EXPERIMENT NO. 4

NAME OF EXPERIMENT: TO DETERMINE THE VELOCITY OF SOUND IN THE LAB BY RESONANCE AIR COLUMN METHOD.

APPARATUS REQUIRED

1. Resonance Apparatus
2. Tunning fork
3. Rubber pad

THEORY

A vibrating tuning fork held slightly above the free end of the Resonance tube forces the air column in it to vibrate and sets up stationary waves in it. While adjusting the length of the air column, a position will be obtained when the intensity of sound will be maximum. This will occur when the frequency of the vibrating air column will be the same as that of the tuning fork. There will be an antinode at the open end and a node at the closed end. In this position for the 1st resonance,

$$v = 4f(l_1+x) \quad \text{—— (i)}$$

where, v = velocity of sound
f = frequency of the tuning fork

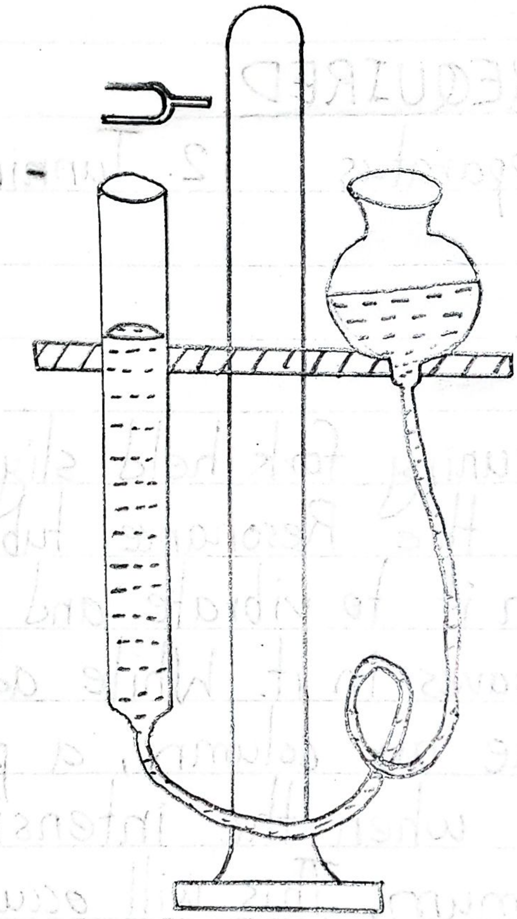

fig. Resonance tube

l_1 = length of the 1st resonance air column.
x = end correction = 0.3d, d is the internal diameter of the tube.

For the 2nd resonance,

$$V = \frac{4f(l_2+x)}{3}$$

or, $3V = 4f(l_2+x)$ —— (ii)

where, l_2 = length of the 2nd resonance

From (i) and (ii) by subtraction,

$$V = 2f(l_2 - l_1)$$

This gives the velocity of sound in the lab temp. and pressure. To convert it into vel. in dry air at N.T.P. we have

$$V_0 = V\sqrt{\frac{P-0.375f}{P}\left(1-\frac{1}{2}\alpha t\right)}$$

where, P = atmospheric pressure in cm. in the lab.
f = aqueous tension at the lab. temp.
α = coeff. of cubical expansion of air,
t = lab. temp.

PROCEDURE

1. The tuning fork was struck against a rubber pad and was held slightly above free end of the tube. The water level was adjusted till an approximate resonance was obtained with the smallest length of the air column. ~~an~~
2. The length of the air column was adjusted properly by raising or lowering the water level till maximum resonance was obtained. This was adjusted once by gradually increasing the length of air column and next decreasing it.
3. These operations were repeated at least thrice. The mean was taken as the 1st resonance air column.
4. The length of the air column was gradually increased till the second resonance was heard. The mean was taken as in (3). Then the velocity of sound was calculated by using the above formula.
5. The Barometer reading P was taken. The lab. temp. was noted. The aqueous tension at lab. temp. was found out from the Physical Tables. Then V was calculated.

OBSERVATIONS

Barometer reading = 74 cm of Hg

Laboratory temperature = 24°C
Aqueous tension from tables = 22.351 mm of Hg
= 2.235 cm of Hg
Coefficient of cubical expansion in air (α) = $\frac{1}{273}$

OBSERVATION TABLE

Positions	No. of Obs.	Length of the air Column l cm Increasing	Length of the air Column l cm Decreasing	Mean length l cm	Freq. of the fork	Velocity $v=2f(l_2-l_1)$
1^{st} Resonance l_1	1	19.8	19.8			
	2	19.7	19.7	19.67	426	
	3	19.5	19.5			336.54 m/s
2^{nd} Resonance l_2	1	59.1	59.1			
	2	59.2	59.2	59.17	426	
	3	59.2	59.2			

CALCULATIONS

$$V_\theta = 2f(l_2 - l_1)$$
$$= 2 \times 426 (59.17 - 19.67)$$
$$= 336.54 \text{ m/s}$$

Lab temp, θ = 24°C
Velocity of sound at 24°C,
$$v = 336.54 \text{ m/s}$$

Again,

$$V_{NTP} = V\sqrt{\frac{P-0.375f}{P} \times \left(1-\frac{1}{2}\alpha t\right)}$$

$$= 336.54\sqrt{\frac{74-0.375\times 2.235}{74} \times 1-\frac{1}{2}\times\frac{1\times 24}{273}}$$

$$V_c = 327.19 \text{ m/s}$$

∴ Value of sound at N.T.P,

$$V_s = 332 \text{ m/s}$$

$$\% \text{ Error} = \frac{V_s - V_c}{V_s} \times 100\%$$

$$= \frac{332-327.19}{332} \times 100\%$$

$$= 1.45\%$$

RESULT

Hence, the velocity of sound in air at 24°C was calculated as 336.54 m/s.