Sound level and distance

FizziQ activity · High school · 35 min

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Two smartphones run FizziQ: one emits white noise while the other measures decibels at increasing distances, letting students test the inverse square law for sound.

Learning objectives

- Measure sound level at multiple distances from a source and record the data systematically
- Verify the inverse square law for sound propagation: doubling the distance reduces the level by approximately 6 dB
- Understand the logarithmic nature of the decibel scale and its relationship to perceived loudness
- Evaluate the hearing risks associated with proximity to loud sound sources
- Apply the formula $L = L_0 - 20 \times \log(d/d_0)$ to predict sound levels at various distances

Instruments and sensors

Sound level meter (dB) · Microphone

Materials

- Two smartphones with the FizziQ application
- A quiet space for measurements
- A tape measure to precisely measure distances
- FizziQ experiment notebook
- Note: the protocol remains adaptable to any comparable sound level measurement tool.

Protocol

1. Set up the experiment in a quiet, open space with minimal reflections (outdoors is ideal; indoors, choose a large room away from walls).
2. On the first smartphone, open FizziQ and use the Sound Library or Synthesizer to emit white noise at a constant, moderate volume.
3. Place the emitting smartphone on a stable surface at a fixed position. This is your sound source.
4. On the second smartphone, open FizziQ and select the Sound Level (dB) sensor.
5. Measure and mark distances of 0.25 m, 0.50 m, 1.0 m, 1.5 m, 2.0 m, 3.0 m, and 4.0 m from the source using the tape measure.
6. Place the measuring smartphone at 0.25 m from the source. Record the sound level for at least 10 seconds and note the average value.
7. Repeat the measurement at each marked distance, always waiting for the reading to stabilize and recording for at least 10 seconds.
8. Enter all data pairs (distance, sound level) into your FizziQ notebook.
9. Plot the graph of sound level (dB) versus distance (m). The curve should decrease steeply at first, then more gradually.
10. Now plot sound level versus log(distance). This graph should be approximately linear with a slope close to -20 dB per decade (a factor of 10 in distance).
11. Verify the 6 dB rule: compare the sound level at 1 m and 2 m. The difference should be approximately 6 dB.
12. Using your measurements, calculate the minimum safe distance from a speaker producing 110 dB to

stay below the 85 dB safety threshold.

Expected results

Students should observe a clear decrease in sound level with increasing distance. For an ideal point source, each doubling of distance should produce a drop of approximately 6 dB. In practice, reflections from walls, floor, and ceiling will reduce this drop slightly (typically 4-5 dB per doubling indoors versus the theoretical 6 dB). The plot of sound level versus log(distance) should be approximately linear. At very short distances (under 25 cm), near-field effects may cause deviations from the inverse square law. Background noise will set a lower limit on measurable sound levels, typically around 35-45 dB indoors. The calculated safe distance from a 110 dB source to reach 85 dB should be approximately 5-6 meters in theory, though indoor conditions may alter this value.

Questions

- Why does the inverse square law predict a 6 dB decrease for each doubling of distance?
- In what conditions might the measured decrease be less than 6 dB per doubling? More than 6 dB?
- How long can a person safely be exposed to 85 dB? To 100 dB? To 110 dB?
- Why is white noise used instead of a pure tone for this experiment?
- How do concert venues manage sound levels to protect audience hearing while maintaining the experience?
- What is the difference between sound intensity (W/m^2) and sound level (dB)?

Going further

- Compare indoor and outdoor measurements to evaluate the effect of room reflections on the inverse square law
- Use a pure tone instead of white noise and investigate whether frequency affects the distance-level relationship
- Measure the sound level at various positions around the source to check whether it radiates omnidirectionally
- Calculate the total acoustic power output of the smartphone speaker from the measured illuminance at a known distance
- Investigate how different materials (curtains, cushions, hard walls) affect sound propagation and reflection