Faraday standing waves

FizziQ activity · High school · 30 min

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A water tray on a speaker driven by the FizziQ smartphone frequency generator produces Faraday waves; students sweep 20-200 Hz and study resonant patterns.

Learning objectives

- Create standing waves on the surface of a liquid using a loudspeaker
- Identify the resonant frequencies of a vibrating system
- Observe and photograph the geometric patterns formed at different frequencies
- Measure the wavelength and relate it to the driving frequency
- Understand parametric resonance and subharmonic response

Instruments and sensors

Frequency generator (synthesizer)

Materials

- Smartphone or tablet with FizziQ
- A powerful loudspeaker (portable speaker or desktop speaker)
- A shallow tray or plate
- Water and food coloring
- Optional: cornstarch for non-Newtonian fluid
- Note: the protocol remains adaptable to any comparable frequency generation tool.

Protocol

1. Place a powerful loudspeaker flat, membrane facing up. A bass speaker or a round desktop speaker works well.
2. Place a small shallow tray (plate, plastic lid, small pie tin) on the speaker membrane. It should sit stably.
3. Fill the tray with a thin layer of water (3 to 5 mm). Add a few drops of food coloring or milk to make the waves visible.
4. Open FizziQ and use the frequency generator (synthesizer) to produce a sinusoidal sound. Connect the smartphone to the speaker via Bluetooth or cable.
5. Start with a low frequency (about 20 Hz) and moderate volume. Gradually increase the volume until you see the surface begin to vibrate.
6. Slowly sweep the frequencies from 20 Hz to 200 Hz. Observe the different patterns that appear at certain resonant frequencies.
7. At each resonant frequency, the waves form a regular geometric pattern: concentric circles, square grid, hexagons, or radial star shapes.
8. Note the frequencies at which patterns appear. Measure the wavelength λ (distance between two nodes or two antinodes).
9. Spectacular variant: replace the water with a cornstarch-water mixture (non-Newtonian fluid). At certain frequencies, the surface forms finger-like protrusions that dance on the speaker.
10. Present your observations and best photos in your FizziQ experiment notebook.

Expected results

The water surface remains flat below a vibration amplitude threshold. Above the threshold, standing waves appear abruptly (bifurcation). The patterns become more complex and finer at higher frequencies. Typical resonant frequencies range from 30 to 150 Hz depending on the tray size and water depth. The wavelength decreases as the frequency increases, consistent with the dispersion relation.

Questions

- Why do Faraday waves vibrate at half the excitation frequency?
- How does the container geometry influence the patterns that form?
- Why is there a minimum amplitude threshold for waves to appear?
- What is the relationship between the observed wavelength and the vibration frequency?
- How do these patterns compare with Chladni figures on a solid plate?
- Why does a non-Newtonian fluid behave so differently from water?

Going further

- Compare the patterns obtained with containers of different shapes (round, square, triangular)
- Vary the liquid depth and observe the effect on wavelength and pattern geometry
- Try different liquids (oil, soap solution, glycerin) and compare the patterns
- Photograph the patterns and classify them by frequency and symmetry type
- Use strobe lighting to freeze the wave motion and observe the patterns more clearly