Speed of Sound Waves in Air

Apparatus

resonance tube about 50 cm long
large glass cylinder
meter stick
2 tuning forks (256 hertz or above),
rubber hammer for tuning fork

The Investigation

The speed of all waves is given by the relationship,

$$v = f\lambda$$

where v is the speed of the wave in the medium, f is the frequency of the wave, and λ is the wavelength of the wave. The frequency of a wave is necessarily the same as the frequency of the vibration generating the wave. Sound waves created by a tuning fork vibrating at 256 vibrations per second are said to have a frequency of 256 hertz (cycles per second). *During this investigation you will measure the wavelength of sound waves of a known frequency and then calculate the speed of the sound waves in air.* You are going to use the principle of resonance to determine the wavelength of sound waves. You first used the principle of resonance when, as a child, you discovered how to pump or push a swing effectively. A swing is a pendulum and it has a natural frequency. Only when you push a swing at the proper frequency will the energy content of the swing build up and become increasingly large. The best frequency with which to push is that frequency which is the same as the swing's natural frequency of vibration. If a vibrating tuning fork having the same natural frequency as an air column is held above the air column, the vibrating fork will push the air column at just the right frequency to start the air column vibrating. This is called *sympathetic vibration.* The vibration of the air column will increase in amplitude with each vibration of the fork (just as the amplitude of a swing increases with each push). The

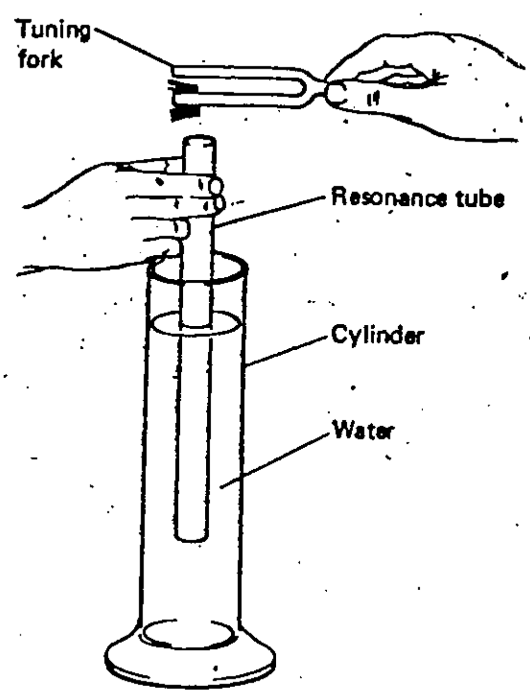

Figure 29-1. Hold the tuning fork so that the vibrations are directed into the tube (one prong directly above the tube). Adjust the tube length until the loudest sound is heard.

sound waves from the vibrating column of air will become much louder than the sound from the tuning fork. Thus. sound waves from the tuning fork are reinforced by sound waves from the air column. For a tube closed at one end. resonance occurs when the length of the tube is approximately one-fourth the length of the sound waves being reinforced.

Procedure

1. Add water to the glass cylinder until it is three fourths full. Hold the resonance tube vertically in the cylinder with one of its ends in the water. The water will seal one end of the tube. By raising and lowering the tube you can vary the length of the air column in the tube.
2. Strike the tuning fork with the rubber hammer. Hold the vibrating tuning fork horizontally as close to the open end of the tube as you can. Move the tube and fork up and down until the sound is *best* reinforced. You may find more than one position where reinforcement occurs so try moving the tube up and down several times to find the position that gives the loudest sound.
3. Hold the tube in the position of best sound reinforcement. Have your partner measure the distance from the top of the resonance tube to the water in centimeters. Record the length in Table 29–1.
4. The length of the air column must be increased by four-tenths of the diameter of the tube ($0.4d$) to correct for the small amount of air just outside the top of the tube that vibrates with the air column in the tube. Measure the diameter of the tube in centimeters and find four-tenths of this. Add this to the length (l) of the tube to get the corrected length (L) according to the equation:

$$L = l + 0.4\,d$$

Enter the corrected length in centimeters in Table 29–1. Enter the frequency of the tuning fork in the table. Complete the table. Note that in Table 29–1 L is expressed in centimeters but $4L$ is expressed in meters.

Data and Observations:

Table 29–1. Speed of Sound in Air

Frequency (f) (Hz)	Measured length of air column (cm)	Corrected length of air column $L = (l + 0.4d)$ (cm)	Wavelength $\lambda = 4L$ (m)	Speed (v) (m/sec)

POSTLAB QUESTIONS:

1. The speed of sound in air can also be expressed as 331 m/sec at 0°C. It increases 0.6 m/sec for each Celsius degree above zero. Determine the temperature of the room. Calculate the speed of sound in m/sec. Circle final answer.

2. Calculate your percentage error using the value determined in Question # 1, for each tuning fork.

3. A hiker determines the length of a lake by listening for the echo of her shout reflected by a cliff at the far end of the lake. She hears the echo about 1.0 sec. after shouting. How long is the lake? Temperature was at 15°C.

4. An observer sees lightning flash from a distant thunderstorm and 12 seconds later hears the sound. If the temperature of the air is 20 C how far from the storm is the observer? (Assume that light travels instantaneously.)

Name: ______________________________

Date Due: __________ Mod __________

_____ 5 Technique

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_____ 10 Postlab

_____ 20 Total