CHAPTER -(11)-

SOUND

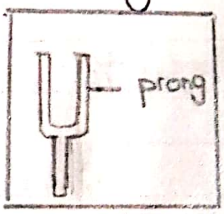
- Sound is a form of energy that travels in the form of waves.
- Sound is generated due to the vibrations of particles.
- vibrations of air produce sensation of sound in our ear.

Examples:

* In a guitar, sound is produced due to the vibrations of its strings.
* Our voice results from the vibrations of vocal chords.
* Vibrations of heart and lungs produce sound.

Sound is produced by a vibrating body

Take a tuning fork. Strike it on a rubber pad. The tuning fork will vibrate and produce a sound.

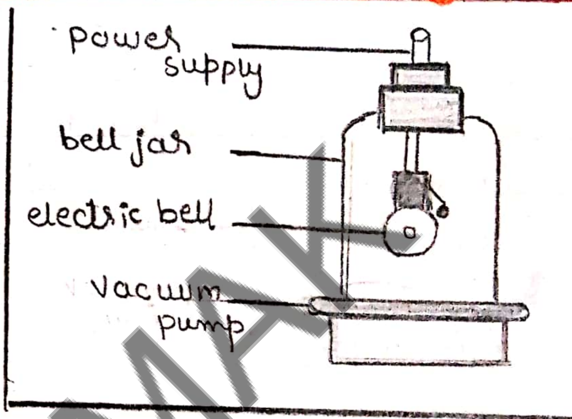


How can we feel the vibrations ?

* We can feel the vibrations by slightly touching one of the prongs of the vibrating tuning fork with a ball suspe[nded] from a thread. As we touch the ball with the prong o[f] vibrating tuning fork, the ball will move due to the vibrations of tuning fork.

* We can also feel the vibrations of the tuning fork by dipping it into a glass of water. As we dip the tuning fork into a glass of water, it will cause a splash due to the vibrations.

Sound waves require a medium for its propagation



Apparatus

- ~~Bell~~ glass jar
- vacuum pump
- electric bell
- power supply.

Working

1. Hang an electric bell in a glass jar.
2. Provide power supply, we will hear bell ring.
3. Now create a vacuum in a glass jar, provide power supply to electric bell. Now we can't hear the bell.
4. As the ~~medium~~ vaccum is created in the glass jar, so there is no medium for the propagation of sound.

Result

Sound waves require medium for their propagation.

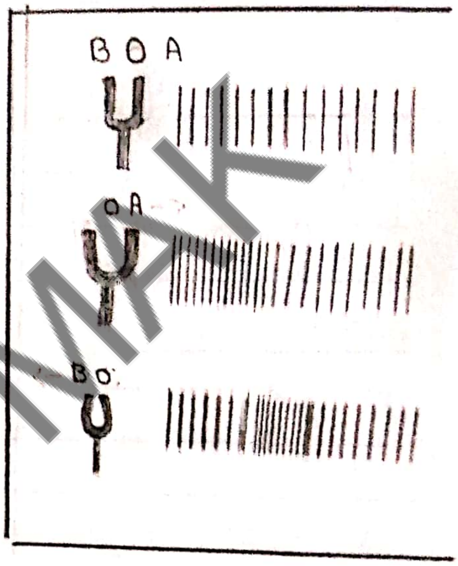
Longitudinal Nature of Sound Waves

— source of waves

* Tuning fork is required to produce sound waves.

O = M.P
A, B = E.P

rubber pad = when we strike T-F with rubber pad prong will vibrate



* Before the vibrations of the tuning fork, the layers of air are distributed around the prongs equally so, the density of air is uniform.

* When the vibrations are generated in the tuning fork, let its one (end) prong move toward O to A in the right side.

* Prong will compress the layers of air so the compression is generated or it is exerting pressure on the air layers.

* When prong moves from A to O the rarefaction is produced on right side while compression move forward.

* Prong will move from O to B, similarly generate compression on left side and so on.

Result: • This shows that set of compression and rarefaction will generate sound wave.
• Direction of propagation of sound wave is along the direction of oscillating air molecules.

Note: Set of compression and rarefaction are generated by the vibration of tuning fork.

Characteristic of Sound Waves

→ Sound of different objects can be distinguished on the basis of different characteristics.

- **Loudness** (loud and faint)
- **Pitch** (Shrill and grave)
- **Quality**
- **Intensity**

Condition of ear

A sound appears louder to a person with sensitive ear than to a person with defective ear

Loudness

Amplitude of vibrating body

Relation:

The amplitude of vibrating body is directly proportional to the loudness.

Amplitude $\propto$ Loudness

Example:

Consider a surface of drum, the membrane of drum is thin. If we beat the drum forcefully, the amplitude will increase and a loud Sound can be heard. If we beat the drum with less force, a faint sound can be heard due to the small amplitude.

Area of vibrating body

Relation:

Area of vibrating body is directly proportional to the loudness.

Area $\propto$ Loudness

Example:

Consider a surface of 2 drums, one with a large area and another with small area. If we beat both drums with same force, the drum having a large area will produce a loud sound and the one having a smaller area will produce a faint sound.

Distance from vibrating body

Relation:

Distance from vibrating body is inversely proportional to the loudness

Distance $\propto \frac{1}{L}$

Example:

If the distance between the vibrating body and a listner is less then a loud Sound can be heard. If the distance between the vibrating body and a listner is more then a faint sound can be heard.

Pitch

depends upon the frequency

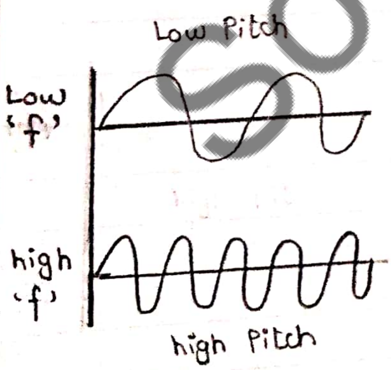
Pitch ∝ f

If no. of waves are greater then waves have high pitch and high frequency, and vice versa.

Due to pitch, we can differentiate between 'grave' and 'shrill' sound.

Example:

The voice of ladies and children is shrill and of high pitch whereas the voice of men is grave and of low pitch.



Quality

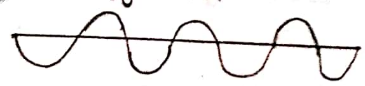
2 sounds of same loudness and pitch.

- Same loudnes = Same Aplitude
- same pitch = Same no. of waves

Example:

while standing outside a room, we can differentiate b/w the notes of piano and flute being played inside the room. This is due to difference in quality of these notes.

Tuning fork



Flute

Clarinet

The loudness and pitch of tunig fork, flute clarinet are same but their wave forms are different so their quality is different and they can be distinguished from each other.

Intensity

→ Energy per unit area held perpendicular to direction of propagation of sound wave.

→ It is represented by 'I'

$$I = \frac{E}{A \cdot t} = \frac{J}{m^2 s} = \frac{W}{m^2} = Wm^{-2}$$

Other units:

$\frac{Nm}{S \cdot m}$, $\frac{J}{Sm^2}$

Kg / S^3

Sound Intensity Level

The loudness of a sound is directly proportional to logrithm of intensity.

$$L \propto \log I$$
$$L = K \log I \longrightarrow (1)$$

K is proportionality constant

For faintest sound

$$L_o = K \log I_o \longrightarrow (2)$$

L = loudness ~~at some temperature for Intensity~~ of unknown sound
L_o = loudness of faintest sound.
I = Intensity
I_o = Intensity of faintest sound.

Now, subtruct eq (2) from eq (1)

$$L - L_o = K \log I - K \log I_o$$
$$\Delta L = K(\log I - \log I_o)$$
$$\Delta L = K \log \frac{I}{I_o} \longrightarrow (3)$$

ΔL = Intensity level

If $I = 10 I_o \longrightarrow (4)$

Put value of I in eq (3)

$$\Delta L = K \log \left(\frac{10 I_o}{I_o}\right)$$

$$\Delta L = K \log 10$$

Intensity level = K = 1

Intensity level = $\log \frac{I}{I_0}$ (bell)

1 Bell = 10 dB

$\Delta L = \log \frac{I}{I_0}$ 10 dB

$\Delta L = 10 \log \frac{I}{I_0}$ (dB)

Bell

* Bell is a very large unit of Intensity level.
* Small unit decibel (dB) is used.
* 1 Bell = 10 dB
* $\Delta L = 10 \log I / I_0$ (dB)
* Decibel Scale is a logarithmic measure of the amplitude of Sound waves.
* In logarithmic scale, equal intervals correspond to multiply by 10 instead of adding equal amounts.

Reflection (ECHO) of Sound

Statement: "When sound is incident on surface of a medium, it bounce back into the first medium. This phenomenon is called echo or reflection of sound."

→ The sensation of sound persist in our brain for about 0.1 s.

→ $t_1 + t_2 = 0.5 + 0.5 \Rightarrow \Delta t = 1 s.$

→ $S_1 + S_2 = 17 + 17 \Rightarrow S_{total} = 34$ m.

→ $S = vt$

$= 340 \times 0.1$

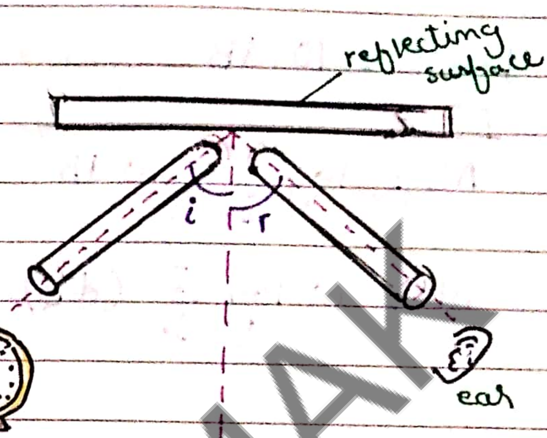
$= 34$ m.

Speed of sound = constant = 340 m/s

→ We can hear echo if object is placed at 17m from the source of sound.

~ Activity 11.3 ~

A screen is there in the centre, place 2 pipes on the side of screen. Place a clock on the side of one pipe. The sound of the clock will travel through the pipe and will strike the surface. As it strikes, the sound will reflect and bounce back. If we change the position of pipe reflection will occur but will not hear a clear sound. It means $\angle i = \angle r$ to hear a clear sound.



Speed of Sound

- Nature of medium will affect the speed of the sound waves.
- $(V_{sound})_{liquid} = 5 V_{gases}$.
- $(V_{sound})_{solid} = 15 V_{gases}$
- $(V_{sound})_{solid} > (V_{sound})_{gases}$.
- Speed of sound in air is affected by 'T', 'P' and 'humidity'.

> - In liquids, the molecules are packed less tightly together.
> - In solids, the molecules are tightly packed together.

- Speed of sound = 343 m/s when T = 21°C and P = 1 atm
- Speed of sound can be measured by $v = f\lambda$

(Noise)	(Music)
• Such sounds which have unpleasent effect on our ear are known as noise.	• Such sounds which have pleasent effect on our ear are known as music.
• It create jarring effect	• It create pleasent effect
• They have irregular wave forms.	• They have regular wave form.
• sudden change in amplitude	• no sudden change in amplitude
• It has negative effect on health.	• It has positive effect on health

Safe Level of Noise Depends On:

* Level of (volume) of noise
* Period of exposure to noise.

The level of noise recommende in most countries is usually 85 - 90 dB over an 8 hour workday

Noise Pollution Can be Reduced by:

* replacing the noisy machinery with environment friendly machinery and equipments.
* putting sound - reducing barriers.
* using hearing protection devices.

Acoustic Protection

Statement

The technique or method used to absorb undesirable sounds by soft and porous surface is called acoustic protection.

Important Features

→ Reflection of sound is more prominent if the surface is rigid and smooth.

→ Reflection of sound is less prominent if the surface is soft and irregular.

→ Soft, porous materials, rugs absorb large amount of sound.

→ If sound reflects from multiple hurdles them sound become garbled.

→ Multiple reflections called "reverberation".

Reverberation can be Reduced by:

Reverberation can be reduced by covering walls and ceiling of enclosed space with the help of sound absorbing materials.

How to obtain clear sound ?

In the design of lecture halls, auditorium or theater halls, a balance must be achieved between reverberation and absorption. It is often advantageous to place reflective surfaces behind the stage to direct sound to audience.

Audible Frequency Range

* Range of frequencies which a human ear can hear is called audible frequency range.

* Audible frequency range is between 20 Hz to 20 kHz.

* Relation between Energy and frequency is direct

$$\left[\begin{array}{l} E = hf \;,\; E \propto f \\ h = 3.36 \times 10^{-32} \end{array}\right]$$ energy is less

* Relation b/w f and λ is inverse.

$$\left[E = \frac{hv}{\lambda} \;,\; f \propto \frac{1}{\lambda} \right]$$

* energies are less $E = hf \quad E \propto f$

* large λ

$v = f\lambda$

$$f \propto \frac{1}{\lambda}$$

Non-Audible Frequency Range / Ultra Sound

* Range of frequencies which a human ear cannot hear is called non-audible frequency range.

* Non-Audible frequency range is greater than 20 kHz (f > 20 kHz)

* The Energy of ultra sound is greater than the energy of audible frequency range.

$E_{ultra} > E_{audible\,f}$

As energy is higher so λ of Non audible f range is greater than audible frequency range.

* energies are more $E \propto f$.

* small wavelength

$$f \propto \frac{1}{\lambda}$$

~ UltraSound ~

"Sound of frequency higher than 20KHz which are inaudible to normal human ear are called ultrasound or ultrasonic waves".

Uses

1. They are used in medical and technical fields.
2. They are used to diagnose and treat different aliments.
3. They are used to remove blood clots formed in arteries.
4. It is used to get the picture of thyroid gland for Examinatio
5. Used to find the depth of sea (SONAR).
6. They are used to see the shape and size of object.
7. They reach in visible areas so wear and tear in heavy machines can be checked.
8. Germs and bacteria in liquids can be destroyed by the use of ultrasound.