1.414	2.000 •
± 0 dB	1.000	1.000	1.000
- 3 dB	0.812	0.707	0.500 •
- 6 dB	0.660	0.500 •	0.250
- 10 dB	0.500 •	0.316	0.100
- 20 dB	0.250	0.100	0.010

From: [http://www.bv-elbtal.de/html/was\\_ist\\_larm\\_.html](http://www.bv-elbtal.de/html/was_ist_larm_.html)

## Sound loudness - Sound pressure - Sound intensity

Different wines. The wine in the middle tastes best.

"Loudness" should never be mixed or set equal to "intensity".



Realm of Psychoacoustic - Relationship between phon and sone  
Conversion of sound units (levels)  
Total Level Calculation (Adding of levels)  
Factor or Ratio and Level in Decibels (dB)

**The often unknown formulas for level and ratio.  
 Loudness formula - pressure formula - intensity  
 formula**

<b>Psychoacoustics -</b> Level change <b>loudness</b> $\Delta L = 10 \cdot \log_2 x$	Ratio for " <b>loudness</b> " $x = 2^{\frac{\Delta L}{10}}$
• <b>Field quantity -</b> Level change <b>sound pressure</b> $\Delta L = 20 \cdot \log_{10} y$	• Ratio for " <b>sound pressure</b> " $y = 10^{\frac{\Delta L}{20}}$
<b>Energy or power quantity -</b> Level change <b>sound intensity</b> $\Delta L = 10 \cdot \log_{10} z$	Ratio for " <b>sound intensity</b> " $z = 10^{\frac{\Delta L}{10}}$

log to the base 10 =  $\log_{10}$  is named lg and log to the base 2 =  $\log_2$  is named ld.

$$\Delta L = (10/\log_{10}(2)) \cdot \log(x) = 33.22 \cdot \log(x) = 10 \cdot \log_2(x) \quad x = 10^{(\Delta L/33.22)} = 2^{(\Delta L/10)}$$

A typical question: **How many decibels more is the 3-fold subjective loudness?** Some people have problems with the idea of "twice as loud", or "three times as loud."

I confess – I am one of them. The solution of the top calculator shows 15.85 dB. Hmm ...

The psychoacoustic values of volume (loudness) are always signal, pulse and frequency-dependent.

Therefore a statement about this perceived quantity must be viewed with a certain caution.

Kurt Tucholsky wrote: "Our own dog does not make noise, it only barks."

The work of most acoustical consultants belongs to noise control. We speak of the **volume** as loudness level in phon or loudness in sone. The perception of loudness is not proportional to the sound pressure or the sound intensity. Hearing does not have the same sensitivity for all pitches.

The defined sound level is therefore not the perceived loudness of a sound. We get a rough approximation to human auditory perception by the use of an A-weighted filter, which approximates the sound signal in the different frequency areas according to the sensitivity of the hearing mechanism, but only at low levels. For louder signals than 40 dB, this A-weighted filter cuts off too many low frequencies incorrectly. The marketing department likes this!

**Note:** The concept of doubling or halving a loudness, is quite vague. Who really knows exactly when a sound is half as loud? This corresponds to the impossible exact rating when is a cup of coffee half as hot? Therefore, this theoretical assumption should not be taken too seriously.

This evaluation belongs to psychoacoustics.



Car freaks und "dB Drag Racing" fans need for their loudspeakers:

## ● **The Big Power Formulas** Electrical and mechanical power calculation

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# **The psycho-acoustic volume or loudness is a subjective sensation of size.**

**Is 10 dB or 6 dB sound level change for a doubling or halving of the loudness (volume) correct?**

About the connection between sound level and loudness, there are various theories.

Widely accepted is still the theory of psycho-acoustic pioneer Stanley Smith Stevens, indicating that the doubling or halving of the sensation of loudness corresponds to a level difference of 10 dB. Recent research by Richard M. Warren, on the other hand leads to a level difference of only 6 dB. \*) This means that a double sound pressure corresponds to a double loudness. The psychologist John G. Neuhoff found that our hearing is more sensitive to rising levels of sound as to falling levels. That is for the same sound level difference the change of loudness from quiet to loud is stronger than from loud to quiet.

It is suggested that the sone scale of loudness reflects the influence of known experimental biases and hence does not represent a fundamental relation between stimulus and sensation.

**\*) Richard M. Warren, "Elimination of Biases in Loudness Judgments for Tones", 1970, Journal of the Acoust. Soc. Am. Volume 48, Issue 6B, pp. 1397 - 1403 and**

**Richard M. Warren, "Quantification of Loudness", 1973, American Journal of Psychology,**

**Vol 86 (4), pp. 807 - 825**

**John G. Neuhoff, "An adaptive bias in the perception of looming auditory motion", 2001,**

**Ecological Psychology 13 (2) pp. 87 - 110 and**

**John G. Neuhoff, "Perceptual Bias for Rising Tones", 1998, Nature, Volume 395, 10 September**

Citation: When known experimental biases were eliminated, half loudness was equal to half sound pressure level (-6 dB) from 45 to 90 dB.

**It follows that the determination of the volume (loudness) which is double as loud should not be dogmatically defined. More realistic is the following claim:**

**A doubling of the sensed volume (loudness) is equivalent to a level change approximately between 6 dB and 10 dB.**

**... by the way: You cannot usefully double or multiply any "level".**

There is double voltage and double sound pressure. What is double the level?

3 dB, 6 dB or 10 dB? Aha - therefore it's better to avoid this expression.

"Double the level" means carelessly, that there is really double the voltage.

The expression: "Double the level equals 3 dB" is nonsense.

What is the doubling of 10 decibel? That is no good question.

Typical question: Is 3 decibel more level twice as loud? Answer: No!

Psychoacousticians tell us, that we must feel a level boost of 6 to 10 dB as twice as loud.

**Level dynamics and spectral dynamics (timbre dynamics)**

Equally important as the level dynamics, is the timbre dynamics, also called spectral dynamics. The perceived volume (loudness) is almost independently characterized by amplitude level through a specific timbre spectrum range played by musical instruments as dynamic stages.

A weighting filter is used to emphasise or suppress some aspects of a phenomenon compared to others for measurement or other purposes. In the measurement of loudness, for example, an A-weighting filter is commonly used to emphasize frequencies around 3 to 6 kHz where the human ear is most sensitive, while attenuating very high and very low frequencies to which the ear is insensitive. The aim is to ensure that measured loudness corresponds well with subjectively perceived loudness. A-weighting is only really valid for relatively quiet sounds and for pure tones as it is based on the 40-phon equal-loudness contour; see the weighting filtered levels **dB(A) and dB(C)**.

Another difficult issue is:

How does the volume (loudness) decrease with distance from a sound source?

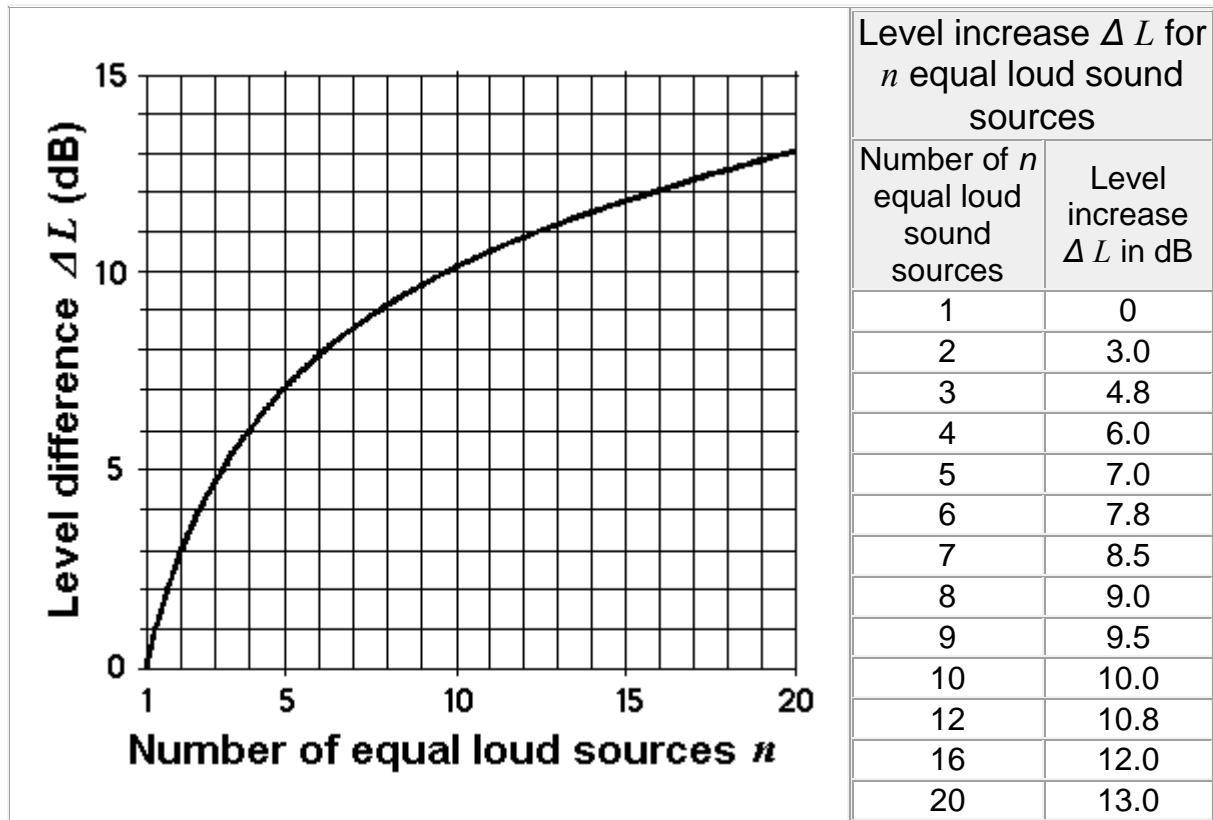
How does the sound pressure (voltage) decrease with distance from a sound source?

How does the sound intensity (not the sound power) decrease with distance from a sound source?

The beginners question is quite simple: **How does the sound decrease with distance?**

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## **Adding of equal strong non-coherent sound sources**



**Formulas:  $\Delta L = 10 \times \log n$  or  $n = 10^{(\Delta L/10)}$**

$\Delta L$  = level difference;  $n$  = number of equal loud sound sources.

$n = 2$  equally loud incoherent sound sources result in a higher level of  $10 \times \log 2 = +3.01$  dB compared to the case that only one source is available.

$n = 3$  equally loud incoherent sound sources result in a higher level of  $10 \times \log 3 = +4.77$  dB compared to the case that only one source is available.

$n = 4$  equally loud incoherent sound sources result in a higher level of  $10 \times \log 4 = +6.02$  dB compared to the case that only one source is available.

## Calculator: Adding level of equal loud sound sources

To use the calculator, simply enter a value.

The calculator works in both directions of the  $\leftrightarrow$  sign.

<b>Number of sound sources</b> <b><math>n</math>:</b> <input type="text" value="4"/>	$\leftrightarrow$	<b>Increase of level <math>\Delta L</math>:</b> <input type="text" value="6"/> dB
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$n = 10^{\frac{\Delta L \text{ in dB}}{10}}$	$\Delta L \text{ in dB} = 10 \log_{10}(n)$
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The total level in decibels is the level of one sound source plus the increase of level in dB.

The very special case of active noise cancellation (compensation) by obliterating level addition - which is labeled "Active noise control" - is not considered here.

## The decrease of sound with distance

For a **spherical wave** we get:

The **sound pressure level** (SPL) decreases with doubling of distance by (-)6 dB.

The sound pressure falls to 50% or 1/2 fold of the initial value of the sound pressure.

The sound pressure decreases with the ratio  $1/r$  of the distance.

The **sound intensity level** decreases with doubling of distance also by (-)6 dB.

The intensity falls to 25% or 1/4 fold of the initial value of the acoustic or sound intensity.

The sound intensity decreases with the ratio  $1/r^2$  of the distance.

The **loudness level** decreases with doubling of distance also by (-)6 dB.

The loudness falls to 63% or ca. 2/3 fold of the initial value of the sensed loudness.

The loudness decreases with the ratio  $1/(2^{0.66} r) = 1/1.581 r$  to the distance.

Levels of sound pressure and levels of sound intensity decrease equally with the distance from the sound source. **Sound power** or **sound power level** has nothing (!) to do with the distance from the sound source.

Thinking helps: A 100 watt light bulb has in 1 m and in 10 m distance really always the same 100 watts, which is emitted from the lamp all the time.

Watts don't change with distance.

### Sound pressure and Sound power – Effect and Cause

The doubling of the "loudness impression" will require an increase of sound pressure level of about 10 dB. **Who knows exactly how loud the sensation "sounds twice as loud" is?**

A measurement of the doubling of the sound pressure, however, equals exactly +6 dB.

### Frequently used false statements in the context of sound values and the distance of the sound source

Correct version

Wrong expression



<p><b>Sound pressure</b> (amplitude) falls inversely proportional to the distance <math>1/r</math> from the sound source. <b>That is the <math>1/r</math> law or the inverse distance law.</b></p>	<p><b>Sound pressure</b> (amplitude) falls inversely proportional to the square of the distance <math>1/r^2</math> from the sound source. really wrong</p>
<p><b>Sound pressure level</b> decreases by <b>(-6 dB)</b> for doubling of the distance from the source to <b>1/2 (50 %)</b> of the sound pressure initial value.</p>	<p><b>Sound pressure level</b> decreases as the distance increases for doubling of the distance from the source by <b>(-3 dB)</b>. wrong</p>
<p><b>Sound intensity</b> (energy) falls inversely proportional to the square of the distance <math>1/r^2</math> from the sound source. <b>That is the inverse square law <math>1/r^2</math>.</b></p>	<p><b>Sound intensity</b> (energy) falls inversely proportional to the distance <math>1/r</math> from the sound source. wrong</p>
<p><b>Sound intensity level</b> decreases by <b>(-6 dB)</b> for doubling of the distance from the source to <b>1/4 (25 %)</b> of the sound intensity initial value.</p>	<p><b>Sound intensity level</b> decreases inversely as the square of the distance increases for doubling of the sound source by <b>(-3 dB)</b>. wrong</p>

## Sound pressure is not intensity

**Neither the sound power nor the sound power level decreases in doubling the distance. Why is this so?**

The sound power level quantifies the totally radiated sound energy from an object.

Different to the sound pressure the sound power is independent of the distance to the sound source, the surrounding area and other influences.

### How does the sound decrease with distance?

Knowing the intensity of a sound wave allows one to calculate the decibel (dB) level of that sound. Use the Decibel Calculator widget to determine the decibel rating from any intensity in watt/meter<sup>2</sup>. Enter intensities using scientific notation – for example, enter  $5e^{-5}$  for  $5.0 \times 10^{-5}$ .

### WolframAlpha Decibel Calculator

#### Determine the perceived loudness of a sound

Half loudness $\equiv$ level	-10 dB	Double loudness $\equiv$ level	+10 dB
Half sound pressure $\equiv$ level	-6 dB	Double sound pressure $\equiv$ level	+6 dB
Half power $\equiv$ level	-3 dB	Double power $\equiv$ level	+3 dB
Four times power $\equiv$ level	+6 dB	Ten times power $\equiv$ level	+10 dB
Double distance $\equiv$ level	-6 dB	Double sources (Double power) $\equiv$	+3 dB

### Simple rule of thumb:

When working with power, 3 dB means double (twice) the factor and 10 dB means 10-fold.

When working with voltage or current, 6 dB means double (twice) the factor and 20 dB means 10-fold.

Sound level change of perceived factor sound levels volume doubling loudness decibel scale log compare intensities formula calculate power level noise sound pressure intensity power relationship logarithm loudness volume decibel dB twice as loud 10 dB double distance half level dependence audio auditory hearing listening sound noise fold 3 dB 6 dB 10 dB loudness of sound SPL increase decrease - sengpielaudio

Deutsche Version flag s/w - sengpielaudio D-flag - sengpielaudio

Poll: Is 3 dB, 6 dB or 10 dB SPL double the sound pressure?

This is not a trick question. This is not about the subjective perceived loudness of hearing and not how to add sound sources. SPL is the abbreviation for "Sound Pressure Level". The term loudspeaker and amplification is not specifically raised with the previous survey. It's all about sound pressure the most important sound value.

There is only one correct answer: Twice the sound pressure is an SPL of +6 dB.

We should go on reading, if we want to know more and want to understand all this stuff.

- Sound (music) and noise (bang) ●

Subjectively perceived loudness (volume),

objectively measured sound pressure (voltage), and theoretically calculated sound intensity (acoustic power)

You will find here the dependence of sound levels in dB, the respective factors, and evaluation of measurements and personal perceptions.

More often it's not about music, but about noise and noise level

It's not easy to understand the relationship between these terms: There is the subjectively and artificially perceived concept of loudness, the objectively measurable audio voltage from a microphone which is proportional to the sound pressure (a sound field size) and last, but not least there is the calculated sound intensity (acoustic strength) or acoustic power (a sound energy size).

How many decibels (dB) is twice (double, half) or three times as loud?

Loudness/Volume – What is the dependence of the level in decibels?

What does the common phrase "sound level" mean? Is it the volume level, the loudness level, the sound pressure level – thus proportional to the voltage level, the sound intensity level, the sound power level – or does it mean the A-weighted or C-weighted sound level? This is about the level dynamics of the amplitudes.

It's often necessary to estimate how much a sound level changes. Our ears interpret a wide range of sound amplitudes, volume or loudness as change in level and change in loudness. The decibel is a very convenient

unit for measuring signal levels in electronic circuits or sound pressure levels in air. However, changes in the loudness of sounds as perceived by our ears do not conform exactly to the corresponding changes in sound pressure level. Loudness is the quality of a sound that is the primary psychological correlation of physical strength (amplitude). Loudness, a subjective feeling, is often confused with objective measures of sound pressure level SPL such as decibels.

Definitions:

Sound level or noise level is a physical quantity measured with measuring instruments.

Loudness is a psycho-physical sensation perceived by the human auditory perception or the human ear/brain mechanism. That is not the same.

We are told by psycho-acousticians that a level 10 dB greater usually means "double the loudness" or "twice as loud".

A decibel is one-tenth of a bel, which is the logarithm of the ratio of any two energy-like quantities or two field-like quantities.

Ratio doubling means:

- a power level of +3 dB, or a sound intensity level of +3 dB
- an electric voltage level of +6 dB, or a sound pressure level of +6 dB
- a loudness level of about +10 dB
- 10 dB more SPL means 10 times increase in amplifier (electric) power.

In the newsgroups these often misunderstood statements are explained rather less accurately. Decibels can also mean dB SPL or dBA, while a level change is always in dB. The perceived loudness of the sound depends on several factors: the amplitude, the sound pressure level, the frequency, and the time behaviour of the sound. A typical question on the internet: "Is 3 dB or 6 dB double the loudness?"

The answer is: "It is neither 3 dB, nor 6 dB – it is closer to 10 dB".

Decibel levels and perceived volume change

A person feels and judges sound events by exposure time, spectral composition, temporal structure, sound level, information content and subjective mental attitude. Three physically measurable parameters can be identified and separated from each other in musical material and can be described as the pitch (or fundamental frequency  $f$ ), the tone duration (or time interval  $\Delta t$ ), and the volume (or amplitude  $y_0$ ).

Sometimes, even the timbre or the acoustic spectrum representing the number and relative strength of overtones is regarded as one of the parameters. However, "timbre" can only count as a parameter in a figurative sense, because it does not consist of a variable with a discrete value. Never forget the change of volume caused by the distance between the source of sound and the listener.

A typical question: "How many more times "intense" would the 18 dB sound seem compared to the 6 dB sound?" The level difference is 18 dB minus 6 dB = 12 dB.

The calculator answers: 12 dB level difference equals a sound intensity factor of 15.85 or a sound pressure factor of 3.98, or a loudness factor of 2.3. Do we know what intensity means? Do we really need this intensity?

Doubled loudness (volume) is how many dB? Really loudness?

Avoid using the psychoacoustical terms loudness perception and volume.

This subjective sound-sensation is not clearly measurable without ambiguity.

The term "loudness" or "volume" is a problem because it belongs to psycho-acoustics and this personal feeling is not correct definable.

Loudness as a psychological correlate of physical strength (amplitude) is also affected by parameters other than sound pressure, including frequency, bandwidth, spectral composition, information content, time structure, and the duration of exposure of the sound signal. The same sound will not create the same loudness perception by all individuals (people).

As psycho-acoustic parameters to describe the "loudness" there is the "loudness level" with the unit phon and the "loudness" with the unit sone.

Levels in decibels (dB) and their different factors

Faktor und Decibel

Double or twice the loudness = factor 2 means about 10 dB more sensed loudness level (psycho acoustic)

Double or twice the voltage = factor 2 means 6 dB more measured voltage level (sound pressure level) ●

Double or twice the power = factor 2 means 3 dB more calculated power level (sound intensity level)

While every 6 dB SPL represents a doubling of amplitude, a non-exact rule-of-thumb is that every 10 dB increase is a doubling of perceived loudness - psycho-acousticians tell us.

Don't use the term "doubling of decibels, or doubling of dB". Always the factor is doubled.

Sound level change and loudness ratio

To use the calculator, simply enter a value.

The calculator works in both directions of the  $\leftrightarrow$  sign.

Level change  $\Delta L_{\text{loud}}$  (psychoacoustics)

dB  $\leftrightarrow$  Ratio x for loudness (volume)

times

Loudness level =  $33.22 \cdot \log(x)$  Factor loudness

● Level change  $\Delta L_p$  (field quantity)

dB  $\leftrightarrow$  ● Ratio y for sound pressure (voltage)

times

Sound pressure level Sound pressure factor

Level change  $\Delta L_I$  (energy quantity)

dB  $\leftrightarrow$  Ratio z for acoustic intensity (power)

times

Formel5 Formel6

The ratio (factor) is in mathematics part of a product. A ratio is x times the increase of a basic value. Loudness or volume are not the same as intensity. Aha, that is a light bulb moment.

The sound wave's amplitude (RMS) is the fluctuation in sound pressure as the wave passes by.

Ratio x for loudness (volume)

times (sensation)  $\leftrightarrow$  Level change  $\Delta$  Lloud (psychoacoustics)

dB

Factor loudness Loudness level =  $33.22 \cdot \log(x)$

• Ratio y for sound pressure (voltage)

times (field size)  $\leftrightarrow$  • Level change  $\Delta$  Lp (field value)

dB

Sound pressure factor Sound pressure level

Ratio z for acoustic intensity (power)

times (energy size)  $\leftrightarrow$  Level change  $\Delta$  LI (energy value)

dB

Acoustic intensity Acoustic intensity level

"Loudness" cannot be the same as "intensity" and "sound intensity" is not the same as "sound pressure".

Distinguish clearly between loudness, sound pressure, and (sound) intensity. And what is amplitude?

When talking about sound as heard by our ears or by microphones, take care to speak in terms of sound pressure as sound field quantity. The sound energy measurements such as sound intensity and sound power have not much use here and are mostly misleading. Air pressure fluctuations considered desirable such as speech or music are pleasant to the ear, while undesirable ambient sound such as traffic noise is annoying.

Twice, two fold, and doubling sound . . .

Which sound?

Doubling of the volume (loudness) should be sensed as a level difference of +10 dB – acousticians say.

Doubling the sound pressure (voltage) corresponds to a measured level change of +6 dB •

Doubling of sound intensity (acoustic energy) belongs to a calculated level change of +3 dB.

+10 dB is the level of twice the perceived volume or twice as loud (loudness) in psychoacoustics – mostly sensed.

+6 dB is the level of twice the (RMS) value of voltage respectively sound pressure – mostly measured •

+3 dB is the level of twice the energy or power respectively intensity – mostly calculated.

For voltage and sound pressure in acoustics the measured RMS value (root mean square) is usually specified.

For sinusoidal AC signals, the peak value  $V_0$  or  $p_0$  is denoted by the term amplitude.  $V_{RMS} = |V_0| / \sqrt{2}$ .

The doubling of the factor (twice the factor) means:

for the loudness level: +10 dB,  
 for the sound pressure level: +6 dB SPL and for the electric voltage level: +6 dB,  
 for the sound intensity level: +3 dB and for the power (energy) level: +3 dB  
 ... and 10 dB SPL more means, the amplifier needs 10 times more power.

20 dB gain change should give about the ratio of 4 (four times) for sensed volume and loudness,  
 20 dB gain change gives the ratio of 10 for measured voltage and sound pressure and  
 20 dB gain change gives the ratio of 100 for calculated sound power and acoustic intensity.

Decibel (dB) can also mean dB SPL or dBA; but a level change is always in decibels dB.

The sensed volume or the loudness of a sound depends on several factors: the amplitude, the sound pressure level, the frequency, and the time behaviour of the sound.

A typical question on the internet: "Are 3 dBs or 6 dBs double the loudness (or twice as loud)?"

Answer: "It's neither 3 dB, nor 6 dB – it's closer to 10 dB more."

The human perception of loudness

Sound Level Comparison Chart and the Ratio

Table of sound level dependence and the change of the respective ratios of subjective volume (loudness), objective sound pressure (voltage), and sound intensity (acoustic power).

How many decibels (dB) level change is double, half, or four times as loud?

How many dB appear twice as loud (two times)? Here are all the different ratios.

Ratio means "how many times" or "how much" ... Doubling of loudness.

Level

change Volume

Loudness Voltage

Sound pressure Acoustic Power

Sound Intensity

+60 dB 64 1000 1000000

+50 dB 32 316 100000

+40 dB 16 100 10000

+30 dB 8 31.6 1000

+20 dB 4 10 100

+10 dB 2.0 = double 3.16 =  $\sqrt{10}$  10

+6 dB 1.52 times 2.0 = double 4.0

+3 dB 1.23 times 1.414 times =  $\sqrt{2}$  2.0 = double

---- ±0 dB ---- 1.0 ----- 1.0 ----- 1.0 -----

-3 dB 0.816 times 0.707 times 0.5 = half

-6 dB 0.660 times 0.5 = half 0.25

-10 dB 0.5 = half 0.316 0.1

-20 dB 1/4 = 0.25 0.100 0.01

-30 dB 0.125 0.0316 0.001

-40 dB 0.0625 0.0100 0.0001

-50 dB 0.0312 0.0032 0.00001

-60 dB      0.0156   0.001      0.000001  
 Log. size Psycho size Field size Energy size  
 dB change Loudness multipl. Amplitude multiplier Power multiplier

Ratio /  
 Factor Change in Sound  
 Loudness Level Change in Sound  
 Pressure Level Change in Sound  
 Power Level

40	+53.22 dB	+32.04 dB	+16.02 dB
30	+49.07 dB	+29.54 dB	+14.77 dB
20	+43.22 dB	+26.02 dB	+13.01 dB
15	+39.07 dB	+23.52 dB	+11.76 dB
10	+33.22 dB	+20 dB	+10 dB
5	+23.22 dB	+13.98 dB	+6.99 dB
4	+20 dB	+12.04 dB	+6.02 dB
3	+15.58 dB	+9.54 dB	+4.77 dB
2	+10 dB	+6.02 dB	+3.01 dB

----- 1 ----- ±0 dB ----- ±0 dB ----- ±0 dB -----

1/2 = 0.5	-10 dB	-6.02 dB	-3.01 dB
1/3 = 0.3333	-15.58 dB	-9.54 dB	-4.77 dB
1/4 = 0.25	-20 dB	-12.04 dB	-6.02 dB
1/5 = 0.2	-23.22 dB	-13.98 dB	-6.99 dB
1/10 = 0.1	-33.22 dB	-20 dB	-10 dB
1/15 = 0.0667	-39.07 dB	-23.52 dB	-11.76 dB
1/20 = 0.05	-43.22 dB	-26.02 dB	-13.01 dB
1/30 = 0,033	-49.07 dB	-29.54 dB	-14.77 dB
1/40 = 0,025	-53.22 dB	-32.04 dB	-16.02 dB

The loudness ratio 4 (four times the loudness) changes the sound loudness level by 20 dB.  
 The sound pressure ratio 4 (four times the pressure) changes the sound pressure level by 12.04 dB.  
 The sound power ratio 4 (four times the intensity) changes the sound power level by 6.02 dB.

The loudness ratio 3 (three times the loudness) changes the sound loudness level by 15.58 dB.  
 The sound pressure ratio 3 (three times the pressure) changes the sound pressure level by 9.54 dB.  
 The sound power ratio 3 (three times the intensity) changes the sound power level by 4.77 dB.

The loudness ratio 2 (two times (twice) the loudness) changes the sound loudness level by 10 dB.  
 The sound pressure ratio 2 (two times the pressure) changes the sound pressure level by 6.02 dB.  
 The sound power ratio 2 (two times the intensity) changes the sound power level by 3.01 dB.

Loudness is a subjective feeling that is often confused with objective SPL measurements in decibels. With sound level we usually mean a logarithmic ratio of measurable sound pressures. The number of sones to a phon was chosen so that a doubling of the number of sones sounds to

the human ear like a doubling of the loudness, which also corresponds to increasing the sound pressure level by (+)10 dB, or increasing the sound pressure by a ratio 3.16 = root of 10.  
"What are sones and phons?": <http://www.sengpielaudio.com/calculatorSonephon.htm>

Sound loudness - Sound pressure - Sound intensity  
The factors and their levels in decibels (dB).  
Loudness perception - sound pressure effect - sound intensity cause

Loudness - Sound Pressure - Sound Intensity

From: [http://www.bv-elbtal.de/html/was\\_ist\\_larm\\_.html](http://www.bv-elbtal.de/html/was_ist_larm_.html)

Sound loudness - Sound pressure - Sound intensity  
Different wines. The wine in the middle tastes best.  
"Loudness" should never be mixed or set equal to "intensity".

Loudness - Sound pressure - Intensity

Realm of Psychoacoustic - Relationship between phon and sone  
Conversion of sound units (levels)  
Total Level Calculation (Adding of levels)  
Factor or Ratio and Level in Decibels (dB)

The often unknown formulas for level and ratio.  
Loudness formula - pressure formula - intensity formula

Psychoacoustics –  
Level change loudness Formula loudness level  
Ratio for "loudness"  
Ratio loudness

- Field quantity –  
Level change sound pressure  
Sound pressure level ● Ratio for "sound pressure"  
Sound pressure factor

Energy or power quantity –  
Level change sound intensity  
Formel5 Ratio for "sound intensity"  
Formel6



log to the base 10 = log<sub>10</sub> is named lg and log to the base 2 = log<sub>2</sub> is named ld.

$$\Delta L = (10/\log_{10}(2)) \cdot \log(x) = 33.22 \cdot \log(x) = 10 \cdot \log_2(x) \quad x = 10(\Delta L/33.22) = 2(\Delta L/10)$$

A typical question: How many decibels more is the 3-fold subjective loudness?

Some people have problems with the idea of "twice as loud", or "three times as loud."

I confess – I am one of them. The solution of the top calculator shows 15.85 dB. Hmmm ...

The psychoacoustic values of volume (loudness) are always signal, pulse and frequency-dependent.

Therefore a statement about this perceived quantity must be viewed with a certain caution.

Kurt Tucholsky wrote: "Our own dog does not make noise, it only barks."

The work of most acoustical consultants belongs to noise control.

We speak of the volume as loudness level in phon or loudness in sone. The perception of loudness is not proportional to the sound pressure or the sound intensity. Hearing does not have the same sensitivity for all pitches.

The defined sound level is therefore not the perceived loudness of a sound. We get a rough approximation to human auditory perception by the use of an A-weighted filter, which approximates the sound signal in the different frequency areas according to the sensitivity of the hearing mechanism, but only at low levels. For louder signals than 40 dB, this A-weighted filter cuts off too many low frequencies incorrectly. The marketing department likes this!

Note: The concept of doubling or halving a loudness, is quite vague. Who really knows exactly when a sound is half as loud?

This corresponds to the impossible exact rating when is a cup of coffee half as hot? Therefore, this theoretical assumption should not be taken too seriously.

This evaluation belongs to psychoacoustics.

Aha!

Car freaks und "dB Drag Racing" fans need for their loudspeakers:

Red Power Dot The Big Power Formulas

Electrical and mechanical power calculation

Regenbogenlinie

The psycho-acoustic volume or loudness

is a subjective sensation of size.

Is 10 dB or 6 dB sound level change for a doubling or halving of the loudness (volume) correct?

About the connection between sound level and loudness, there are various theories. Widely accepted is still the theory of psycho-acoustic pioneer Stanley Smith Stevens, indicating that the doubling or halving of the sensation of loudness corresponds to a level difference of 10 dB. Recent research by Richard M. Warren, on the other hand leads to a level difference of only 6 dB. \*) This means that a double sound pressure corresponds to a double loudness. The psychologist John G. Neuhoff found that our hearing is more sensitive to rising levels of sound as to falling levels. That is for the same sound level difference the change of loudness from quiet to loud is stronger than from loud to quiet.

It is suggested that the sone scale of loudness reflects the influence of known experimental biases and hence does not represent a fundamental relation between stimulus and sensation.

\*) Richard M. Warren, "Elimination of Biases in Loudness Judgments for Tones", 1970, Journal of the Acoust. Soc. Am. Volume 48, Issue 6B, pp. 1397 - 1403 and  
Richard M. Warren, "Quantification of Loudness", 1973, American Journal of Psychology,  
Vol 86 (4), pp. 807 - 825

John G. Neuhoff, "An adaptive bias in the perception of looming auditory motion", 2001,  
Ecological Psychology 13 (2) pp. 87 - 110 and  
John G. Neuhoff, "Perceptual Bias for Rising Tones", 1998, Nature, Volume 395, 10 September

Citation: When known experimental biases were eliminated, half loudness was equal to half sound pressure level (-6 dB) from 45 to 90 dB.

It follows that the determination of the volume (loudness) which is double as loud should not be dogmatically defined. More realistic is the following claim:

A doubling of the sensed volume (loudness) is equivalent to a level change approximately between 6 dB and 10 dB.

... by the way: You cannot usefully double or multiply any "level".  
There is double voltage and double sound pressure. What is double the level?  
3 dB, 6 dB or 10 dB? Aha - therefore it's better to avoid this expression.  
"Double the level" means carelessly, that there is really double the voltage.  
The expression: "Double the level equals 3 dB" is nonsense.  
What is the doubling of 10 decibel? That is no good question.

Typical question: Is 3 decibel more level twice as loud? Answer: No! Psychoacousticians tell us, that we must feel a level boost of 6 to 10 dB as twice as loud.

Level dynamics and spectral dynamics (timbre dynamics)

Equally important as the level dynamics, is the timbre dynamics, also called spectral dynamics. The perceived volume (loudness) is almost independently characterized by amplitude level through a specific timbre spectrum range played by musical instruments as dynamic stages.

A weighting filter is used to emphasise or suppress some aspects of a phenomenon compared to others for measurement or other purposes. In the measurement of loudness, for example, an A-weighting filter is commonly used to emphasize frequencies around 3 to 6 kHz where the human ear is most sensitive, while attenuating very high and very low frequencies to which the ear is insensitive. The aim is to ensure that measured loudness corresponds well with subjectively perceived loudness. A-weighting is only really valid for relatively quiet sounds and for pure tones as it is based on the 40-phon equal-loudness contour; see the weighting filtered levels dBA and dBC.

Another difficult issue is:

How does the volume (loudness) decrease with distance from a sound source?

How does the sound pressure (voltage) decrease with distance from a sound source?

How does the sound intensity (not the sound power) decrease with distance from a sound source?

The beginners question is quite simple: How does the sound decrease with distance?

Regenbogenlinie

Adding of equal strong non-coherent sound sources

Level adding

Level increase  $\Delta L$  for

n equal loud sound sources

Number of n equal loud sound sources Level increase

$\Delta L$  in dB

1 0

2 3.0

3 4.8

4 6.0

5 7.0

6 7.8

7 8.5

8 9.0

9 9.5

10 10.0

12 10.8

16 12.0

20 13.0

Formulas:  $\Delta L = 10 \times \log n$  or  $n = 10^{(\Delta L/10)}$

$\Delta L$  = level difference; n = number of equal loud sound sources.

n = 2 equally loud incoherent sound sources result in a higher level of

$10 \times \log 2 = +3.01$  dB compared to the case that only one source is available.

n = 3 equally loud incoherent sound sources result in a higher level of

$10 \times \log 3 = +4.77$  dB compared to the case that only one source is available.

n = 4 equally loud incoherent sound sources result in a higher level of

$10 \times \log 4 = +6.02$  dB compared to the case that only one source is available.

Calculator: Adding level of equal loud sound sources

To use the calculator, simply enter a value.

The calculator works in both directions of the  $\leftrightarrow$  sign.

Number of sound sources n:

↔ Increase of level  $\Delta L$ :

dB

Formula1 Formula2

The total level in decibels is the level of one sound source plus the increase of level in dB.

The very special case of active noise cancellation (compensation) by obliterating level addition - which is labeled "Active noise control" - is not considered here.

The decrease of sound with distance

For a spherical wave we get:

The sound pressure level (SPL) decreases with doubling of distance by (-)6 dB.

The sound pressure falls to 50% or 1/2 fold of the initial value of the sound pressure.

The sound pressure decreases with the ratio  $1/r$  of the distance.

The sound intensity level decreases with doubling of distance also by (-)6 dB.

The intensity falls to 25% or 1/4 fold of the initial value of the acoustic or sound intensity.

The sound intensity decreases with the ratio  $1/r^2$  of the distance.

The loudness level decreases with doubling of distance also by (-)6 dB.

The loudness falls to 63% or ca. 2/3 fold of the initial value of the sensed loudness.

The loudness decreases with the ratio  $1/(20.66 r) = 1/1.581 r$  to the distance.

Levels of sound pressure and levels of sound intensity decrease equally with the distance from the sound source. Sound power or sound power level has nothing (!) to do with the distance from the sound source.

Thinking helps: A 100 watt light bulb has in 1 m and in 10 m distance really always the same 100 watts, which is emitted from the lamp all the time.

Watts don't change with distance.

Sound pressure and Sound power – Effect and Cause

The doubling of the "loudness impression" will require an increase of sound pressure level of about 10 dB.

Who knows exactly how loud the sensation "sounds twice as loud" is?

A measurement of the doubling of the sound pressure, however, equals exactly +6 dB.

Frequently used false statements in the context of sound values and the distance of the sound source

Correct version Wrong expression

Sound pressure (amplitude) falls inversely proportional to the distance  $1/r$  from the sound source.

That is the  $1/r$  law or the inverse distance law. Sound pressure (amplitude) falls inversely proportional to the square of the distance  $1/r^2$

from the sound source. really wrong

Sound pressure level decreases by (-)6 dB for

doubling of the distance from the source to  $1/2$  (50 %) of the sound pressure initial value. Sound pressure level decreases as the distance increases for doubling of the distance from the source by  $(-)$ 3 dB. wrong

Sound intensity (energy) falls inversely proportional to the square of the distance  $1/r^2$  from the sound source. That is the inverse square law  $1/r^2$ . Sound intensity (energy) falls inversely proportional to the distance  $1/r$  from the sound source. wrong

Sound intensity level decreases by  $(-)$ 6 dB for doubling of the distance from the source to  $1/4$  (25 %) of the sound intensity initial value. Sound intensity level decreases inversely as the square of the distance increases for doubling of the sound source by  $(-)$ 3 dB. wrong

Sound pressure is not intensity

Neither the sound power nor the sound power level decreases in doubling the distance. Why is this so?

The sound power level quantifies the totally radiated sound energy from an object.

Different to the sound pressure the sound power is independent of the distance to the sound source, the surrounding area and other influences.

How does the sound decrease with distance?

Knowing the intensity of a sound wave allows one to calculate the decibel (dB) level of that sound. Use the Decibel Calculator widget to determine the decibel rating from any intensity in watt/meter<sup>2</sup>. Enter intensities using scientific notation – for example, enter  $5e^{-5}$  for  $5.0 \times 10^{-5}$ .

WolframAlpha Decibel Calculator

Determine the perceived loudness of a sound

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Four times power $\equiv$ level	+6 dB	Ten times power $\equiv$ level	+10 dB
Double distance $\equiv$ level	-6 dB	Double sources (Double power) $\equiv$	+3 dB

Simple rule of thumb:

When working with power, 3 dB means double (twice) the factor and 10 dB means 10-fold.

When working with voltage or current, 6 dB means double (twice) the factor and 20 dB means 10-fold.