CHAPTER 13

SOUND

Student's learning outcomes (SLOs)

After studying this chapter, students will be able to:

- describe the production of sound.
- describe the longitudinal nature of sound waves.
- state the approximate range of frequencies audible to humans as 20 Hz to 20,000 Hz.
- justify why sound waves cannot travel in vacuum (including experiments to demonstrate this).
- describe how changes in amplitude and frequency affect the loudness and pitch of sound waves.
- describe how different sound sources produce sound waves with different quality (including making reference to the shape of the traces on an oscilloscope).
- describe an echo as the reflection of sound waves.
- justify simple experiments to show the reflection of sound waves.
- illustrate a method involving a measurement of distance and time for determining the speed of sound in air.
- state that the speed of sound in air is approximately 330-350 $m\ s^{-1}$.
- describe that, in general, sound travels faster in solids than in liquids and faster in liquids than in gases.
- define ultrasound as sound with a frequency higher than 20 kHz.
- illustrate and analyze the uses of ultrasound (in cleaning, parental and other medical scanning, and in sonar, including calculation of depth or distance from time and wave speed).
- illustrate the use of infrasound (e.g., by elephants in communication and in the study of seismic activity).
- analyze the effects of noise pollution on the environment.
- justify the importance of acoustic protection.
- describe how knowledge of the properties of sound waves is applied in the design of buildings with respect to acoustics.
- explain the use of soft materials to reduce echo sounding (such as in classroom studies and other public gathering buildings).
- explain, with examples, how sound can reflect, refract, and diffract.

Sound waves are simple to generate. When we speak, our vocal cords vibrate, producing sound waves. Any object that vibrates in the air causes nearby air layers to vibrate as well, which in turn affects adjacent layers. This continuous vibration pushes and pulls the air, creating waves of compression and rarefaction. When these waves reach our ears, they cause our eardrums to vibrate, allowing us to perceive sound. As these vibrations move through the air, they form sound waves. These waves are longitudinal, meaning air particles oscillate back and forth in the same direction as the wave's energy transfer. The speed at which sound waves travel through the air is approximatly 330-350 m s^{-1} . In this chapter, we will explore the fascinating world of sound, how it moves, reflects, bends, and helps us understand both nature and technology.

13.1 Production and Propagation of sound

Production of Sound

Sound is produced by vibrating objects. When an object vibrates, it makes the air around it to vibrate as well. These air vibrations travel to our ears and create the sensation of sound.

For example, in a guitar, the sound is produced when its strings vibrate (Fig. 13.1). Similarly, our voice is produced by the vibrations of our vocal cords. The human heart and other organs like the lungs also create sound waves when they vibrate. Doctors use a stethoscope to listen to these sounds.

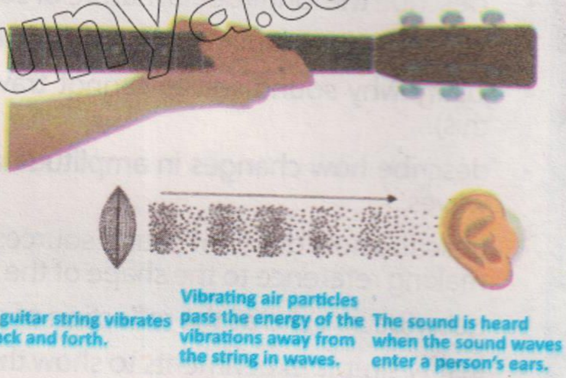


Fig. 13.1: Vibrations of guitar strings produce sound waves

Tidbit

Sound needs a medium (like air, water, or solids) to travel through. In vacuum, there are no particles to vibrate, which is why sound cannot travel there.

Activity 13.1: In school laboratories, tuning fork is used to produce a specific sound. When a rubber hammer is struck with the tuning fork, it begins to vibrate (Fig. 13.2). By bringing it close to our ear, we can hear the sound produced by these vibrations.

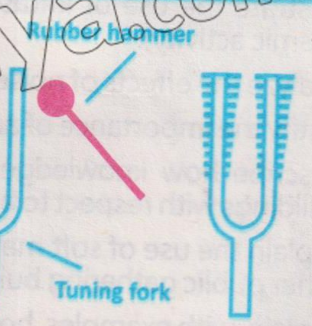


Fig. 13.2: Strike a rubber hammer on a tuning fork to produce vibrations

We can also observe the vibrations of a tuning fork by bringing one of its prongs in contact with a small table tennis ball hanging from a thread (Fig. 13.3). When the vibrating prong touches the ball, the ball moves, showing the presence of vibrations. Similarly, if we place the vibrating tuning fork into a glass of water, we will notice water splashing. But what causes this splash? This simple activity demonstrates that vibrations are responsible for producing sound.

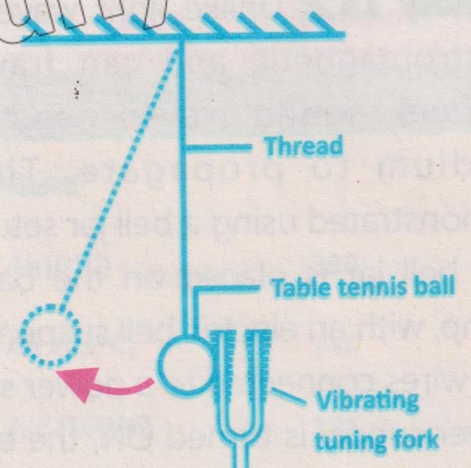


Fig. 13.3: The production of sound waves from a vibrating tuning fork

Propagation of Sound

Sound needs a medium, such as air, water, or a solid, to travel from one place to another. When a tuning fork vibrates, it creates compressions (high pressure) and rarefactions (low pressure) in the air, allowing sound to travel. As the prong moves forward, it pushes air molecules together, forming a compression that moves outward. When it moves back, it creates a rarefaction, where air molecules spread apart. This continuous cycle of compressions and rarefactions propagates sound as a longitudinal wave, meaning air molecules move in the same direction as the wave (Fig. 13.4). The wavelength of a sound wave is the distance between two successive compressions or rarefactions.

Do You Know?

Sound is a
MECHANICAL WAVE

- Sound requires a medium
- Sound can travel in a solid, liquid or gas

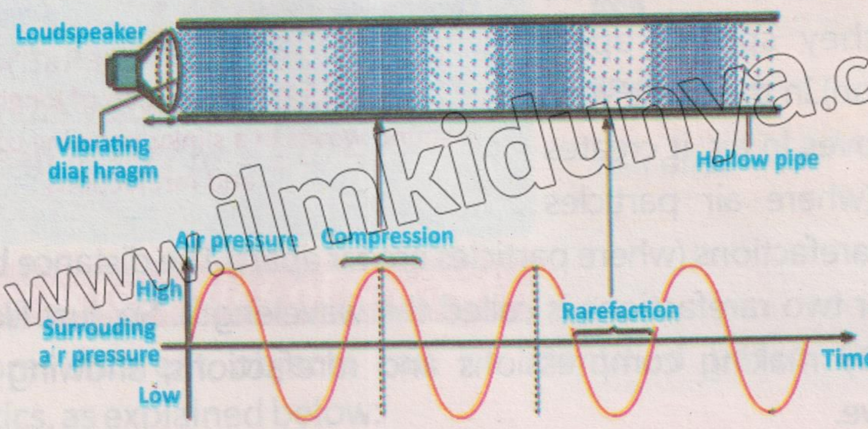


Fig. 13.4: Longitudinal waves showing compression and rarefaction in sound propagation

Activity 13.2: Unlike light waves, which are electromagnetic and can travel through vacuum, sound waves need a material medium to propagate. This can be demonstrated using a bell jar setup (Fig. 13.5). The bell jar is placed on the base of a vacuum pump, with an electric bell suspended inside using two wires connected to a power supply. When the power supply is turned ON, the electric bell rings, and we can hear the sound. Next, air is pumped out of the jar using the vacuum pump. As the air is removed, the sound of the bell becomes weaker and eventually fades, even though the bell continues ringing. When air is reintroduced into the jar, the sound becomes audible again. This demonstrates that sound waves require a medium, such as air, to propagate.

Brain Teaser

If sound is created by vibrations, how do particles move when sound waves pass through the air?

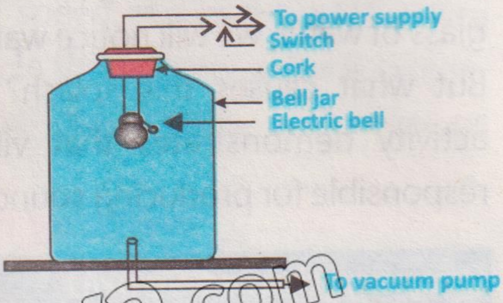


Fig.13.5: Bell jar apparatus

Longitudinal Nature of Sound Waves

The propagation of sound waves can be understood through the example of a slinky (Fig. 13.6). Sound travels in the form of a longitudinal wave. This means the particles of air move back and forth in the same direction as the sound wave. If we push and pull one end of the slinky, we will see some parts where the coils come close together (called compression) and some parts where they spread apart (called rarefaction).In the same way, when sound moves in air, it creates compressions (where air particles are closer) and rarefactions (where particles are far apart).The distance between two compressions or two rarefactions is called the wavelength. So, just like the slinky, sound moves by making compressions and rarefactions, showing that it is a longitudinal wave.

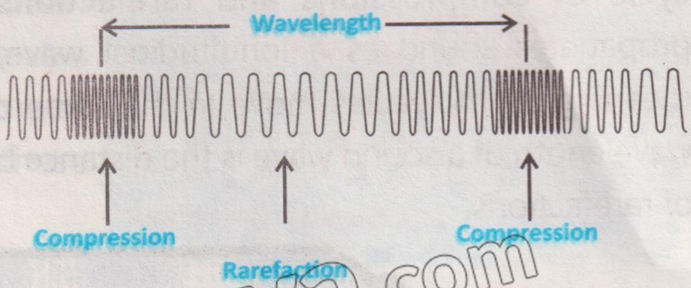


Fig. 13.6: Propagation of longitudinal sound waves in a slinky, showing compressions and rarefactions

13.2 Speed of Sound

Sound waves require a medium with vibrating particles to travel and cannot propagate through vacuum. The speed of sound varies with the type of medium. It moves 5 times faster in liquids and 15 times faster in solids than in gases. In air, factors like temperature, and humidity affect its speed. At room temperature (21°C), sound travels at 343 m s^{-1} in air, increasing with higher temperature and humidity. Since solids and liquids transmit sound faster than gases, the material of the medium plays a key role in determining sound speed. The speed of sound v is calculated using a specific equation:

$$v = f\lambda \text{ .... (13.1)}$$

where v is the speed of sound, f is the frequency, and λ is the wavelength of the sound wave. The speed of sound in various media is shown in

Example 13.1: Calculate the frequency of a sound wave of speed 340 m s^{-1} and wavelength 2.0 m.

Solution:

Given that;

Speed of wave v = 340 m s^{-1}

Wavelength λ = 2.0 m

To find; f =?

Using the formula; $v = f\lambda$ or $f = v/\lambda$

Substituting the values

$$f = 340 \text{ m s}^{-1}/2 \text{ m} = 170 \text{ Hz}$$

Table 13.1: Speed of sound in various media

Medium	Speed (m s^{-1})
Gases	
Air(0°C)	330
Air (25°C)	346
Air (100°C)	391
Hydrogen (0 °C)	1290
Oxygen (0°C)	317
Helium (0°C)	972
Liquids at 25°C	
Distilled water	1498
Sea water	1531
Solids at 25°C	
wood	200
Aluminium	6420
Brass	4700
Nickel	6040
Iron	5950
Steel	5960
Flint Glass	3980

13.3 Characteristics of Sound

Sounds from different objects can be identified based on their distinct characteristics, as explained below:

Loudness

Loudness is a property of sound that allows us to differentiate between loud and faint sounds.

For example, when speaking with friends, our voice is soft, but while addressing a large audience, we speak louder. The loudness of a sound depends on several factors, which influence how we perceive its intensity. Some of these factors are discussed below:

Brain Teaser

Does the loudness of a sound affect the time it takes for an echo to return?

(a) Amplitude of the vibrating body

The loudness of sound depends on the amplitude of the vibrating object (Fig. 13.7). If we pluck the strings of a guitar with more force, the vibrations will have greater amplitude, producing a louder sound. Likewise, striking a drum harder causes its membrane to vibrate more intensely, resulting in a louder noise.

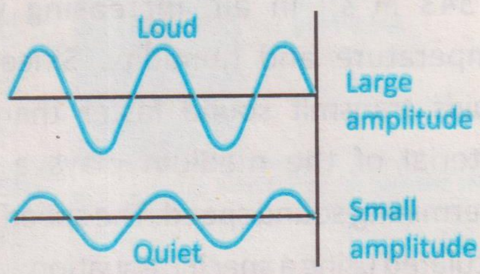


Fig. 13.7: Variation of loudness with amplitude

(b) Area of the vibrating body

The loudness of sound is also influenced by the size of the vibrating surface. A large drum produces a louder sound than a smaller one because its greater surface area allows more air to vibrate. Similarly, striking a tuning fork alone creates a faint sound, but placing it on a solid surface, like a bench, amplifies the sound. This demonstrates that a larger vibrating area increases loudness, while a smaller area produces a weaker sound.

(c) Distance from the vibrating source

The loudness of a sound decreases as the distance between the vibrating source and the listener increases. This occurs because the amplitude of the sound wave diminishes with distance. Additionally, the perception of loudness varies based on the listener's hearing ability. A person with sensitive ears perceives sound as louder compared to someone with hearing impairment. However, there is a physical characteristic of sound that remains independent of the listener's hearing ability. This is known as the intensity of sound, which is a measurable quantity and does not rely on human perception.

Pitch

Pitch is the characteristic of sound that allows us to differentiate between a shrill and a deep (grave) sound.

It is directly related to frequency, higher frequency results in higher pitch, while lower frequency produces lower pitch.

For example, the voices of women and children have a higher frequency, making them shrill and high-pitched, whereas the voices of men have a lower frequency, giving them a deeper and lower-pitched sound.

The relationship between pitch and frequency is represented in Fig. 13.8.

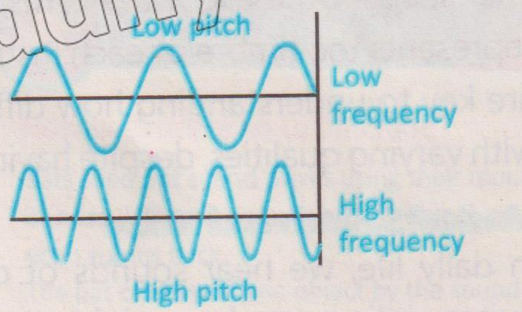
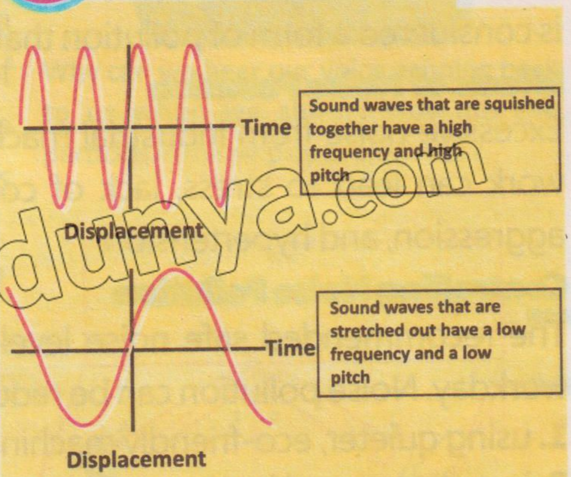


Fig 13.8: Variation of pitch with frequency

Do You Know?



Quality of Sound

The quality of sound allows us to differentiate between two sounds having the same loudness and pitch.

This distinct quality arises due to the unique waveforms produced by each sound source.

For example, a violin, trumpet, flute, and oboe each generate a distinctive waveform. As illustrated in Fig. 13.9, the oscilloscope traces of these instruments show different shapes, with varying levels of complexity and harmonics. The violin has a rich, complex waveform, while the flute produces a simpler, more regular waveform. The trumpet and oboe each exhibit their own unique oscillation patterns, further demonstrating the diversity in sound production among instruments.

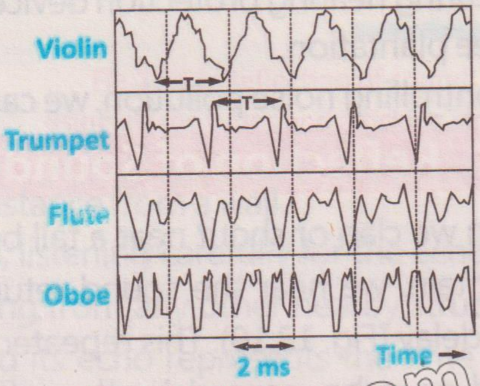


Fig. 13.9: Oscilloscope traces of different sound sources

Tidbit

The shape of a sound wave on an oscilloscope is affected by the instrument's unique construction and the way it produces vibrations.

The shape of these waveforms, when displayed on an oscilloscope, visually represents the timbre of each instrument. These differences in waveform structure are key to understanding how different sound sources can produce sound waves with varying qualities, despite having the same pitch and loudness.

Musical Sounds and Noise

In daily life, we hear sounds of different qualities. Musical instruments like the guitar, violin, recorder, and drum produce sounds with controlled pitch and quality, which are pleasant to hear. Such sounds are called musical sounds. However, some sounds, like traffic noise, door slamming, and machinery, are harsh and unpleasant. These are classified as noise. Noise results from irregular and sudden vibrations and is considered a form of pollution that affects both humans and animals.

Effects of Noise Pollution

Excessive noise from industrial machinery, vehicle horns, alarms, and construction work can lead to stress, lack of concentration, hearing loss, sleep disturbances, aggression, and hypertension.

Controlling Noise Pollution

The recommended safe noise level is 85 – 90 dB for a maximum of eight-hour workday. Noise pollution can be reduced by

1. using quieter, eco-friendly machinery.

2. installing sound barriers.

3. wearing hearing protection devices.

4. Tree plantation.

By controlling noise pollution, we can create a healthier environment.

13.4 Reflection of Sound (Echo)

When we clap or shout near a tall building or mountain, we hear the sound return after a brief delay (Fig. 13.10). This repeated sound is called an echo, caused by the reflection of sound waves from a surface.

Fig. 13.10: Reflection of sound

When sound waves hit a surface and bounce back into the same medium, the phenomenon is called an echo or reflection of sound.

The human brain retains sound for about 0.1 seconds, so to hear a distinct echo, the reflected sound must reach us after at least 0.1 seconds. Given the speed of sound in air (340 m s^{-1}), the minimum distance for an echo to form is 34 metres (total distance travelled by sound), meaning the reflecting surface must be at least 17 metres away. Echoes can also repeat multiple times due to successive reflections.

Activity 13.3: (Reflection of Sound)

Take two identical plastic tubes of appropriate length (or create them using chart paper) as shown in Fig. 13.11. Position the tubes on a table, ensuring they are near a wall. Place a clock close to the open end of one tube and listen for its sound through the other tube. Adjust the alignment of the tubes until the sound of the clock is distinctly heard. Measure the angles of incidence and reflection, then analyze their relationship. Gently raise the right tube slightly upward and observe any changes that occur.

Do You Know?

How bats use echo to find food?

Bats send out sound waves using their mouth or nose. When the sound hits an object, an echo comes back.

The bat can identify an object by the sound of the echo. They can even tell the size, shape and texture of a tiny insect from its echo.

Brain Teaser

Why can we hear our voice echoing back to us when we shout? How do the particles in the air play a role in this?

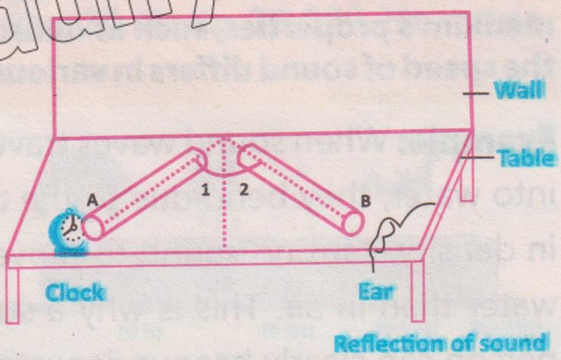


Fig.13.11: Reflection of sound using plastic tubes and a ticking clock

Measuring Speed of Sound by Echo Method

Apparatus: Measuring tape, stopwatch, flat wall that can produce a good echo.

Procedure

1. Use a measuring tape to mark a 50 m distance from a wall.
2. Stand at this point and clap your hands, listening carefully for the echo from the wall. Ensure the echo is not reflecting from any other nearby structures. The time interval between the clap and its echo represents the time taken for sound to travel 100 m.
3. Begin clapping rhythmically and start a stopwatch with the first clap. Count each clap and stop both the clapping and the stopwatch upon hearing the echo of the 10 th clap.
4. Determine the average time for 10 claps. By calculating the time interval t between consecutive claps and applying the formula; $S=vt$, the speed of sound can be computed.

Brain Teaser

Can we hear someone scream if we are in space with him?

Example 13.2: Flash of lightning is seen 2 seconds earlier than the thunder. How far away is the cloud in which the flash has occurred? (Speed of sound = 332 m s^{-1})

Solution:

Given that;

Time t = 2 s

Speed of sound v = 332 m s^{-1}

To find;

Distance S = ?

As distance of the cloud; $S = vt$ = 332 m s^{-1} x 2s ; S = 664 m

13.5 Refraction and Diffraction of Sound

Sound waves, like other waves, exhibit various behaviours, including refraction and diffraction, in addition to reflection. Here is a closer look at these phenomena.

Refraction of Sound

Refraction occurs when sound waves change direction due to a variation in the medium's properties, such as density or temperature. This change occurs because the speed of sound differs in various mediums.

Example: When sound waves travel from air into water, they bend due to the difference in density, causing sound to move faster in water than in air. This is why a submerged person can clearly hear underwater sounds, while someone above the surface may struggle to hear them (Fig. 13.12).

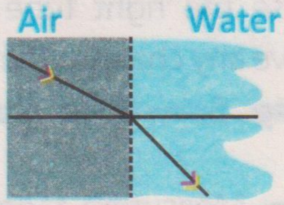


Fig.13.12: Refraction of sound

Diffraction of Sound

Diffraction occurs when sound waves bend around obstacles or spread out after passing through narrow slits (Fig. 13.13). This property allows sound to be heard even when the source is not in direct view.

Example: If someone is speaking from behind a wall, his voice can still be heard because the sound waves bend around the barrier. Similarly, sound can travel through

Fig.13.13: Diffraction of sound waves

an open doorway and spread into a room, allowing people inside to hear noises from the outside even if they cannot see the source.

We can hear someone speaking even if he is around a corner or behind a wall. This is because sound waves diffract around the obstacle and reach our ears.

> **Tidbit**
>
> Refraction of sound occurs when it travels through layers of air at different temperatures. That is why on a cool morning, sound may travel farther it bends back toward the ground due to slower speed in colder air. This is why distant train horns or bird calls sound clearer at dawn.

Diffraction is the bending of sound waves around obstacles or through slits. It allows sound to spread out and be heard even when the source is not directly visible.

13.6 Audible Frequency

The human ear can detect sounds within the 20 Hz to 20,000 Hz range, known as the audible frequency range.

Sounds below 20 Hz or above 20,000 Hz are inaudible to humans (Fig. 13.14). Hearing ability declines with age. Young children can hear up to 20,000 Hz, while older individuals may struggle with sounds above 15,000 Hz.

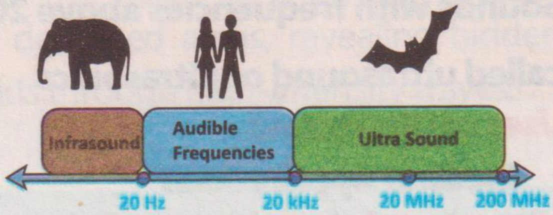


Fig.13.14: Frequency of sound

Infrasound

Infrasound refers to waves below 20 Hz, which humans cannot hear but may feel as vibrations.

> **Tidbit**
>
> Infrasound sensors are used to monitor volcanic eruptions, earthquakes, and even tsunamis before they strike. The low-frequency waves from these natural events travel great distances and help scientists issue early warnings!

Many animals, like elephants and whales, use infrasound for communication. It is produced by natural events (earthquakes, volcanoes), industrial processes, and human activities (machinery, explosions). Due to its ability to travel long distances, infrasound is used for monitoring natural disasters.

Uses of Infrasound

- **Elephant Communication:** Elephants use infrasound to communicate over long distances. Their deep rumbles travel far through air and ground, helping them stay connected. They can sense these vibrations not just with their ears but also through their feet and trunks.

- **Earthquake Detection:** Scientists use infrasound to detect earthquakes before the strong shaking starts. These low-frequency waves act as an early warning system.

Do You Know?

Blue whales, the largest animals on the Earth, sing in infrasound that can travel across entire oceans! These deep calls help them communicate with others even when they are hundreds of kilometres apart.

- **Volcano Monitoring:** When a volcano erupts, it creates unique infrasound waves. Scientists study these waves to predict eruptions and assess risks.
- **Nuclear Explosion Detection:** Special sensors track infrasound waves from nuclear explosions.

Ultrasound

Sounds with frequencies above 20,000 Hz, which are inaudible to humans, are called ultrasound or ultrasonics.

Uses of Ultrasound

- **Medical Applications**

Ultrasound is widely used in medical diagnostics and treatments. When ultrasonic waves pass through the body, they reflect differently from various tissues and organs. These reflected waves are then captured and converted into images on a screen, a process known as ultrasonography. This helps in visualizing organs such as the heart, liver, and kidneys, as well as in monitoring pregnancies.

Do You Know?

Doctors use ultrasound waves to "see" inside the body without cutting it open! These waves are completely non-invasive and safe, making them ideal for monitoring babies during pregnancy or detecting organ problems.

For example, parental scanning uses ultrasound to observe the fetus inside the womb, assess its development, and detect any potential issues. Additionally, ultrasound aids in thyroid gland imaging for diagnosis, providing clear visual representations that help doctors evaluate thyroid health.

Underwater Exploration (SONAR)

Ultrasound is used to measure ocean depth and locate objects on the seabed. SONAR (Sound Navigation and Ranging) works by sending ultrasonic waves into water; the reflected waves help to determine the distance and shape of an object (Fig. 13.15).

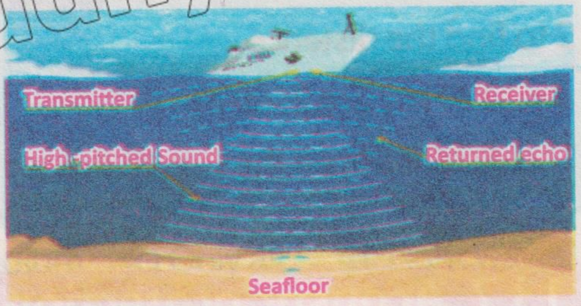


Fig. 13.15: Illustration of sonar used by a ship

Calculating Distance in SONAR

The formula used to calculate distance (or depth) in sonar systems is:

Distance = (Speed of Sound in Water × Time) / 2 .... (13.2)

where speed of sound in water is approximately 1500 m s^{-1} at room temperature. Time is the duration it takes for the ultrasound pulse to travel to the object and return to the source. The distance is divided by 2 because the pulse travels to the object and then returns to the source.

Industrial Applications

Ultrasound helps to detect cracks in machines like turbines, ship engines, and airplane parts. Ultrasound waves reflect from damaged areas, revealing hidden defects. It is also used to destroy bacteria in liquids through high-intensity waves.

Example 13.3: A sonar device on a ship sends out a sound pulse that returns after 3.2 seconds. If the speed of sound in water is 1600 m s^{-1}, what is the distance from the ship to the seafloor?

Solution:

Given that;

Time for the sound pulse to return t = 3.2 seconds

Speed of sound in water v = 1600 m s^{-1}

To find; distance d = ?

The sound pulse travels to the seafloor and back, so the total distance covered is twice the distance from the ship to the seafloor.

Using the formula; $d = v \times t$

Substituting the values

$$d = 1600 \text{ m s}^{-1} \times 3.2 \text{ s} = 5120 \text{ m}$$

Since the distance covered is twice the actual distance to the seafloor, we divide by

2 to find the distance.

$d = 5120 \text{ m} / 2 = 2560 \text{ m}$

The distance from the ship to the seafloor is 2560 metres.

13.7 Acoustic protection of Buildings

Acoustic protection reduces unwanted sound using soft, porous materials like carpets and curtains, which absorb sound and minimize echoes. Hard, smooth surfaces reflect more sound, while excessive absorption can weaken audibility in classrooms and halls (Fig. 13.16-a). Multiple reflections, known as reverberation, can distort sound, so a balance between reflection and absorption is essential in auditoriums, lecture halls, and theatres. Reflective surfaces behind the stage help direct sound to the audience. Additionally, curved ceilings and sound boards are often used to ensure even sound distribution throughout the hall (Fig. 13.16-b).

Tidbit

In concert halls and theatres, curved ceilings and soft walls do not just look stylish. They are engineered to shape sound! While carpets and curtains absorb echoes, curved panels and reflectors bounce the music toward the audience so that even the person in the last row hears every note clearly. That is the science of acoustics protection—a perfect harmony of silence and sound!

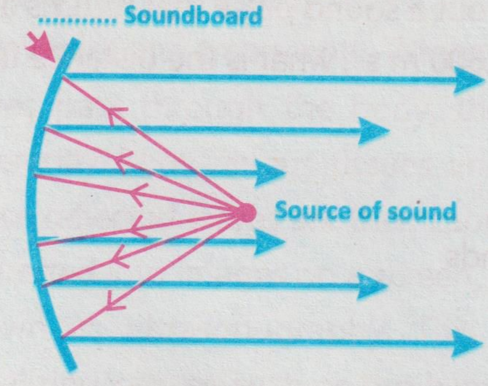


Fig. 13.16(a): Soundboard used in a big hall

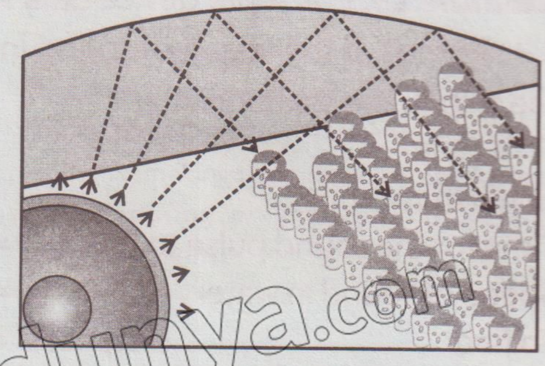


Fig. 13.16(b): Curved ceiling of a conference hall

EXERCISE

A. Multiple Choice Questions

Tick (✓) the correct answer.

13.1 What is required for the production of sound?
(a) A vacuum (b) Vibrations of a medium (c) Only air (d) Light waves

13.2 An echo is produced due to:
(a) refraction of sound waves (b) reflection of sound waves
(c) diffraction of sound waves (d) absorption of sound waves

13.3 An example of a longitudinal wave is:
(a) light wave (b) water wave (c) sound wave (d) radiowave

13.4 In which medium does sound travel the fastest?
(a) Gases (b) Liquids (c) Solids (d) Vacuum

13.5 What is the approximate speed of sound in air?
(a) 150 m s^{-1} (b) 330-350 m s^{-1} (c) 500 m s^{-1} (d) 1,000 m s^{-1}

13.6 Why is acoustic protection important in building design?
(a) To increase noise pollution (b) To reduce echo and improve sound quality
(c) To amplify sound (d) To increase the speed of sound

13.7 For a normal person, the audible frequency range for sound waves lies between:
(a) 10 Hz and 10 kHz (b) 20 Hz and 20 kHz
(c) 25 Hz and 25 kHz (d) 30 Hz and 30 kHz

B. Short Answer Questions

13.1 How does the medium affect the speed of sound?
13.2 Does sound waves show reflection?
13.3 What factors influence the loudness of sound?
13.4 Why do we hear an echo when we clap near a building?
13.5 What is ultrasound, how is it used in medicine?

C. Constructed Response Questions

13.1 Why does a tuning fork placed on a wooden table produce a louder sound than when held in the air? What does this tell us about the role of surface area in sound propagation?
13.2 If sound needs a medium to travel, how does the bell jar experiment prove this requirement? What happens when air is removed, and why?
13.3 A person hears his echo when shouting near a tall building. Why must the building be at least 17 metres away for the echo to be heard clearly?

13.4 Why do voices of men sound deeper than those of women or children, even when they are speaking at the same intensity? Explain using the relationship between frequency and pitch.

13.5 In what ways do soft materials like carpets or curtains improve the acoustics of a room? How do they affect echoes and sound quality?

13.6 When a person claps near a canyon and hears the echo after a few seconds, how can they calculate the distance to the canyon? What principle is used in this method?

D. Comprehensive Questions

13.1 What is the approximate speed of sound in air, and what factors affect it?

13.2 Why does sound travel faster in solids than in liquids and gases? Explain.

13.3 How do amplitude and frequency, affect the quality of sound? Explain.

13.4 How does echo occur? Explain.

13.5 How do reflection, refraction, and diffraction affect the behaviour of sound waves?

13.6 What are infrasound and ultrasound, and how are they used in different applications?

E. Numerical Problems

13.1 At a particular temperature, the speed of sound in air is 333 m s^{-1}. If the wavelength of a sound wave is 3 cm, calculate the frequency of the sound wave. Is this frequency in the audible range of the human ear?

[Ans: 11 kHz, yes audilble]

13.2 A clock chimes 48 times in 1 minute. Calculate the frequency and period of the chimes.

[Ans: 0.8 Hz, 1.25 s]

13.3 A car horn emits a sound with a wavelength of 0.5 m. If the speed of sound in air is 340 m s^{-1}, calculate the frequency of the sound produced by the car's horn.

[Ans: 680 Hz]

13.4 A wave travels with a speed of 500 m s^{-1} and has a wavelength of 2 metres. Calculate the time period of the wave.

[Ans: 0.004 s]

13.5 A research boat sends a sound wave straight to the seabed and receives the echo 2 seconds later. The speed of sound in seawater is 1600 m s^{-1}. Find the depth of the sea at this position.

[Ans: 1600 m]

13.6 A person claps his hands near a mountain and hears the echo after 6 seconds. If the speed of sound is 343 m s^{-1}, what is the distance of the mountain from the person?

[Ans: 1029 m]