

Doubling the Distance Does Not Halve the Noise

— A point source falls **6.0206** dB per doubling, but the **10** dB that halves perceived loudness needs **3.1623** times the distance — a road, being a line source, falls only **3.0103** dB per doubling and needs **10.0000** times

— [Paper 456]

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— *From thinking to syncing.* —

Abstract

Moving away from a noise source makes it quieter—so it is thought. This paper shows that the distance needed to halve it differs by a factor of **3.16** with the shape of the source—**3.1623** times for a point, **10.0000** for a line. No new theorem or law is claimed. First, a point source falls **6.0206** dB per doubling of distance (Section 2). Second, a line source falls only **3.0103** dB, exactly half as much (Section 2). Third, this is the core of the paper. The **10** dB that halves perceived loudness needs **3.1623** times the distance for a point and **10.0000** for a line (Section 3). Fourth, moving a road from 100 m to 200 m buys only **3.0103** dB (Section 3). Fifth, doubling the distance, in most cases, does almost nothing (Section 3). Sixth, the separator is whether the source is a point or a line (Section 4). **Keywords:** noise, distance attenuation, inverse-square law, loudness, line source.

Scope of this paper (scope note): No new theorem or law is claimed—the inverse square law, the distance decay of point and line sources and the relation of loudness to sound pressure level are all standard. No noise control is designed—barriers, absorbers and building sound insulation are not the subject. No regulation is discussed—environmental standards and ordinances are not the subject. Atmospheric absorption and ground effect are excluded—they matter at high frequency and near the ground, but only geometric spreading is treated here. 10 dB is taken as “half as loud”—an empirical rule that varies with frequency and level. Reflection and diffraction are excluded—reflections from buildings and terrain, and diffraction round barriers, are not the subject. Relation to earlier papers: Paper 455 showed that how dry one wants it switches the limiting stage—there too, the same action had a different effect under a different condition. Paper 300 showed that common root and distinct root can be decided—“the distance decay of a point source” and “of a line source” are distinct roots by that criterion. Paper 454 showed that both sides grow with the same power—there too, the power itself was the heart of the matter. What is added is tabulating the decay of point and line sources, giving the distance for 10 dB as 3.1623 and 10.0000, showing the ratio between them to be 3.1623, giving the gain from 100 to 200 m as 3.0103 dB, and placing the separator at point versus line.

1. Notation and the Question

Setting: Sound from a point source spreads over a sphere, so its intensity falls as r^{-2} and the decay from r_1 to r_2 is

$$\Delta L_{\text{point}} = 20 \log_{10} \frac{r_2}{r_1} \text{ [dB]}$$

From an infinitely long line source such as a road or railway it spreads over a cylinder, falls as r^{-1} , and

$$\Delta L_{\text{line}} = 10 \log_{10} \frac{r_2}{r_1} \text{ [dB]}$$

Below, 10 dB is taken as the rule for halving perceived loudness.

Observation 1.1

Moving away makes it quieter—so it is thought. And that in itself is right—the decay is monotone.

Observation 1.2

But how far is enough acts through a logarithm. Doubling the distance does not halve the loudness—and the distance required changes with the shape of the source.

Question: How far must one go to halve it.

2. 6.0206 dB per Doubling, or 3.0103

Computation 2.1: Take the decay per doubling for the two sources.

Source	Decay per doubling [dB]
Point (spherical spreading)	6.0206
Line (cylindrical spreading)	3.0103

Observation 2.2

The 6.0206 dB agrees with the known “6 dB per doubling”.An independent check—it is only $20 \log_{10} 2$, but it lands on the known value.

Observation 2.3

The line source is exactly half. $3.0103 \times 2 = 6.0206$ —changing the spreading surface from a sphere to a cylinder halves the decay.

Observation 2.4

This is about intensity, not about loudness.6 dB means a quarter of the intensity—but what a person hears is not a quarter as loud.

3. Halving Needs 3.1623 Times, or 10.0000

Computation 3.1: Take the distance ratio needed for 10 dB.

Source	Distance ratio for 10 dB
Point	3.1623
Line	10.0000

Observation 3.2

Even a point source needs **3.16** times the distance. Doubling gives only 6.0206 dB—10 m becomes 32, 100 m becomes 316.

Observation 3.3

A line source needs ten times **3.1623** times as far as the point source—to buy the same effect one must go **3.16** times further out.

Observation 3.4

Check it in reverse. Feeding **3.1623** into the point formula gives 10.000000000 dB and 10.0000 into the line formula gives 10.0000—both return to 10.

Observation 3.5

Moving a road 100 m away to 200 m buys **3.0103** dB. For the land it takes to double the distance—only three tenths of the 10 dB.

Observation 3.6

So solving noise by distance alone rarely pays. Ten times the land is required—which is the arithmetic behind barriers and treatment at the receiving building.

4. The Separator

The separator: is the source a point or a line.

Observation 4.1

A point spreads over a sphere. Area grows as r^2 —giving a $20 \log_{10}$ decay.

Observation 4.2

A line spreads over a cylinder. Area grows only as r —giving only a $10 \log_{10}$ decay.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “distance decay”—one a squared dilution, one a linear one.

Observation 4.4

This stands where Paper 454 stands. There, the heart of it was that load grows as the square and moment as the cube—here it is whether dilution goes as the square or the first power. In both, the power itself is the question.

Observation 4.5

It overlaps Paper 455 as well. There, the effect of the same action changed with the target—here the same “double the distance” has twice the effect depending on the shape of the source.

Observation 4.6

And a source changes type with distance. Very near a road, individual vehicles look like point sources; further out, the road is a line—the same object belongs to a different type depending on where one stands.

Observation 4.7

To be honest—only geometric spreading has been treated. Atmospheric absorption, ground effect, reflection and diffraction are all excluded—in practice they add on, and mostly in the direction that strengthens “doubling is not enough”.

5. Roll Call and Closing

1. **Point: 6.0206 dB per doubling** (Computation 2.1): **matches the known 6 dB.**
2. **Line: 3.0103 dB** (Computation 2.1): **exactly half.**
3. **Intensity, not loudness** (Observation 2.4): **it acts through a logarithm.**
4. **10 dB needs 3.1623 for a point** (Computation 3.1): **the core.**
5. **And 10.0000 for a line** (Computation 3.1): **3.1623 times further.**
6. **The inverse returns 10** (Observation 3.4): **checked both ways.**
7. **100 to 200 m gives 3.0103 dB** (Observation 3.5): **three tenths of 10.**
8. **Distance alone rarely pays** (Observation 3.6): **ten times the land.**
9. **The separator is point or line** (Observation 4.3): **distinct roots by Paper 300.**
10. **Type changes with distance** (Observation 4.6): **point near, line far.**

Closing: Moving away from a noise source makes it quieter—so it is thought—and that in itself is right, since the decay is monotone. But how far is enough acts through a logarithm: doubling the distance does not halve the loudness, and the distance required changes with the shape of the source. The effect of doubling differs twofold with that shape—a point source falls **6.0206 dB** and a line source **3.0103**, exactly half. The 6.0206 agrees with the known “6 dB per doubling”, which makes it an independent check. Changing the spreading surface from a sphere to a cylinder halves the decay—and this is about intensity, not loudness. 6 dB means a quarter of the intensity, but what a person hears is not a quarter as loud. Halving means going much further out—the 10 dB that halves perceived loudness needs **3.1623** times the distance for a point and **10.0000** for a line. Even a point source takes 10 m out to 32, or 100 m out to 316. A line source needs **3.1623** times as far again, so buying the same effect means going 3.16 times further out. Checked in reverse, 3.1623 in the point formula gives 10.000000000 dB and 10.0000 in the line formula gives 10.0000: both return to 10. Moving a road 100 m away to 200 m buys only **3.0103 dB**—for the land it takes to double the distance, three tenths of the 10 dB. So solving noise by distance alone rarely pays: ten times the land is required, and that is the arithmetic behind barriers and treatment at the receiving building. One thing separates them—is the source a point or a line. A point spreads over a sphere, area grows as r^2 , and the decay is $20 \log_{10}$. A line spreads over a cylinder, area grows only as r , and the decay is only $10 \log_{10}$. They are distinct roots by the criterion of Paper 300, one a squared dilution and one a linear one. This stands where Paper 454 stands, where the heart of it was that load grows as the square and moment as the cube: in both, the power itself is the question. It overlaps Paper 455 too, where the effect of the same action changed with the target: here the same “double the distance” has twice the effect depending on the shape of the source. And a source changes type with distance—very near a road individual vehicles look like point sources, while further out the road is a line. The same object belongs to a different type depending on where one stands. To be honest—only geometric spreading has been

treated, with atmospheric absorption, ground effect, reflection and diffraction all excluded. In practice they add on, and mostly in the direction that strengthens “doubling is not enough”.

References

- 1. Rayleigh, J. W. S. (1877). *The Theory of Sound*. Macmillan.
- 2. Stevens, S. S. (1936). A Scale for the Measurement of a Psychological Magnitude: Loudness. *Psychological Review*.
- 3. Beranek, L. L., & Vér, I. L. (Eds.) (1992). *Noise and Vibration Control Engineering*. Wiley.
- 4. Yamagishi, Y. (2026). *The Three Hundredth Census: Whether Two Things Share a Root Is Decidable* [Paper 300]. Zenodo. 10.5281/zenodo.22171914
- 5. Yamagishi, Y. (2026). *The Water Load Grows as the Square, and the Dam Only as the First Power* [Paper 454]. Zenodo. 10.5281/zenodo.22732989
- 6. Yamagishi, Y. (2026). *How Dry You Want It Decides Which Stage Is Rate-Limiting* [Paper 455]. Zenodo. 10.5281/zenodo.22733024

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