Kuwait University	Course 125 Phys. Lab. I
Physics Department	Experiment 3:Velocity of Sound

Determination of the Velocity of Sound using a Resonance Tube

Objectives

- To study the Phenomenon of Resonance.
- To determine the velociy of sound in Air at room temperature.

Equipment to be used

- Resonance Tube apparatus (Figure 1)
- Tuning Forks of different frequances
- Rubber Hammer

Theory

The velocity with which sound travels in a medium may be determined if the frequency and the wavelength are known. This relation is shown in the equation:

$$C = f\lambda \tag{1}$$

where C is the velocity of sound propagation, f is the frequency, and λ is the wavelength. In this experiment the velocity of sound in air is to be found by using a tuning fork of known frequency to produce a wave whose length will be measured by means of a resonating column of air. When sound waves propagate down the tube, they are reflected at the closed end and stationary vibrations of air molecules are produced due to the interference of the incident and reflected wave trains. The air column will then vibrate strongly in segments, with a frequency. Only if the frequency of vibration of the air column is equal to the frequency of the tuning fork a **Resonance** occures. This is indicated by the sudden increase in the intensity of the sound when the column is adjusted to the proper length. At the closed end of the tube the incident and the reflected waves interfere in such a way that thier amplitudes cancel each other out then the air molecules remains at rest and this defines a **Node** (Figure 2). **Antinode**, however; occures at a short distance e (known as the end correction) above the open end of the tube where the incident and the reflected waves reinforce each other. Figure 2 indicates the conditions of vibration for the first two positions of resonance, from which we have :

$$L_1 + e = \frac{\lambda}{4} \tag{2}$$

$$L_2 + e = \frac{3\lambda}{4} \tag{3}$$

by subtraction we can find λ in terms of L_1 and L_2. Substituting this result back in equation (1) we get:

$$C = 2f(L_2 - L_1) \tag{4}$$

This experimental value of C can be compared to the result calculated from the formula:

$$C_t = C_o\sqrt{1 + \frac{t}{273}} \tag{5}$$

where $C_o = 331$ m/s , which is the velocity of sound in air at 0^o C tempreture. The value of the end correction e for the tube can be calculated :

$$e = \frac{1}{2}(L_2 - 3L_1) \tag{6}$$

Procedure

1. Raise the water level in the glass tube until it is near the top. Do so by moving the water tank upward on the metal support .

2. Excite the tuning fork (strike it with rubber hammer) and hold it just above the open end of the tube.

3. lower the water level in the glass tube by moving the water tank slowly downward on the metal support until the air column resonates producing a maximum sound.

4. Measure the length (L_1)of the air column from the open end of the glass tube till the surface of the water.

5. Repeat steps (1) through (4) two more times and calculate the average value of L_1.

6. lower the water level in the glass tube even further by moving the water tank slowly downward on the metal support until the air column resonates producing a maximum sound for the second time.

7. Measure the length (L_2)of the air column from the open end of the glass tube till the surface of the water.

8. Repeat steps (6) and (7) two more times and calculate the average value of L_2.

9. Repeat steps (1) through (8) two more times for two different tuning forks.

10. Determine the value of C using equation (4) and **compare** it to the calculated value obtained from equation (5).

11. Determine the value of the end correction e using equation (6).

12. Plot the graph of (L_1) versus ($\frac{1}{f}$). **Calculate** the value of C from the slope of your graph.

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Laboratory Assignment

1. How are stationery waves formed? What are their characteristics?

2. Dose the velocity of sound in air vary with barometric pressure? Explain.

3. Why did we apply the end correction factor e to the resonance experiment?

4. Sound travels much more rapidly in light hydrogen gas than in air at the same pressure. Explain why?

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Worksheet for Experiment 3

Frequency(f)	$\frac{1}{f}$	L_1	L_1	L_1	$\bar{L_1}$	L_2	L_2	L_2	$\bar{L_2}$	C

$\bar{C}$ (from the table) =

C (from the graph) =

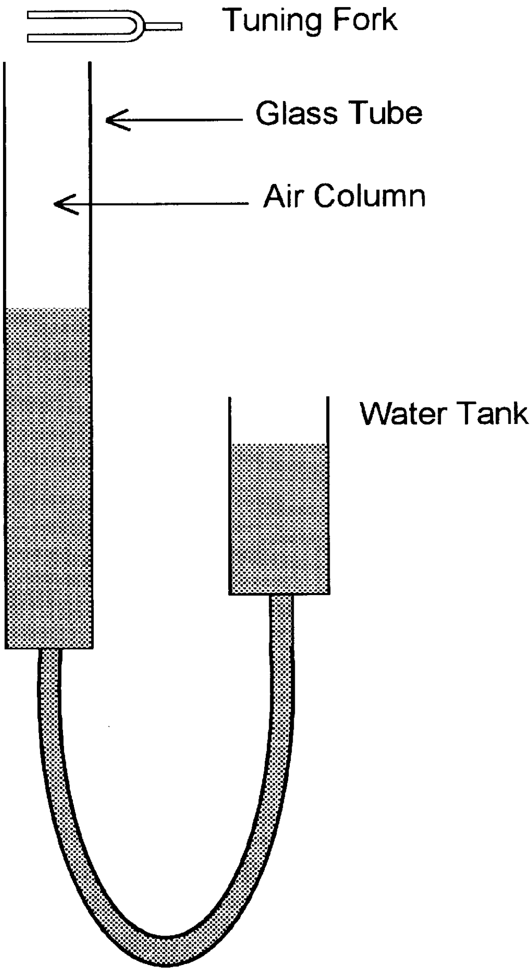

Figure (1) : Experimental Setup of the Resonance Tube

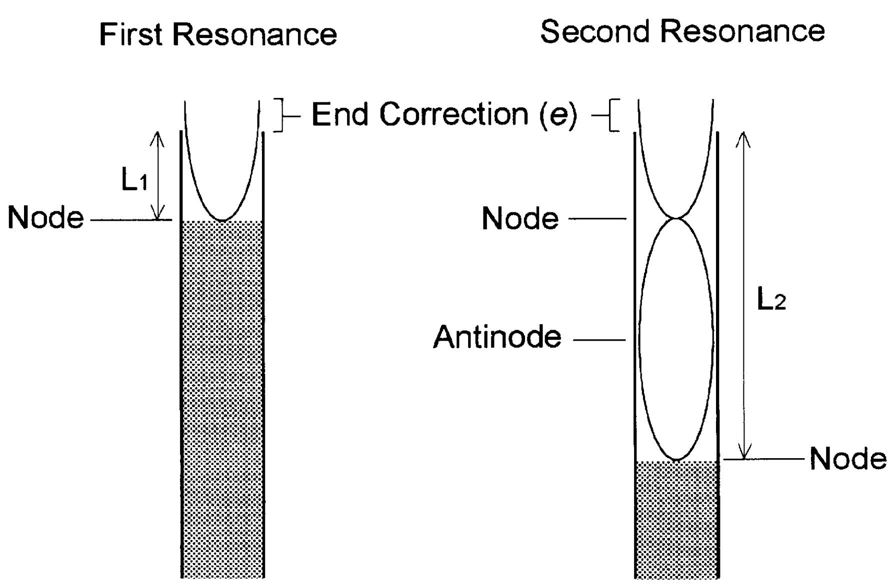

Figure (2): Condition of vibration for the first two positions of Resonance