Date : 15-07-2021

Expt. No : 7

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7. HELMHOLTZ RESONATOR

AIM:

(i) To verify the relation between the frequency (n) and the resonating volume (V)

(ii) To find the unknown frequency of the given tuning fork.

APPARATUS:

1. Resonator bottle
2. Set of turning fork
3. Rubber pad
4. Measuring jar

INTRODUCTION:

A phenomenon in which an external force or a vibrating system forces another system around it to vibrate with greater amplitude at a specified frequency is known as "Resonance". The specified frequency is known as Resonance frequency.

Hermann Von Helmholtz's study of sound is one of the most important contributions, beats of musical tones and their interrelations and resonators.

Study of Helmholtz resonators is an important experiment in physics because of its wide applications. A coke bottle is a simple volume resonator, which makes a unique sound when air is blown into it.

Teacher's Signature :

Some applications are,

(i) Volume resonators are used as sound absorbers in noise reduction applications

(ii) The resonators are placed inside the walls of sound producing device and sound is absorbed at the resonance frequency.

(iii) This has been used in ducting employed in airconditioning and in silencers fitted in automobile engines.

(iii) These resonators are also used in musical instruments, including guitar and violin.

PRINCIPLE:

In the resonators water is filled completely and some amount is released by loosing the cork. Then the water in the Helmholtz resonator oscillators producing sound. If the frequency of the tuning fork matches the (frequency) resonating column then a high sound is produced.

It is like a spring mass system. Air in the neck will act like piston alternating compressing and rarefying the air contained in the resonator when tuning fork is sounded above the neck.

If 'n' is the frequency of the tuning fork and 'V' is the resonating air volume, then for a particular resonator

$n^2V = \text{constant}$

And the unknown frequency (n_{max}) of a tuning fork is calculated by using the formula;

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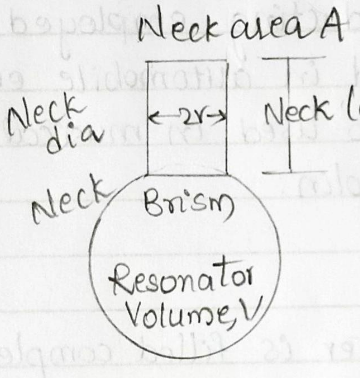

Figure-1.

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If 'n' is the frequency of the tuning fork and 'V' is the resonating air volume, then for a particular resonator
n^2V = constant
And the unknown frequency (n_{unk}) of a tuning fork is calculated by using the formula,

$N_x^2 V = \text{Constant} \Rightarrow N_x = \left[\frac{(n^2 V)_{mean}}{V_x}\right]^{1/2}$

A graph plotted between V and $1/n^2$ should be straight line N_x can can be found from this graph.

THEORY :

Helmholtz resonator is a vessel with a narrow neck, as shown in Fig-1. If air is blown into it, the air in the neck gets compressed and expanded similar to spring mass system as we discussed earlier. Instead, one can make the air in the neck portion to move by the sound wave generated by placing a tuning fork above the neck.

The amplitude of sound produced depends on the neck length, cross-sectional area of the neck and volume of the resonator.

PROCEDURE :

1. First, fill the resonator up to neck with water
2. The tuning forks of unknown frequency that are given are arranged in decreasing order
3. So that filling the bottle up to the neck again and again is not required.
3. Start the experiment for highest frequency tuning fork. Vibrate it by striking against the rubber pad.
4. Now hold this (striking) vibrating tuning fork at the top of the mouth of resonator and allow the water to flow out.

OBSERVATION TABLE :

S.No	Frequency (n)	Volume (V) in ml	$1/n^2$	n^2V
1	512	90	3.8147×10^{-6}	23592960
2	480	119	4.3403×10^{-6}	27417600
3	426	137	5.5104×10^{-6}	24862212
4	389	159	6.6085×10^{-6}	24060039
5	341	193	8.5998×10^{-6}	22442233
6	320	223	9.7656×10^{-6}	22835200
7	288	264	12.0563×10^{-6}	21897216
8.	256	381	15.2588×10^{-6}	24969216
9.	n	268	$1/n^2$	$n^2 \times 268$

CALCULATIONS :

$$(n^2V)_{mean} = \frac{23592960 + 27417600 + 24862212 + 24060039 + 22442233 + 22835200 + 21897216 + 24969216}{8}$$

$$= \frac{192076678}{8}$$

$$= 24009584.5$$

$$n^2V = 24009584.5$$

$$n^2 = \frac{240095845}{268}$$

$$n = \sqrt{\frac{24009584.5}{268}} = 299.3125\ Hz$$

Graph for Record Book

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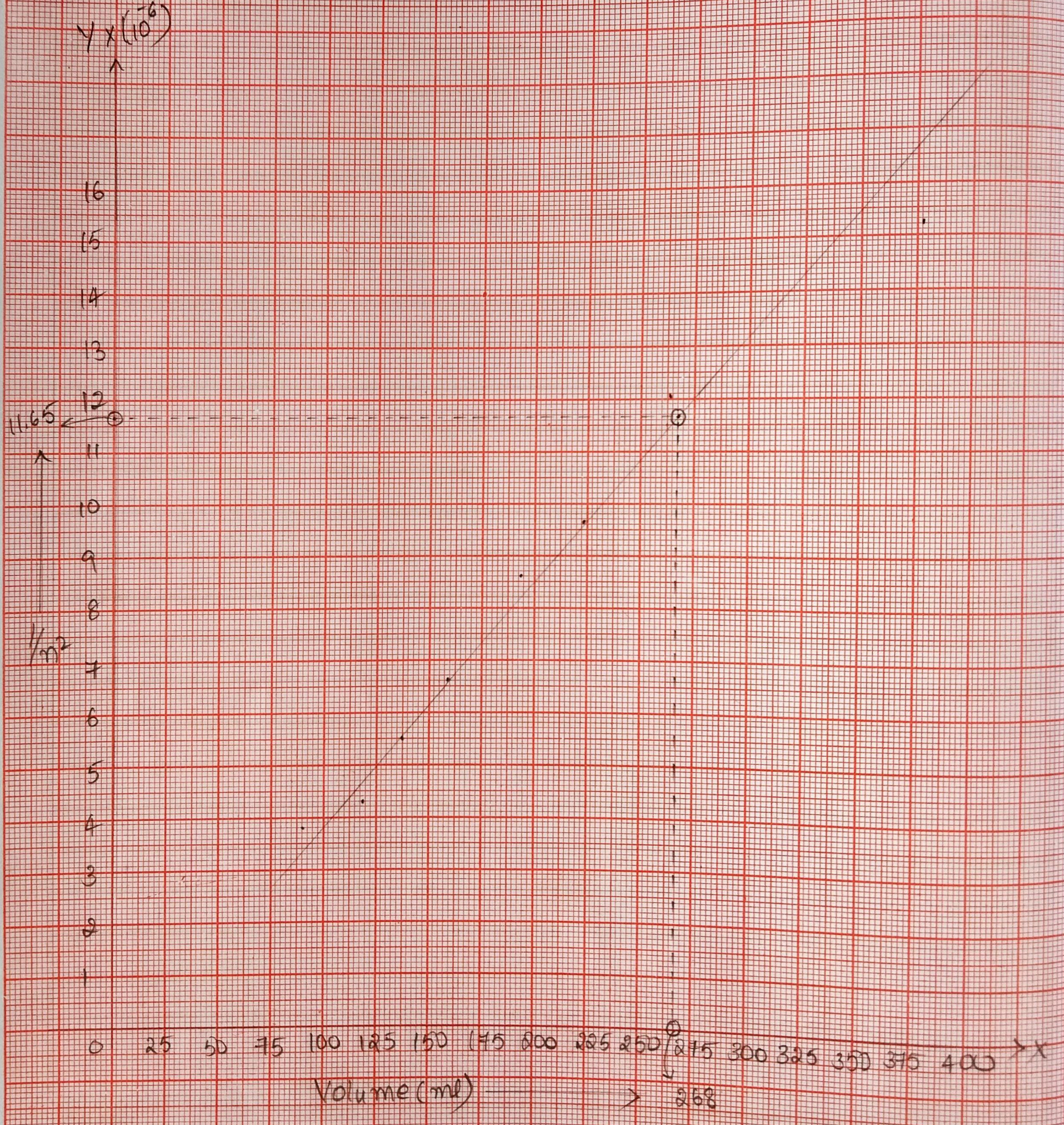
Scale:
X-axis, 1cm = 25 ml
Y-axis, 1cm = 1×10^{-6} unit



From graph,

$\frac{1}{n^2}$ at $V = 268$ ml is 11.65×10^{-6}

$$n = \sqrt{\frac{1}{11.65 \times 10^{-6}}} = 292.9794 \text{ Hz}$$

$$n = 292.97494 \text{ Hz}$$

$$\text{Final } n = \frac{n_{table} + n_{graph}}{2}$$

$$= \frac{299.8125 + 292.9794}{2}$$

$$n = \underline{\underline{296.14595}} \text{ Hz}$$

5. Repeat the procedure till resonance is attained. The sound produced by vibrating tuning fork will be maximum at resonance.
6. By finding the volume of water from the resonator, the volume of air column corresponding to that particular tuning fork can be found.
7. Repeat the experiment for other tuning forks of lower frequency and note the values in the table.
8. And also plot the graph V vs $1/n^2$ with the values obtained in the table.

RESULT :

1) The relation n^2V = constant is verified
2) The Unknown frequency of the tuning fork

By Calculation = 299.3125 Hz

By graph = 292.9799 Hz

CONCLUSION:

The unknown frequency of the tuning fork is 296.14595 Hz

PRECAUTIONS :

1. Take care at eyelevel and avoid parallax error
2. Pour water completely and ensure stray drop are not allowed.