Adding sound levels in decibels

FizziQ activity · Middle and high school · 30 min

Scan to open in FizziQ

Using three smartphones and the FizziQ sound meter, students measure the level of two 60 dB white-noise sources played together and find a 3 dB rise, not a doubling.

Learning objectives

- Measure and compare the sound level of one source versus two identical sources playing simultaneously
- Discover that combining two identical sound sources produces an increase of approximately 3 dB, not a doubling
- Understand the logarithmic nature of the decibel scale
- Investigate whether the type of sound (pure tone vs. white noise) affects the result
- Apply the formula $L = 10 \times \log(I/I_0)$ to predict the combined sound level

Instruments and sensors

Sound level meter (dB) · Synthesizer (white noise and pure tone generator) · Microphone

Materials

- Three smartphones with the FizziQ app installed (one set up as sound level meter, the other two as sound emitters)
- A quiet space with minimal echo
- A tape measure to fix and check distances between the phones
- Note: the protocol remains adaptable to any comparable sound level measurement tool.

Protocol

1. Open FizziQ on three smartphones. Designate one as the measuring device and the other two as emitters.
2. On the measuring smartphone, open the Sound Level (dB) sensor and verify it reads the ambient noise level (ideally below 40 dB).
3. On emitter smartphone 1, use the FizziQ synthesizer to produce white noise at a moderate volume. Adjust until the measuring phone reads approximately 60 dB at a distance of 30 cm.
4. On emitter smartphone 2, produce the same white noise at the same volume. Individually verify that it also reads approximately 60 dB at 30 cm.
5. Place both emitter smartphones equidistant from the measuring phone (about 30 cm), side by side.
6. First, record the sound level with only emitter 1 playing for 10 seconds. Note the average value.
7. Stop emitter 1. Record with only emitter 2 playing for 10 seconds. Note the average value.
8. Now play both emitters simultaneously for 10 seconds. Record the combined sound level.
9. Compare the three measurements. The combined level should be approximately 3 dB higher than each individual source.
10. Repeat the experiment using a pure 440 Hz tone instead of white noise on both emitters. Note any differences in the result.
11. Try a third trial with different frequencies on each emitter (e.g., 440 Hz and 880 Hz) and compare the results.
12. Record all data in your FizziQ notebook and calculate the theoretical prediction using $L_{total} = L_1 + 10 \times \log(2) \approx L_1 + 3$ dB.

Expected results

When each source individually produces about 60 dB and both play simultaneously, the combined level should measure approximately 63 dB (±1-2 dB), confirming the 3 dB rule for adding uncorrelated noise sources. White noise sources should follow this rule reliably because they are uncorrelated. For pure tones of the same frequency, results may vary depending on the phase relationship: if the waves happen to be in phase, the increase could reach up to 6 dB; if partially out of phase, the increase may be less than 3 dB. For pure tones of different frequencies (440 Hz and 880 Hz), the 3 dB rule should hold well since the signals are uncorrelated. Measurement precision is typically ±1-2 dB due to environmental noise and smartphone microphone calibration differences.

Questions

- Why does doubling the number of sound sources increase the level by only 3 dB instead of doubling it?
- What is the physical meaning of the logarithmic scale in the context of human hearing?
- Why might two pure tones of the same frequency produce a different result than two white noise sources?
- If you combined 10 identical sound sources, what would the expected increase in decibels be?
- How does this principle apply to real-world situations like traffic noise or a crowd cheering?
- What is the relationship between sound intensity (in watts per square meter) and sound level (in decibels)?

Going further

- Investigate the effect of distance: repeat the experiment with the sources at different distances from the microphone
- Gradually add more sources (using additional smartphones) and plot the sound level versus the number of sources
- Compare the addition rule for pure tones of the same frequency with tones of different frequencies
- Explore the effect of phase by trying to synchronize two pure tone sources and observing constructive or destructive interference
- Calculate and verify the theoretical prediction for combining three or four sources simultaneously