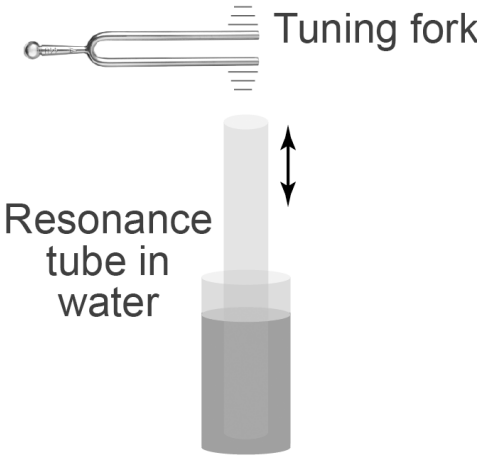
Investigation 16D: Resonance and sound

Essential question: How do we create specific frequencies of sound, such as in music?

A guitar string vibrates at its natural frequencies. Other objects, such as wine glasses and tuning forks, also vibrate at their natural frequencies. The frequencies are controlled by properties such as size, mass, and string tension.

Part 1(a): Measuring the natural frequency

1. Open the **16D_ResonanceAndSound** experiment file in your software.
2. Strike a tuning fork with a rubber mallet and hold it next to the microphone. Using the FFT in your software, confirm that its natural frequency matches the marked value.
3. Strike the tuning fork again and hold it over the resonance tube, partially immersed in water.
4. Raise and lower the tube until you hear the loudest amplification of the tuning fork note. Measure and record the frequency of the tuning fork and height of the tube above the waterline in Table 1. Repeat for two other tuning forks.



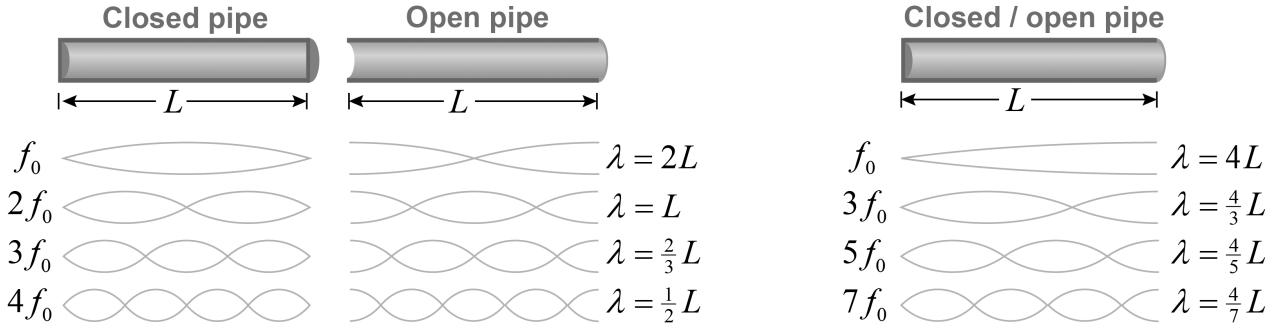


Table 1: Frequency and length data

frequency (Hz)	height, *h* (m)	wavelength (m)	$f \times \lambda$ (m/s)

Questions

a. Why did the tube resonate at a particular position? What characteristics of a resonance tube determine its natural frequency? Refer to the figure of resonant modes in pipes on the previous page in your answer.

b. Calculate the wavelength and then the product of wavelength and frequency for each tuning fork you tested and record the data in Table 1 above.

c. Does the product of wavelength and frequency vary between tuning forks? Why or why not?

Part 1(b): Measuring the natural frequency

5. Firmly hold the stem of the wine glass while running a wet finger lightly around its rim. The glass should ring in a clear tone. Measure and record the glass dimensions and frequency in Table 2.
6. Add water to the glass in small increments and repeat the measurements.

Table 2: Resonant frequency data for wine glasses

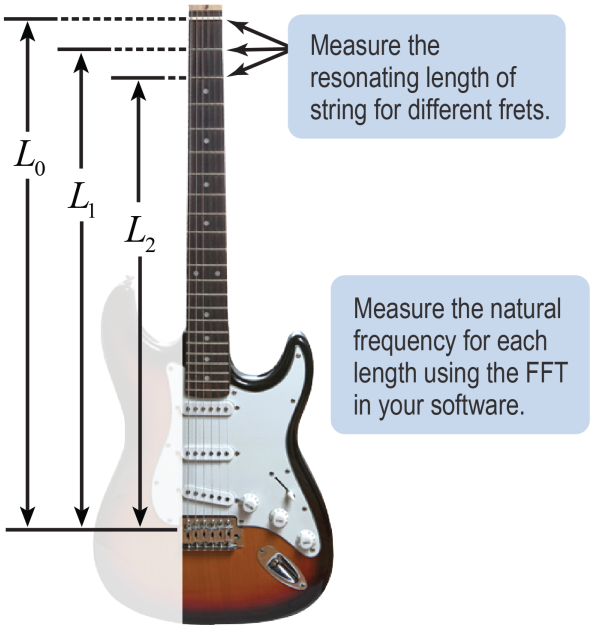
major diameter (cm)	height of bowl (cm)	water depth (cm)	Measured resonant frequency (Hz)

Questions

d. Discuss with your group and propose a hypothesis that explains the variation in resonant frequency with the height of water in the wine glass. How is your hypothesis supported by your observations?

Part 2: Controlling the natural frequency through resonance

1. Measure the length of string for your instrument at each of its different frets, or fingerboard positions.
2. Use the FFT in your software to determine the natural frequency for each different string length.
3. Repeat the procedure for at least two additional strings. Record data in Table 3.



Questions

a. Graph frequency vs. length of a single string. Explain why the graph has the shape that it does.

b. On the same graph, plot frequency vs. length for a different string. Explain the difference between the two curves using Newton's laws.

c. Explain how resonance controls which frequencies persist in a vibrating system.

Table 3: Guitar string length and frequency data for two different strings

length, L (m)						
frequency, f (Hz)						

length, L (m)						
frequency, f (Hz)