(S1-1) Speed of Sound Using Closed Columns

Aim of experiment

Determination of the speed of sound in air by using a tube closed at one end.

Apparatus

Cylindrical Glass Container Filled With Water- Open Sides Sliding Metal Cylindrical Tube- Tuning Forks of Different Frequencies- Meter Ruler.

Theory of experiment

Waves transmit energy from one point to another without the transfer of matter. There are two types of waves:

1. Mechanical waves, which require an elastic medium to transfer energy

2. Electromagnetic waves, which can transfer energy through a vacuum.

The wave type depends on the di-rection in which the particles of the disturbed medium move relative to the direction of wave propagation. Therefore waves can also be classified as either transverse waves or longitudinal waves.

1. *Transverse wave*, in which the particles of the disturbed medium move perpendicular to the direction of the wave prop-agation.
2. *Longitudinal wave*, in which the particles of the disturbed medium move parallel to the direction of the wave propagation.

The Nature of Sound Waves

Sound waves are longitudinal waves traveling through an elastic medium. The source of sound waves is a vibrating object such as a loudspeaker or a tuning fork. The air (or any other elastic medium) in the path of the sound wave becomes alternately denser and rarer. When the molecules are forced closer together than normal, the region of higher density is called a *compression,* whereas the region of lower density is called *a rarefaction*.

Resonance in a Closed-End Tube

If a vibrating tuning fork is held over the open end of a tube that has one end closed, air waves will be sent down the column of air in the tube. These waves will be reflected with a 180^o phase change when they strike the water sur-face at the closed end of the tube. The reflected waves will then travel back up the tube. The waves sent out by the tun-ing fork and the reflected waves will superimpose on each other and form complex patterns called *standing waves.* If the length of the air column in the tube is such that the reflected waves arrive at the tuning fork so that they are in phase with the waves sent out by the tuning fork, the two waves will constructively interfere with each other.

Since the two waves reinforce each other, a louder sound will then be produced. This phenomenon is called resonance.

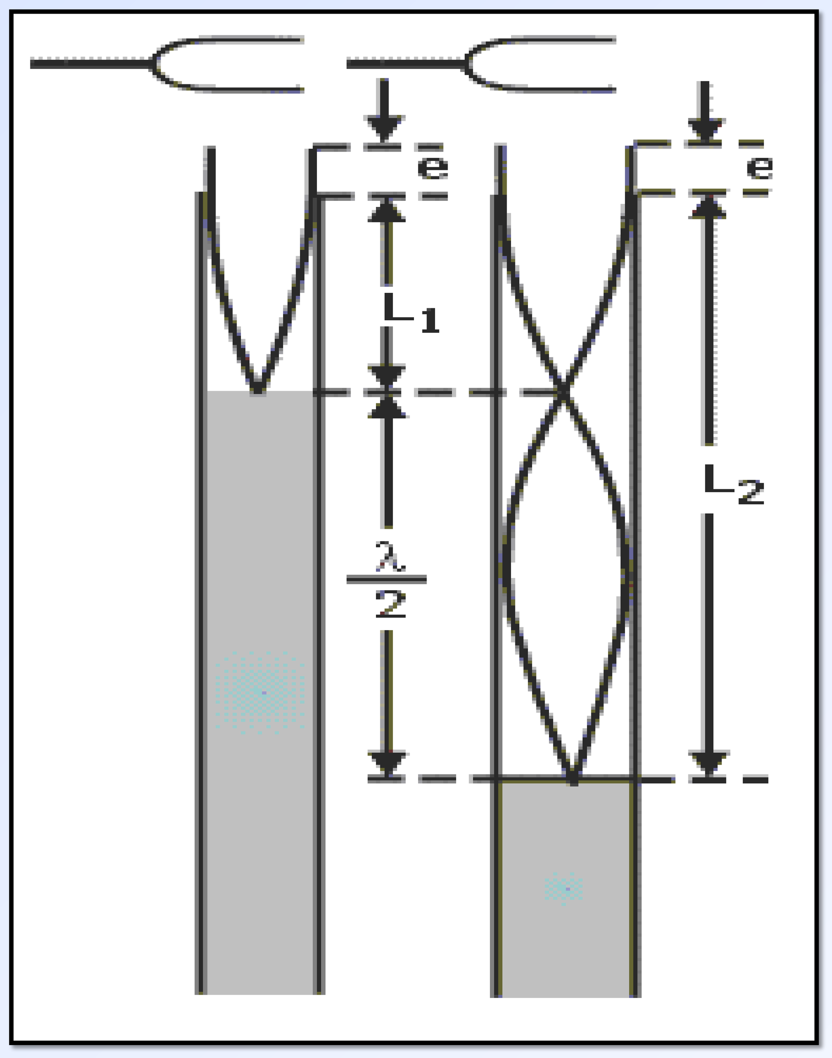

Figure 1. Different modes of resonance in closed end tube

Resonance will occur when the standing wave pattern in the vibrating air column has an antinode (*maximum amplitude*) at the open end of the tube and a node (*minimum amplitude*) at the closed end of the tube see *figure 1.* The length of the vibrating air column is the length between the top (open) end of the resonance tube and its closed end (water level).

As can be seen in *figure 1*, the first resonance position has the smallest air column length L_1 and corresponds to a standing wave pattern of one quarter of a wavelength. From *figure 1*, we see that

$$L = \lambda / 4$$

Thus, the wavelength of the sound wave is equal to

$$\lambda = 4\,L$$

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Procedure

1. Record the marked frequency f of the tuning fork on your data sheet.
2. Gently strike the end of the tuning fork and hold it above the open end of the resonance tube.
3. Slowly vary the tube length and listen for resonance to occur. At this point, the sound will be quite loud, even though the sound of the tuning fork itself is barely audible. Determine the resonance position by reading the position of the top of the water to the top of resonance tube.
4. Convert this reading to meters and calculate the corresponding wave length, λ_1, and record on your data sheet.
5. Perform two additional trials to determine this position. Record these two additional readings in meters and find the average of all three readings.
6. Repeat steps 1 to 5 using different tuning forks.
7. Plot a graph between $1/f$ on x-axis and λ_{av} on y-axis.
8. Calculate the slope.
9. Determine the speed of sound in air.

Results

f (Hz)	$1/f$ (s)	λ_1 (m)	λ_2 (m)	λ_3 (m)	$\lambda_{av} \pm \Delta\lambda$ (m)

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