SOUND

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INTRODUCTION

Sound is a form of energy that produces the sensation of hearing in our ears. The speed of light is 3×10^8 m/s and the speed of sound in the air under normal conditions is 340 m/s. So, the light travels almost instantaneously, whereas sound takes some time.

HOW IS SOUND PRODUCED

Sound is produced by vibrations. Thus, vibrating bodies produce sound.

In some cases, the vibrations are easily visible to our naked eyes but in some cases they can only be felt and not seen.

HOW DOES SOUND PROPAGATE

When a person speaks, the molecules in the air near his mouth are disturbed. Due to this, these molecules start vibrating to-and-fro about their mean positions. These vibrating molecules then disturb the nearby molecules. This process continues until the molecules in the air next to the listener's ear start vibrating. These vibrating molecules then cause vibrations in the diaphragm of the listener's ear and the sound is heard.

OSCILLATIONS

Have you carefully watched a child on a swing ? The swing repeats its updown and forward-backward motion in a regular fashion. The swing moves to-and-fro on the same path with its mean position in the middle. The motion like that of a swing is called oscillatory motion.

Some examples of oscillatory motion are :

(a) motion of the pendulum of a wall clock,

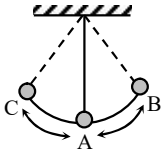
(b) vibrating string of a musical instrument.

(c) motion of the heart muscles in a healthy person.

When a body undergoes an oscillatory motion, it passes through a particular position at regular intervals of time. Therefore, oscillatory motion is a periodic motion.

◈ Oscillation

The movement of a body from one extreme position to the other and back is called an oscillation. In the figure shown the movement of the bob from B to C and back to B is one complete oscillation.



Also, the motion of the bob from A to B, B to C and then from C to A is one complete oscillation.

◈ Amplitude of Oscillation (A)

The maximum displacement of a body from its mean position is called the amplitude of oscillation. Thus, in the figure shown, the displacement AB or AC is called amplitude of the oscillating bob. Amplitude is denoted by A.

For a body oscillating in the air, the amplitude of oscillation gradually decreases due to the air-resistance.

◈ Time period (T)

The time taken to complete one oscillation is called its time period. Time period is denoted by T. In the figure, the time taken by the bob to travel from B to C and back to B is called is its time period.

As long as the amplitude of oscillation is small, the pendulum takes equal intervals of time to complete each oscillation.

◈ Frequency of Oscillation

The number of oscillations made by an oscillating body in one second is called the frequency of oscillation.

Frequency (ν) is related to the time period (T) by the relationship,

Frequency, $\nu = 1/T$

The unit of frequency of oscillation is hertz (Hz).

1 Hz = 1 cycle per second

➢ AUDIBLE AND INAUDIBLE SOUND

The human ear can hear the sounds having frequencies between 20 Hz to 20000 Hz. This is called the audible range. Thus, the audible range of a normal human ear is 20 to 20000 Hz.

- The sound in the audible range (20 to 20000 Hz) is called sonic sound. An infant (about 1 year old) can hear sounds up to 35000 Hz. This limit gradually comes down to 20000 Hz for an adult.
- The sound of frequencies greater than 20,000 Hz is called ultrasonic sound.
- The sound of frequencies lower than 20 Hz is called subsonic or infrasonic sound.

subsonic sound ⇒ Less than 20 Hz

sonic sound⇒ 20 Hz to 20000 Hz

ultrasonic sound ⇒ Greater than 20000 Hz

➢ APPLICATIONS OF ULTRASONIC SOUND

Certain animals such as dog, leopard, monkey and deer can hear ultrasonic sounds. Certain birds like bat can produce sounds of very high frequencies. A bat is able to locate any obstacle or its prey in its path due to reflection of the ultrasonic wave from the object. Dolphins use ultrasonic sound to locate their prey.

◈ Technological / Industrial Applications of Ultrasonic Sound

Ultrasonic waves have short wavelength.

These short wavelength sound waves can be reflected back from the smaller objects. Thus, ultrasound can detect or 'see' smaller objects

(< 1 cm size). The ultrasonic waves do not get scattered.

Some important technological and industrial uses of ultrasonic waves are described below :

- Ultrasonic waves are used to drive away rats, cockroaches etc.
- Ultrasonic waves are used for detecting any deformity in the unborne baby.
- Ultrasonic waves are also used for determining the depth of sea.
- Ultrasonic waves are also used for detecting the presence of submarines, icebergs, sunken ships etc., in the sea. This technique is called by the name SONAR (Sound Navigation and Ranging).

SOUND NEEDS A MEDIUM TO PROPAGATE

You have learnt that vibrations produce sound. To produce & travelling of vibrations, we need a material body. Therefore, we can say that a medium is needed for sound to travel.

SPEED OF SOUND

Sound travels at different speeds in different media .

Medium	Air (dry)	Water	Steel
Speed of sound at 0°C	330 m/s	1500 m/s	6000 m/s

As per definition,

Speed of sound

$$= \frac{\text{Distance travelled by the sound}}{\text{Time taken}}$$

REFLECTION OF SOUND

Like light, sound also gets reflected from a hard surface.

Echo

When sound waves strike a hard surface, they get reflected.

In a small room, the sound that reacthes us directly and the one which gets reflected from the walls, reach our ears almost at the same time. As a result, we hear only one sound.

When the sound gets reflected from a surface which is far away, we hear two sounds. The first sound is the sound which reaches us directly from the source. The second sound is the sound which reaches us after suffering reflection from the far off surfaces.

The sound which is received after reflection from a far off object is called an echo.

An echo is produced only when the listener is at a distance of 11 metres or more from the reflecting surface.

Applications of Echo-sounding

Determining the distance of a sound-reflecting surface by producing echo is called echo-sounding. This method is also called Sound Navigation and Ranging (SONAR).

Echo-sounding (or Sonar) is used

- for determining the depth of a sea
- by ships to detect submarines
- by bats and dolphins to locate any obstacle in their path.

To measure the depth of a sea, pulse of ultrasonic sound (high frequency sound) waves are sent down into the sea from a ship. These pulses after suffering reflection from the sea-bed are received back on the ship. The time taken by the sound to travel down and return back to the ship is measured. By knowing the speed of sound in the

sea water, the depth of the sea at that place can be determined.

Depth of the sea

$= \frac{1}{2} \times$ Total distance travelled by the sound pulse

or Depth of the sea

$= \frac{1}{2} \times$ Speed of sound in sea water $\times$ Total time taken

Ex. A ship out a sound wave and receives an echo after 1 second. If the speed of sound in water is 1500 m/s. What is the depth of the sea at that point ?

Sol. Given :

Total time taken by the sound wave = 1s

Speed of sound in the sea water = 1500 m/s

Then, depth of the sea

$= \frac{1}{2} \times$ Speed of sound $\times$ Total time taken

or, depth of the sea $= \frac{1}{2} \times 1500 \text{ m/s} \times 1\text{s} = 750 \text{ m}$

CHARACTERISTICS OF SOUND

A sound is characterised by the following characterisitcs :

1. Loudness
2. Pitch
3. Quality or tone

Loudness

Loudness of a sound depends on the amplitude of the vibration producing that sound. Greater is the amplitude of vibration, louder is the sound produced by it.

The loudness of a sound also depends on the quantity of air that is made to vibrate. Loudness of sound is measured in decibel (dB) unit.

Pitch

The shrillness of a sound is called its pitch. The pitch of a sound depends upon its frequency. Higher the frequency of a sound, higher is its pitch.

The voice of a child or a women has higher frequency than the voice of a man.

That is why, the voice of a child or a woman is more shrill as compared to the voice of a man.

The stretched membrane of a tabla or mridangam produces sound of a higher frequency (or of higher pitch).

Quality

Quality of a sound is also called its tone. We can easily distinguish between the sounds produced by different sources. Let us see how does it become possible. A tuning fork produces the sound of a single frequency. Most other instruments usually produce sounds (called notes) which consist of a basic or fundamental frequency and a number of overtones or harmonics of different loudness.

Different instruments, depending on their shape and size, produce different number of harmonic of different relative loudness. As a result, the sound produced by an instrument can be distinguished from that produced by other instruments.

NOISE–A HEALTH HAZARD

Loud and harsh sound is called noise. Noise is produced by irregular vibrations.

The disturbance caused by an undesirated loud sound of different kinds is called noise pollution. Noise pollution is caused by motors, trains, aeroplanes, radio, T.V. and loudspeakers etc.

Effect of Noise Pollution

Noise pollution may cause,

- Hearing loss – prolonged exposure to high noise level can lead to loss of hearing.

- Fatigue
- High blood pressure
- Extreme emotional behavior.

◈ Ways to Reduce Noise Level

Noise level can be reduced by the following activities :

- Setting up of industry away from the residential areas and planting more trees.
- Restricted use of loudspeakers, amplifiers, and upto horns.
- Using soft/carpeted floors, curtains and sound absorbers such as cork thermocole indoor can reduce the noise level.

➢ THE HUMAN EAR

Sound waves from outside are collected by the outer ear and reach the eardrum. When the sound waves strike the eardrum, it starts vibrating. These vibrations are passed on to the oval window by three bones (called the hammer, anvil and stirrup) which act as a lever with the pivot at point P. They magnify the force of the vibrations. The oval window has a smaller area than the eardrum. So this increases pressure on the oval window and on the liquid in the cochlea.

The vibrations of the liquid in the cochlea affect thousands of auditory nerves which send message to the brain.

Our ears are very delicated and frangile organs. Proper care must be taken to keep them in healthy state.

Some suggestions to keep the ears healthy are given below :

- Never insert any pointed object into the ear. It can damage the eardrum and make a person deaf.
- Never shout loudly into someone's ear.
- Never hit anyone hard on his/her ear.