Velocity of Sound by Means of A Resonance Tube

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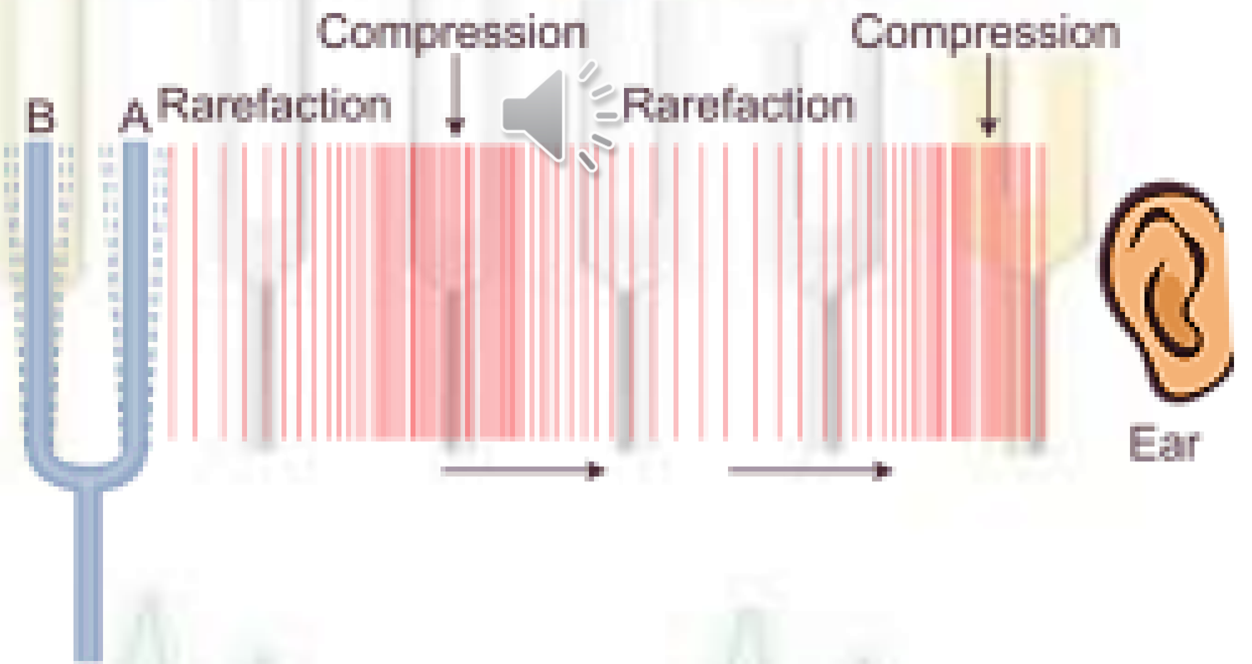
Sound

The word "**sound**" may be defined in two ways (**objectively** and **subjectively**).

Objectively, the sound is a type of wave-motion taking place in a material medium (whether **gaseous**, **liquid** or **solid**) due to an original vibration or mechanical disturbance set up by a sounding body.

Subjectively, it is a sensory experience in the brain conveyed to it by the auditory nerves of the ear.

Sound is a type of **wave**, so are **light** and **earthquake tremors**. Wave that are periodic and go through several cycles before dying out. ***For example***, the sound from a tuning fork is a continuous wave.

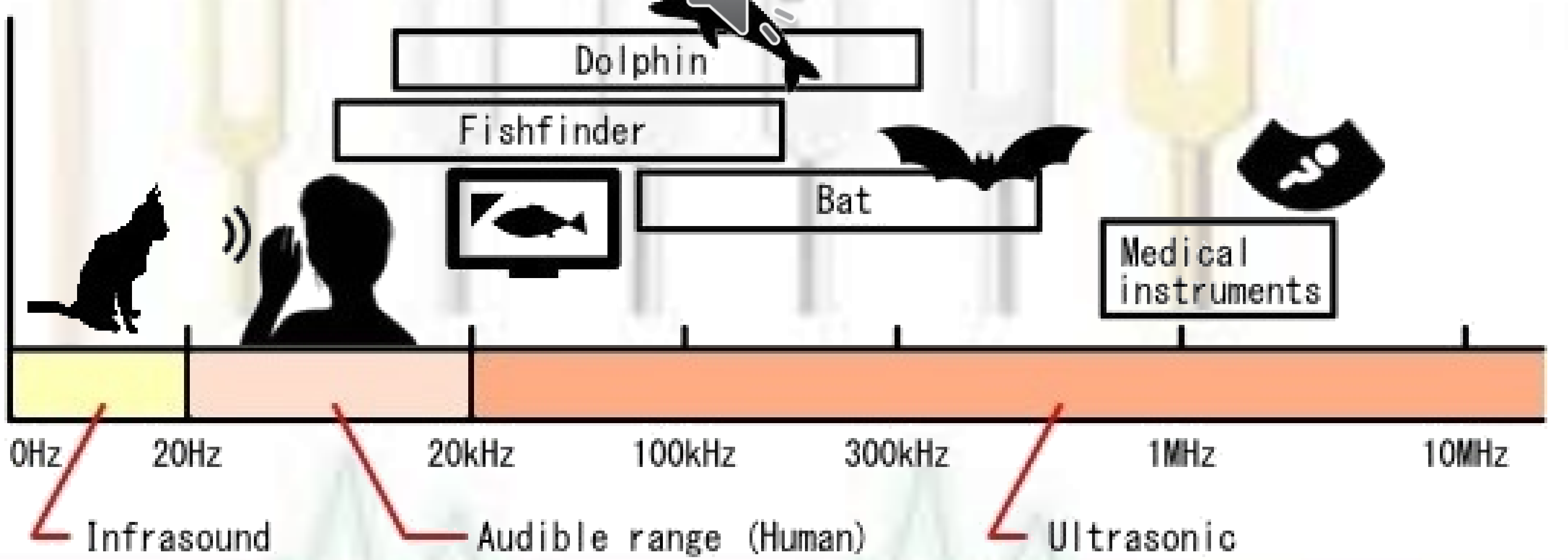


Sound passes through matter by transferring energy through particles, by particles hit other particles to form mechanical waves. **Sound** has no absolute speed; the speed of sound **depends on** material density passing through. **sound** travels faster in water than in air, this is **because** air doesn't have particles density as water. This causes sound loosing their energy faster and disperses more quickly.

- **Sound**: it is **audible waves between (20Hz-20kHz).**

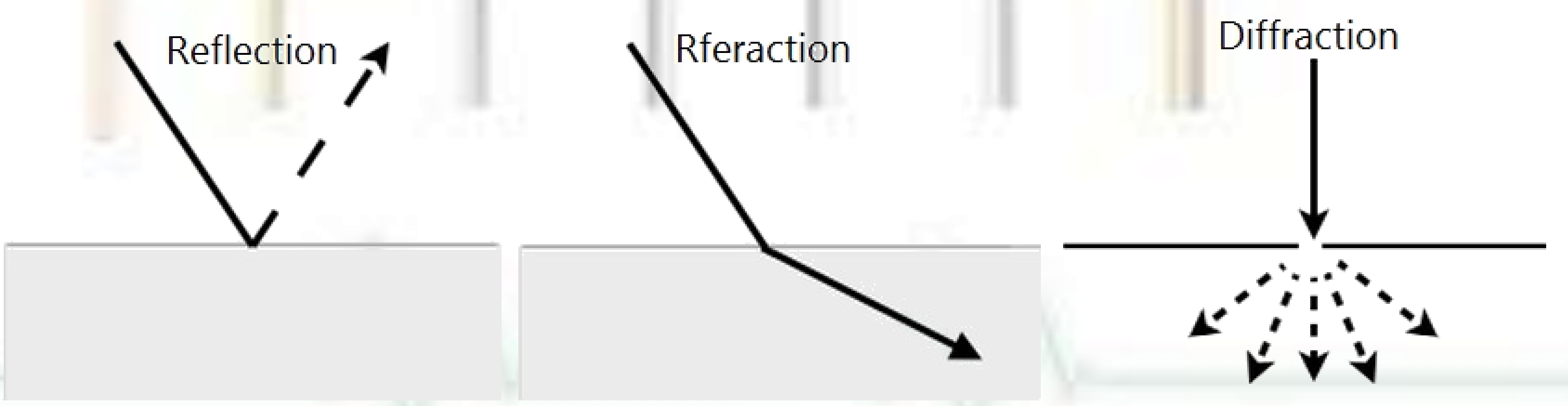
- **Infrasound**: refers to the **sound frequency below** the normal hearing range, or less than (**20Hz**).

- **Ultrasound**: refers to the **sound frequency above** the normal hearing range, or more than (**20kHz**).



Reflection, Refraction and Diffraction

Like any wave, a **sound** wave doesn't just stop when it reaches the end of the medium or when it encounters an obstacle in its path. Rather, a **sound** wave will undergo certain behaviors when it encounters the end of the medium or an obstacle. Possible behaviors include **reflection** off the obstacle, **diffraction** around the obstacle, and **transmission** (accompanied by **refraction**) into the obstacle or new medium.



Types of Motion within Waves

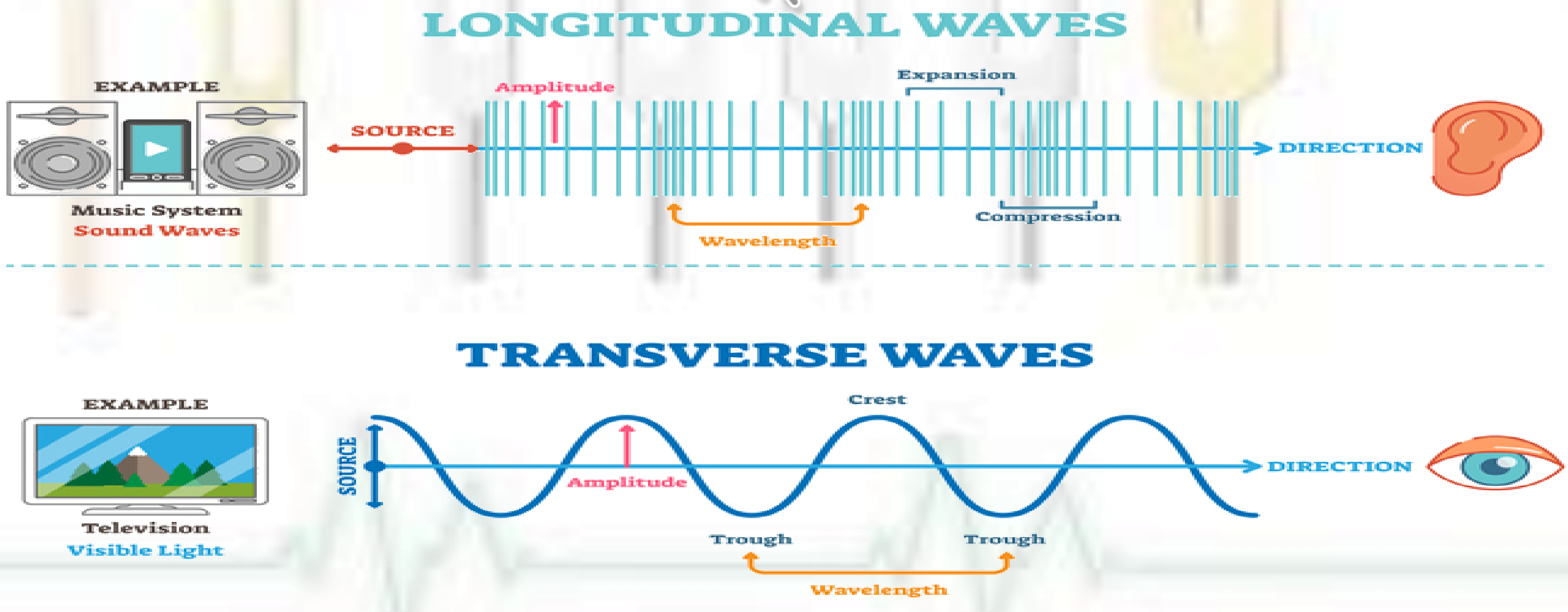
1. A Transverse Wave

Is one in which motion within the wave is **perpendicular** to the travel of the wave.

2. A Longitudinal Wave

Is one in which motion within the wave is **parallel** to the travel of the wave.

Sound is a longitudinal wave.



Wavelength and Other Wave Characteristic

The **wavelength** λ of the sound waves is the distance between consecutive **compressions** or **rarefactions**.

Another common characteristic is that waves travel with some **speed of propagation**, labeled $\boldsymbol{v}$.

The time required for one complete vibration is $\boldsymbol{T}$, the period of the wave. One full wavelength passes to the right in this time. This means that the wave has moved a distance $\boldsymbol{\lambda}$ in a time $\boldsymbol{T}$, so that the speed of propagation $\boldsymbol{v}$ is given by:-

$$v=\lambda/T$$

Given the relationship $\boldsymbol{f=1/T}$, this can also be written:-

$$v=\lambda f$$

The Hearing Mechanism

The ear properly divided into **three** parts: -

1. The Outer Ear

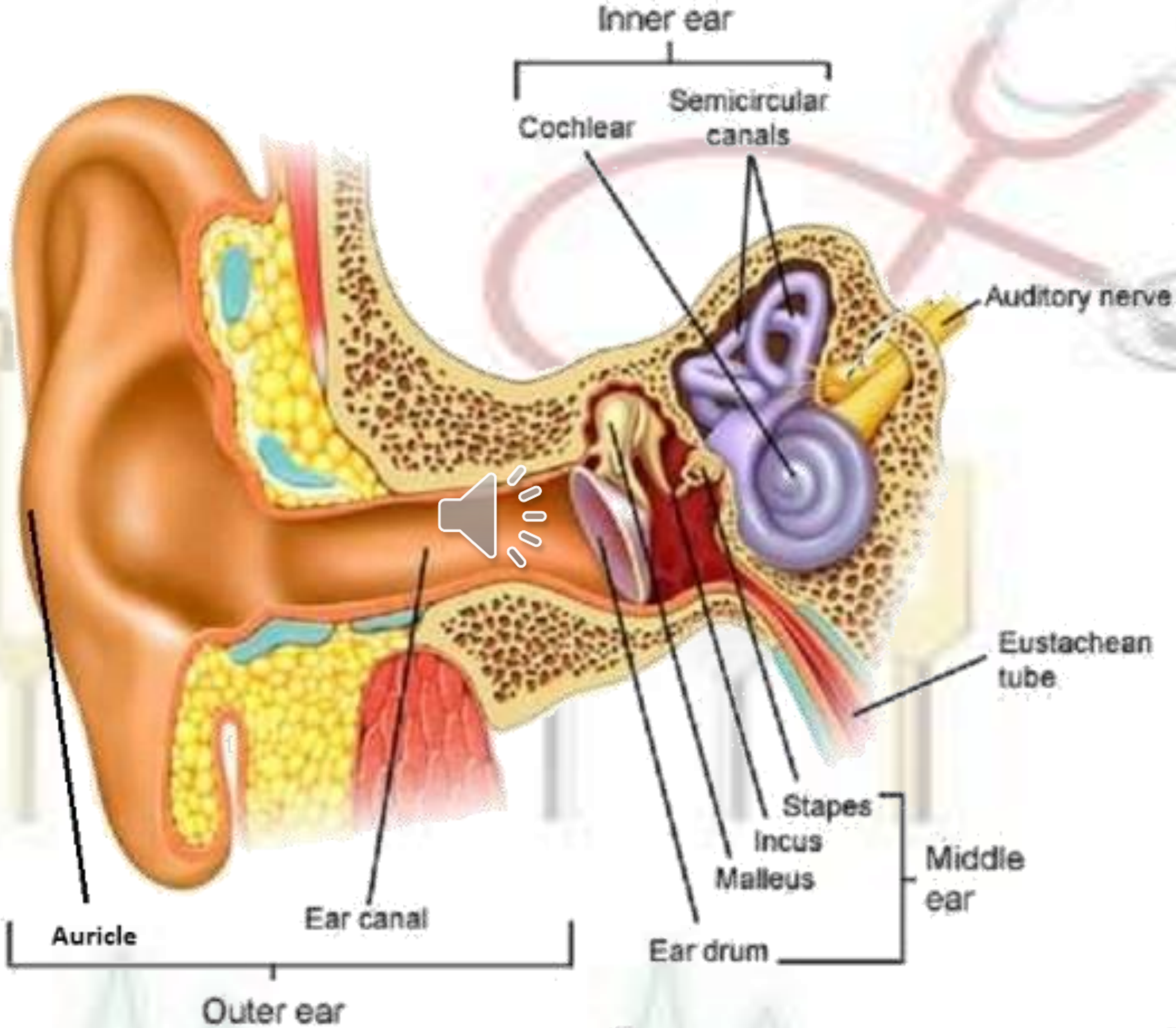
Is just the ear canal, which terminates at the eardrum (**tympanic membrane**).

2. The Middle Ear

Contains three small bones called the hammer, anvil, and stirrup (**malleus**, **incus**, and **stapes**) and an opening to the mouth (**Eustachian tube**).

3. The Inner Ear

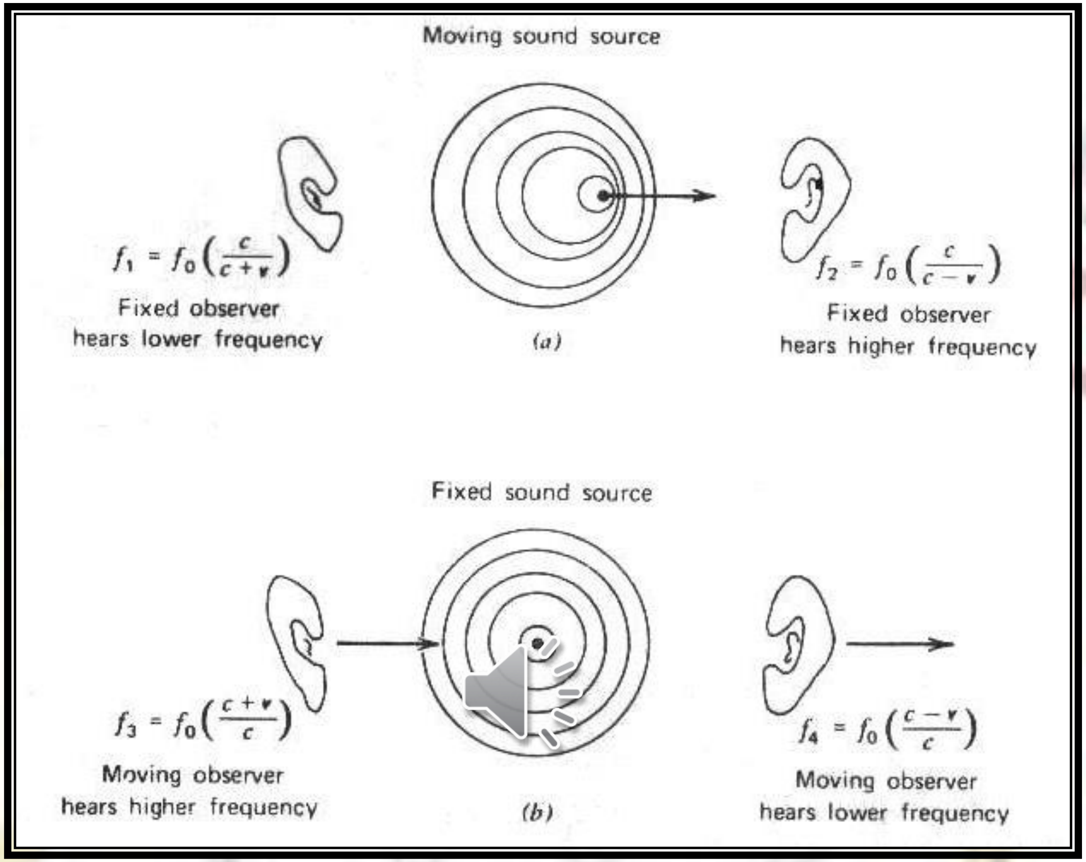
Contains the **cochlea**, the organ that converts sound waves into nerve signal to the brain.



Inner ear
Cochlear
Semicircular canals
Auditory nerve
Eustachean tube
Stapes
Incus
Malleus
Middle ear
Ear drum
Auricle
Ear canal
Outer ear

Doppler Effect: Phenomena occurs when there is relative motion between a source of sound and a listener.

Listener hears a higher frequency from a sound source moving toward him and a lower frequency when it is moving away from him. (***b***) A listener hears a higher frequency when he is moving toward a sound source than when he is moving away from it. Here ***c*** is the velocity of sound in air, ***v*** is the velocity of the source in (***a***) and the listener in (***b***), and f_o is the frequency in the absence of motion.



Doppler Effect can be used to calculate the velocity of moving source.

Medical Applications of Sound

1. Intensity of ultrasound used for **medical diagnostic** is kept low to avoid tissue damage. Intensities of about **10^{-2} W/m^2** are used and seem to cause no ill effects.

2. Ultrasound of considerably higher intensity is used for **therapeutic** purposes. Ultrasound diathermy is deep heating using ultrasound of intensities **1-10W/m^2**.

3. Ultrasonic sound waves sent into the body are **Doppler shifted** by any motion in the objects that reflect them. It is possible, ***for example***, to measure blood velocity by observing the **Doppler shift** of ultrasound reflected from the blood cells. More commonly, the Doppler shift of ultrasound is used to monitor the fatal heart motion.

4. Ultrasound used for sterilization **because** it kills the virus and bacteria.
5. It is also used as massage tool for muscles: cure the cancer, destruction the kidney stone.
6. Many devices use ultra-sonic sound, like **toothbrushes**.
7. Sonic denture cleaner or sonic cleaning device eliminates limescale deposits.
8. Ultra-Max Cube: multiple of uses such as cleaning brushes, dentures, burs, diamonds, etc.


SCALEBLASTER

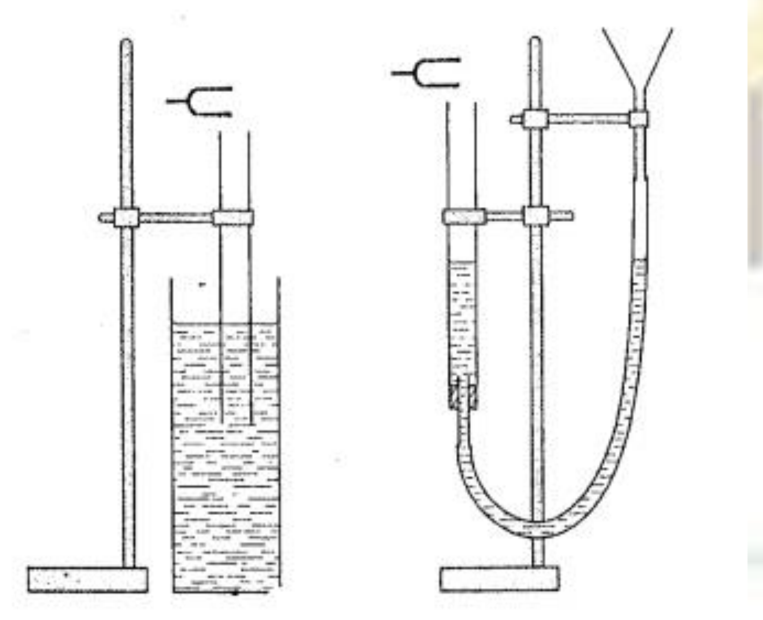
Aim

To Measure The Velocity of Sound

Apparatus

- Resonance tube (see diagrams) about 0.8- 1.0m long and 3-4cm in diameter.
- Set of tuning forks of frequencies 512- 256Hz.
- Metre scale.

The diagrams show two types of apparatus whereby the length of the resonance tube may easily adjusted.



Method: Using two positions of resonance for each fork.

Begin the experiment with the length of the air column in the resonance tube only a few cm in length. Select the fork of the highest frequency, strike it smartly on a rubber pad and hold it over the mouth of the tube.

While the fork is vibrating adjust the length of the resonance column until the tube responds to the vibrations of the fork, i.e, until resonance occurs. By further small adjustments obtain the position of maximum loudness as exactly as you can. Measure the length of the air in the tube, repeat the measurement two or three times and take the mean l_1.

Now find a second and different position of resonance using the same fork but with about three times the length of air and again take the mean l_2 of several readings of the length when resonance occurs.

Obtain different values of l_1 and l_2 using the other forks.

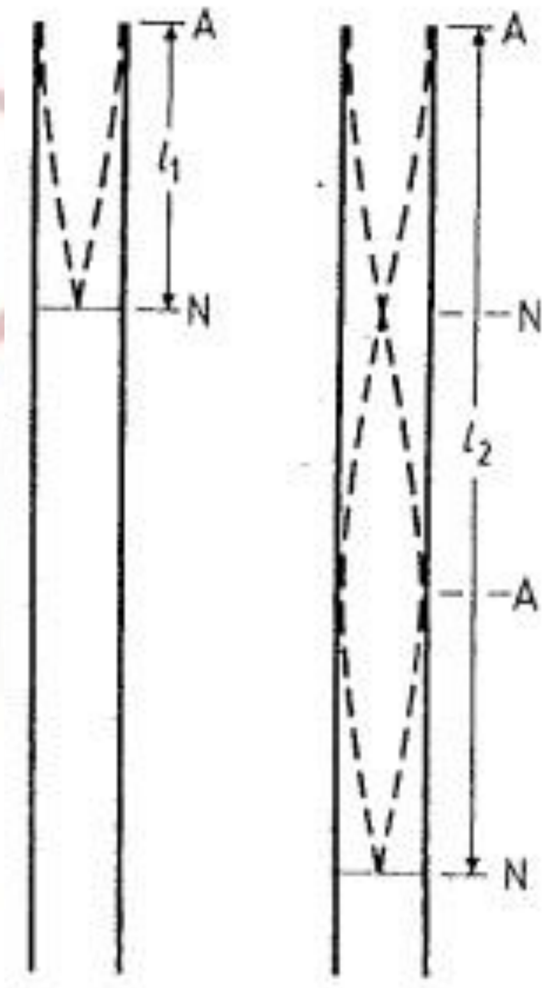
Tabulate the readings

Frequency f/Hz	First resonance position Length of air column l_1/m				Second resonance position Length of air column l_2/m				Velocity of sound c/m s^{-1} from $c = 2f(l_2 - l_1)$	End correction ε/m from $\varepsilon = \frac{1}{2}(l_2 - 3l_1)$
	(1)	(2)	(3)	Mean	(1)	(2)	(3)	Mean		
									Mean	Mean ....

Record the room temperature.

Theory and calculation

The diagrams represent the vibration of the column of the air in the first two position of the resonance. [It must be remembered that the vibrations of the air particles are longitudinal and are only shown as transverse in order to create a picture of what is happening]. Standing waves are set up, the water surface being a displacement node and the open end of the tube almost a displacement antinode. Actually, the antinode at the open end is a little beyond the end and there is therefore and correction ε.



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Thus $l_1 + \varepsilon = \frac{1}{4}\text{ב}$

$$and$$

$$l_2 + \varepsilon = \frac{3}{4}\text{ב} \qquad [\text{ב} = wave\ length]$$

$$\therefore\ l_2 - l_1 = \frac{\text{ב}}{2} = \frac{c}{2f} \qquad c = velocity$$

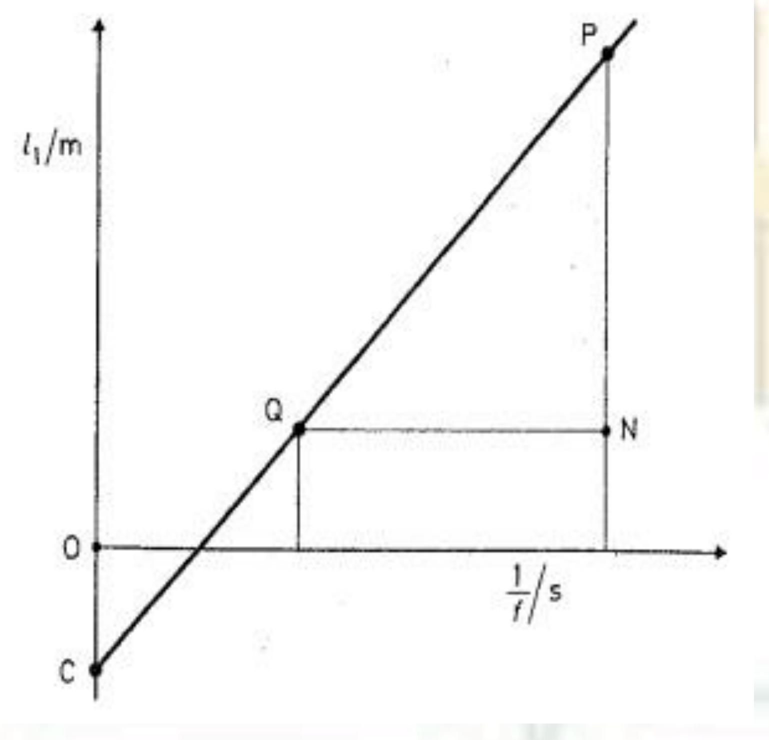
f= frequency

$$Hence\ c = 2f(l_2 - l_1)$$

$$and\ \varepsilon = \frac{1}{2}(l_2 - 3l_1)$$

Graph

Thus the graph of values l_1 /m as ordinates against the corresponding values of $\frac{1}{f}/s$ as abscissae is a straight line whose slope is the numerical value $\frac{c}{4}$, while the negative intercept on the l_1/m axis is the numerical value of ε.



Thank you