White noise: spectral content

FizziQ activity · Middle school · 25 min

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Students listen to white noise, then analyse it with FizziQ's smartphone spectrum analyzer: a flat FFT spectrum shows equal intensity at every audible frequency.

Learning objectives

- Listen to and characterize white noise through sensory observation before scientific analysis
- Use spectral analysis to verify that white noise contains all frequencies at approximately equal intensity
- Compare the spectrum of white noise with that of a pure tone and everyday sounds
- Understand the concept of power spectral density and its constancy for white noise
- Connect the analogy between white noise (acoustics) and white light (optics)

Instruments and sensors

Sound spectrum analyzer (FFT) · Sound synthesizer · Microphone

Materials

- Smartphone or tablet with the FizziQ app installed
- A quiet environment
- Optionally headphones for better listening
- Note: the protocol remains adaptable to any comparable spectral analysis tool.

Protocol

1. Open the app and load white noise from the Sound Library. Before any analysis, simply listen to it for 10 seconds.
2. Write down your sensory impression: does it sound high-pitched, low-pitched, or neither? Does it seem to contain recognizable frequencies?
3. Formulate a hypothesis: what do you think the frequency spectrum of white noise looks like?
4. Now open the Spectrum Analyzer and play the white noise recording. Observe the spectrum.
5. Note that the spectrum shows approximately equal amplitude across all frequencies from low to high. This confirms the defining property of white noise.
6. For comparison, generate a pure 440 Hz tone with the sound synthesizer and observe its spectrum: a single sharp peak at 440 Hz.
7. Compare the two spectra side by side. White noise is flat; the pure tone is a single spike.
8. Take three separate spectrum measurements of the white noise and compare them. The overall shape (flat) should be consistent, but the fine details will differ because white noise is random.
9. Measure the amplitude at several specific frequencies (100 Hz, 500 Hz, 1000 Hz, 5000 Hz, 10000 Hz). They should all be approximately equal.
10. Record and analyze a real-world sound that resembles white noise (running water, fan, wind). Compare its spectrum with true white noise.
11. Discuss: why is white noise useful as a test signal in acoustics? Why is it called 'white'?
12. Research pink noise (1/f spectrum) and discuss how it differs from white noise both mathematically and perceptually.

Expected results

The white noise spectrum should appear approximately flat across the entire audible range (20 Hz - 20 kHz), with random fluctuations of ±3-6 dB around the mean level. This contrasts sharply with a pure tone, which shows a single peak 30-50 dB above the noise floor. Multiple spectrum measurements of the same white noise should show the same overall flat shape but with different fine-grained details, reflecting the random nature of the signal. Real-world sounds like running water or fans will show spectra that are approximately but not perfectly flat, often with more energy at low frequencies (closer to pink noise). Students should recognize that despite sounding uniform to the ear, white noise contains a rich and precisely defined frequency structure.

Questions

- Why is white noise called 'white'? What is the analogy with white light?
- Why does white noise sound the same at every moment, even though it is random?
- What is the difference between white noise and pink noise? Which sounds more natural?
- Why is white noise useful for testing audio equipment and acoustic measurements?
- Why does running water sound similar to white noise? What physical process creates the sound?
- If you filtered out all frequencies above 1000 Hz from white noise, what would it sound like?

Going further

- Compare the spectra of white noise, pink noise, and brown noise to understand the different spectral slopes
- Filter white noise using your hands cupped around the phone speaker and observe how the spectrum changes
- Investigate whether the volume of white noise affects its spectral shape
- Record environmental sounds (rain, traffic, crowd) and determine which most closely resembles white noise
- Generate white noise and a pure tone simultaneously and observe how the tone appears in the combined spectrum