Tuning forks: pitch of A

FizziQ activity · Middle school · 30 min

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Three historical tuning fork recordings analyzed with the FizziQ frequency meter, spectrum and oscillogram trace how the pitch of A became 440 Hz. Middle school.

Learning objectives

- Measure the frequencies of three historical tuning forks using multiple analysis methods
- Compare the measured frequencies and calculate the intervals between them
- Use at least two independent methods (oscillogram, frequency meter, spectrum) to verify each frequency
- Understand the historical evolution of pitch standardization in Western music
- Develop precision measurement skills by cross-validating with multiple techniques

Instruments and sensors

Frequency meter · Sound spectrum analyzer · Oscillogram (waveform) · Microphone

Materials

- Smartphone or tablet with the FizziQ app for sound frequency analysis
- Recordings of the three tuning forks available in the sound library
- Headphones (optional) for better listening quality
- Note: the protocol remains adaptable to any comparable spectral analysis tool.

Protocol

1. Open FizziQ and load the 'Mozart tuning fork' recording from the Sound Library.
2. Use the Frequency Meter to measure the fundamental frequency. Record this value.
3. Switch to the Spectrum Analyzer and identify the fundamental peak. Record its frequency. Compare with the frequency meter reading.
4. Switch to the Oscillogram (waveform) view. Measure the period T of one complete cycle. Calculate the frequency: f = 1/T. Compare with the previous measurements.
5. Create a table with three rows (Mozart, Philharmonic, A3=440 Hz) and three columns (frequency meter, spectrum, oscillogram).
6. Load the 'Philharmonic Pitch' recording and repeat all three measurements.
7. Load the 'A3' (440 Hz standard) recording and repeat all three measurements.
8. Calculate the frequency differences between the three tuning forks in Hz and as a percentage.
9. Calculate how many semitones apart the Mozart and Philharmonic pitches are from the modern 440 Hz standard (use: $n = 12 \times \log_2(f/440)$).
10. Listen to the three recordings in sequence. Can you perceive the pitch differences?
11. Discuss: why did the reference pitch change over time? What factors drove it higher?
12. Research the current debate about A = 432 Hz (Verdi tuning) versus A = 440 Hz and discuss the arguments.

Expected results

The three tuning fork recordings should yield approximately: Mozart ≈ 421-422 Hz, Philharmonic ≈ 452 Hz, and modern A3 = 440 Hz. The frequency meter and spectrum analyzer should agree within ±1 Hz. The oscillogram method is less precise (±2-5 Hz) because it depends on accurately measuring the period of a single cycle. The

Mozart pitch is about 73 cents (approximately three-quarters of a semitone) below 440 Hz, while the Philharmonic pitch is about 47 cents above 440 Hz. The total range spans about 30 Hz (from 422 to 452 Hz), which is more than a full semitone.

Questions

- Why did orchestral pitch rise during the 19th century? What acoustic advantage does higher pitch provide?
- Why did singers object to the rising pitch?
- How does a tuning fork produce a pure tone, and why is it ideal as a frequency reference?
- What is the significance of the number 440 Hz? Could a different frequency have been chosen?
- How does the A = 432 Hz (Verdi tuning) differ perceptually from A = 440 Hz?
- Why do the three measurement methods (frequency meter, spectrum, oscillogram) sometimes give slightly different results?

Going further

- Compare the three tuning fork frequencies with notes on a well-tuned piano to hear the pitch differences in context
- Research and compare tuning standards from other musical traditions (e.g., Indian classical music, Baroque pitch)
- Analyze the decay time of each tuning fork recording and compare their sustain characteristics
- Create a timeline of pitch standards from 1600 to present and plot the trend
- Investigate the physics of a tuning fork: why does it produce such a pure tone?