Decrease in level of sound pressure and sound intensity with distance

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1. Sound pressure p – a sound field quantity – preferred by 'sound engineers'

If a sound source radiates in a **direct field** (free field) uniformly in all directions, the sound pressure decreases inversely proportional to the distance r from the sound source. The sound pressure $p = F / A$ is given as N/m^2 = Pascal (Pa). The sound pressure p (pressure) is force F (force) through area A (area). $p \sim 1 / r$

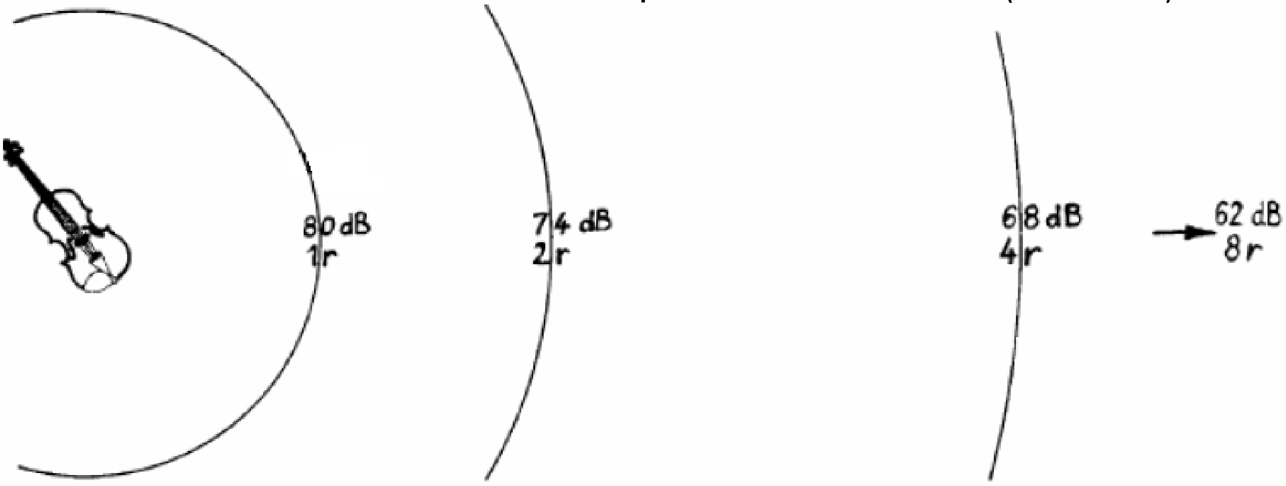
The attenuation of the **sound pressure** is following the "**1 / r law**", the distance law. For example, the sound pressure p is decreased to half the value, if the distance to the sound source is doubled.

The double distance 2 × r changes the sound pressure level compared to 1 × r:

$$\Delta L_p = 20 \times \log 1 / \mathbf{2} = 20 \times \log 0.5 = (–)\ 6\ \text{dB}$$

● **Distance law for sound pressure: $p \sim 1 / r$ $\qquad p_2 / p_1 = r_1 / r_2$**

For an assumed point source applies: Sound pressure waves propagate linearly, when their sound pressure is halved at twice the distance. The decrease of the **sound pressure** follows the **"1 / r law" (Distance law).**



2. Sound intensity I – a sound energy quantity – preferred by 'noise fighters'.

If a sound source radiates in a **direct field** (free field) uniformly in all directions, the surfaces zoom as expansion - designating spherical shells. A specific energy is distributed over the surface of each sphere socket and is spread continuously during stretch over an increasing area. The sound intensity $I = P_{ak} / A$ in W/m^2 decreases sharply with increasing distance r from the source, and while it is inversely proportional to the surface of the sphere. For any point distant from the sound source, the sound intensity is given by:

$$I = P_{ac} / A \sim 1 / r^2 \qquad \text{Sphere area } A = 4\pi \times r^2$$

Here, the sound intensity I is in W / m^2, which use acoustic power P_{ac} in W and the distance r in meters.

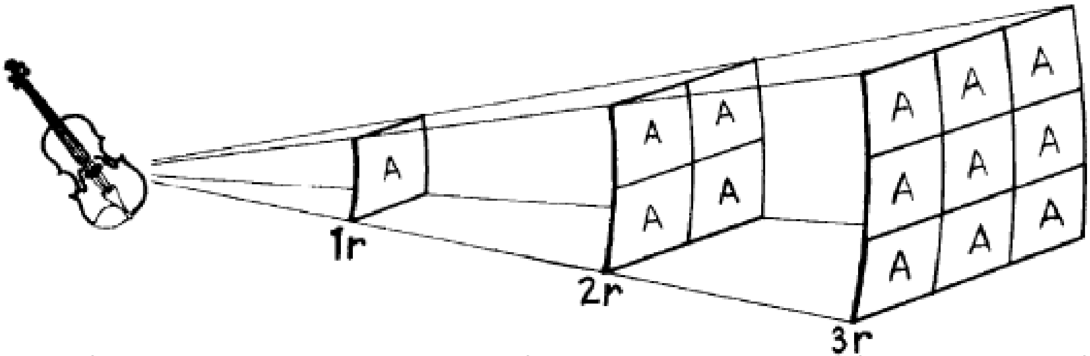
The attenuation of the **sound intensity** is following the "**1 / r^2 law**". For example, the intensity decreases to a quarter when the distance is doubled.

The double distance 2 × r changes the sound intensity level compared to 1 × r:

$$\Delta L_I = 10 \times \log (1 / 2^2) = 10 \times \log (1 / \mathbf{4}) = 10 \times \log 0.25 = (–)\ 6\ \text{dB}$$

With the change in distance and the sound level decrease the dB values for the sound pressure level and sound intensity levels are equal. The sound pressure and the intensity ratios are not equal due to the square correlation. Decrease of sound level: $\Delta L_p = \Delta L_I = 20 \times \log (r_1 / r_2) = 10 \times \log (r_1 / r_2)^2$ but $p_2 / p_1 \neq I_2 / I_1$.

● **Distance law for sound energy: $I \sim 1 / r^2$ $\qquad I_2 / I_1 = r_1^2 / r_2^2$ $\qquad$ Note: p_2 / p_1 not equal to I_2 / I_1.**



The surface area A which occupies a portion of the propagated sound wave follows the square of the distance from the sound source. The decrease in **sound intensity** (energy) follows the **"1 / r^2 law" (Inverse square law).**

Note: The sound pressure and sound intensity can not be set equal. Actually, this should be obvious, but even in textbooks, the term intensity is frequently chosen wrong when sound pressure is meant.

Never use the term intensity when strength, amplitude or level is meant, such as in "The intensity of the sound pressure is 1 Pascal". **Sound pressure is a sound field quantity and intensity is a sound energy quantity.**

How does the sound depend on the distance to the sound source? http://www.sengpielaudio.com/calculator-SoundAndDistance.htm