

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 $330\text{--}350\text{ m s}^{-1}$.
- 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.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

Introduction

Q.1: How is sound produced and how does it propagate?

Ans. The Mechanism of sound waves:

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 receive sound. As these vibrations move through the air, they form sound waves.

Nature of Sound Waves: These waves are longitudinal, meaning air particles oscillate back and forth in the same direction as the waves energy transfer.

Speed of sound waves: The speed at which sound waves travel through the air is approximately $330\text{--}550\text{ ms}^{-1}$. In this chapter, we will explore the fascinating world of sound, how it moves, reflects, bends and helps us to understand both nature and technology.

13.1

Production and Propagation of Sound

Q.2: How is sound produced, and what specific materials or instruments can be used to demonstrate this process?

Ans. Production of Sound:

Sound is produced by vibrating objects. When an object vibrates, it causes the particles in the surrounding medium (like air) to vibrate as well, creating a sensation of sound when those vibrations reach our ears.

Examples of sound production:

Several materials and biological organs can produce sound through vibrations.

Tuning fork and rubber hammer: In a laboratory setting, striking a metal tuning fork with a rubber hammer causes the fork's prongs to vibrate, producing a clear, audible tone.

Guitar Strings: When a guitar string is plucked, it moves back and forth rapidly (vibrates), transferring energy to the air.

Vocal cords: In humans, the vibrations of vocal cords in the throat allow us to speak and



sing.

Internal organs: The heart and lungs also create sound waves as they move, doctors use a stethoscope to amplify these specific vibrations.

Note: Sound cannot travel in a vacuum because it requires a medium (solid, liquid, or gas) to carry the vibrations. Without particles to vibrate, there is no sound.

Q.3: With the help of an activity, how can we produce a sound in school laboratory?

Ans. Activity: 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. By bringing it close to our ear, we can hear the sound produced by these 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. 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. 13.2: Strike a rubber hammer on a tuning fork

Q.4: Describe how sound propagates through a medium as a wave?

Ans. Propagation of sound: Sound needs a medium, such as air, water, or a solid to travel from one place to another.

Sound is a mechanical wave that propagates by creating a continuous cycle of pressure changes in a medium. It moves through the following process.

The Mechanism of Propagation:

Compression: When a vibrating object (like a tuning fork prong) moves forward, it pushes air molecules together, creating a region of high pressure.

Rarefaction: When the object moves back, it creates a region where air molecules spread apart, known as low pressure.

Longitudinal wave: Sound is a longitudinal wave because the particles of the medium move in the same direction as the wave's energy transfer.

Wavelength: This is defined as the distance between two successive compressions or two successive rarefactions.

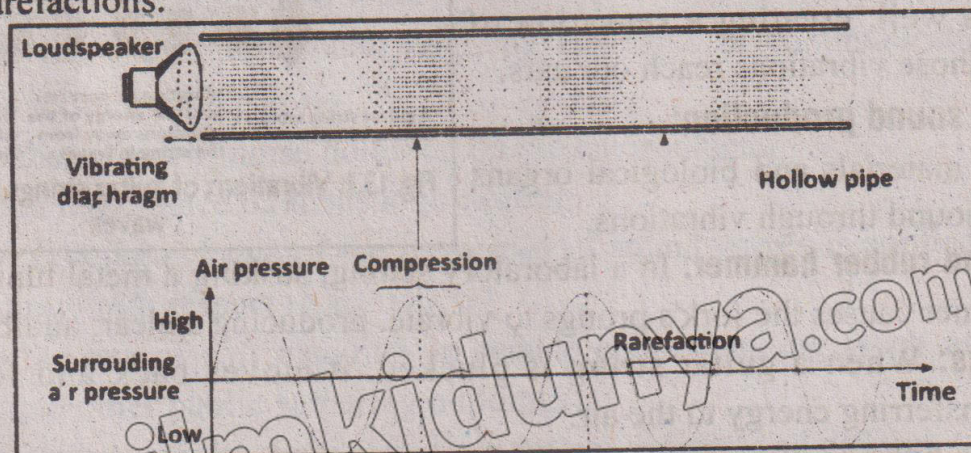


Fig. 13.4: Longitudinal waves showing compression and rarefaction in sound propagations

Q.5: Explain the propagation of sound with the help of an activity.

Ans. Activity: 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.

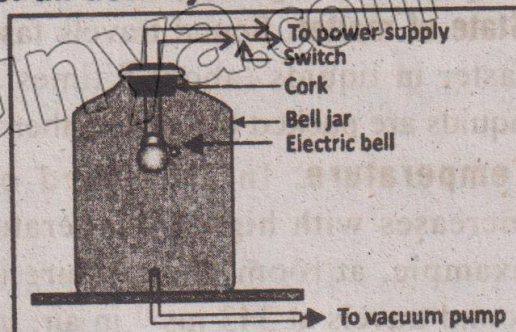


Fig. 13.5: Bell jar apparatus page 50

Q.6: Why is sound classified as a longitudinal wave, and what materials can be used to demonstrate this specific type of motion?

Ans. Longitudinal nature of sound waves:

Sound is classified as a longitudinal wave because the particles of the medium move back and forth in the same direction that the wave travels.

Examples:

- **Slinky (Spring):**

By pushing and pulling one end of a slinky, we can observe parts where the coils come close together (compression) and parts where they spread apart (rarefaction).

- **Sound moves in air:**

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.

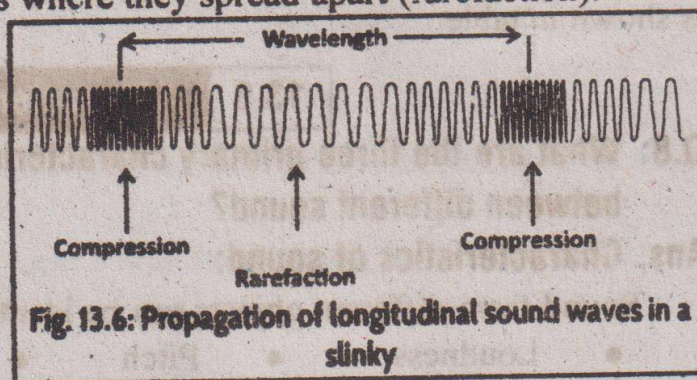


Fig. 13.6: Propagation of longitudinal sound waves in a slinky

Conclusion: So, just like the slinky, sound moves by making compressions and rarefactions, showing that it is a longitudinal wave.

13.2

Speed of Sound

Q.7: Define the speed of sound and explain how it is calculated? Discuss the factors that affect the speed of sound in different mediums such as solid, liquids, and gases?

Ans. Speed of Sound:

"The speed of a sound is the distance traveled by a sound wave per unit time".

Sound waves require a medium with vibrating particles to travel and cannot

propagate through vacuum.

State of matter: Sound travels fastest in solids (about 15 times faster than in gases) and faster in liquids (about 5 times faster than in gases) because particles in solids and liquids are packed closer together to transmit vibrations.

Temperature: In air, speed of sound increases with higher temperatures. For example, at room temperature (21 °C), sound travels at 343 ms⁻¹ in air, increasing with higher temperature.

Humidity: The presence of moisture in the air also affects how quickly sound waves can propagate.

Mathematical calculation: The material of the medium plays a key role in determining sound speed. The speed of sound can be calculated using the following equation:

$$v = f\lambda$$

Where:

- v = speed of sound
- f = frequency of sound
- λ = wavelength of sound wave

The speed of sound in various media is shown in table.

Medium	Speed (ms ⁻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

Q.8: What are the three primary characteristics of sound that allow us to distinguish between different sound?

Ans. Characteristics of sound:

Sound from different objects can be identified based on their distinct characteristics.

- Loudness
- Pitch
- Quality of sound

1. Loudness:

Loudness is the characteristics of sound that allows us to differentiate between a faint (soft) sound and a loud sound.

2. Pitch:

Pitch is the characteristic of sound by which we can distinguish between a shrill (sharp) and a grave (deep) sound.

3. Quality of sound:

Quality of sound is the characteristic that allows us to distinguish between two sounds of the same loudness and pitch produced by different sources e.g. a piano and a violin playing the same note.

Q.9: Define loudness and explain three physical factors of loudness and write also examples.

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

Examples: For example, when speaking with friends, our voice is soft, but while addressing a large audience, we speak louder.

Factors: The loudness of a sound depends on several factors, which influence how we perceive its intensity. Some of these factors are discussed below:

- Amplitude of the vibrating body
- Distance from the vibrating source
- Area of the vibrating body

(a) Amplitude of the vibrating body:

The loudness of sound depends on the amplitude (the maximum displacement of a vibrating particle from its mean position) of the vibrating object.

Example:

- If we pluck the strings of a guitar with more force, the vibrations will have greater amplitude, producing a louder sound.
- Striking a drum harder causes its membrane to vibrate more intensely, resulting in a louder noise.

(b) Area of the vibrating body:

The loudness of sound is also influenced by the size of the vibrating body. It demonstrates that a larger vibrating area increases loudness, while a smaller area produces a weaker sound.

Example:

- A large drum produces a louder sound than a smaller one because its greater surface area allows more to vibrate.
- Striking a tuning fork alone creates a faint sound but placing it on a solid surface, like a bench, amplifies the sound.

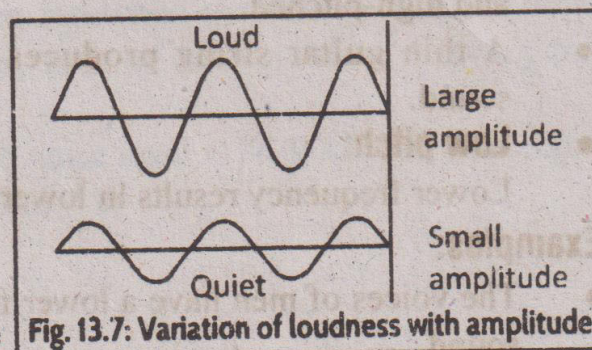
(c) Distance from the vibrating source:

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.

Examples: 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.

Intensity of sound: Intensity of sound is the amount of energy passing per second through a unit area held perpendicular to the direction of propagation of sound waves.

- It is a measurable quantity and does not rely on human perception.



Q.10: Define the pitch of a sound and explain how it is related to frequency?

Ans. Pitch:

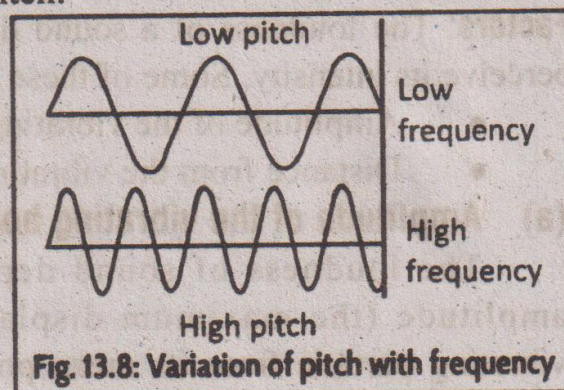
Pitch is the characteristic of sound that allows us to differentiate between a shrill (sharp) and a deep (grave) sound.

Relation with frequency: It is directly related to frequency.

- **High pitch:** Higher frequency results in higher pitch.

Example:

- The voices of women and children have a higher frequency, making them shrill (sharp) and high-pitched.
- A thin guitar string produces a high pitch sound.
- **Low pitch:**
Lower frequency results in lower pitch.



Examples:

- The voices of men have a lower frequency, giving them a deeper and lower-pitched sound.
- A thick guitar strip produce a low pitch sound.

Q.11: What is quality of sound? Explain how quality of sound helps us distinguish between different sound sources even when they have the same pitch and loudness?

Ans. Quality of sound:

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

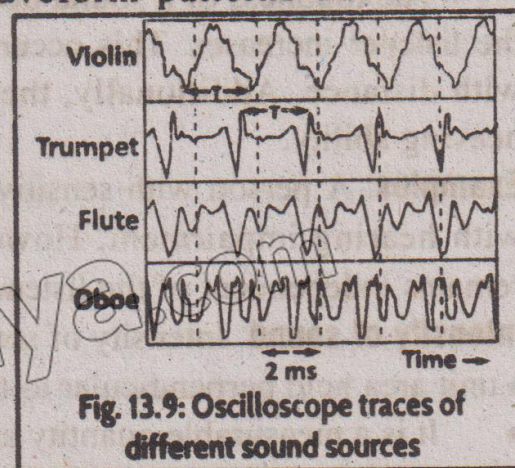
Waveform and Quality of Sound: The shape of sound waveforms, when displayed on an oscilloscope, visually represents the timbre of each instrument. The differences in waveform structure helps us to understand how different sound sources produce sound waves with different qualities. Even if two sounds have the same pitch and loudness, their waveform shapes are different which gives them a different timbre.

Examples: Different instruments create unique waveform patterns due to their construction and the way they produce sound.

Violin: Produces a very complex, jagged waveform, which corresponds to its rich "stringy" tone.

Flute: Produces a much smoother and more regular waveform which sounds "pure" or "mellow" to the ear.

Trumpet and Oboe: These instruments produce distinct, repeating patterns that are neither as smooth as flute nor as jagged as violin, giving them their characteristic brassy or nasal qualities.



Q.12: Define musical sound and noise. Explain its effects and how we can control noise pollution?

Ans. Musical sound:

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.

Noise: "Some sounds are harsh and unpleasant to hear. These are classified as noise".

Examples: For example traffic noise, door slamming and machinery etc.

Noise pollution: Noise results from irregular and sudden vibrations and is considered a form of pollution called noise pollution that affects both humans and animals.

Effects of noise pollutions: 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 85-90dB 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)

Q.13: Define the reflection of sound and explain the phenomenon of "echo" with the help of an example.

Ans. 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".

Echo: An echo is essentially the repetition of a sound, caused by these waves, reflecting off a surface.

Example:

- Clapping our hands near a tall building, we hear the sound repeat after a short delay.
- Standing in the mountains, our voice comes back to us clearly.
- Talking inside a large well, the sound reflects from the walls of the well.
- 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.
- The speed of sound in air (340 ms^{-1}), the minimum distance for an echo to form is

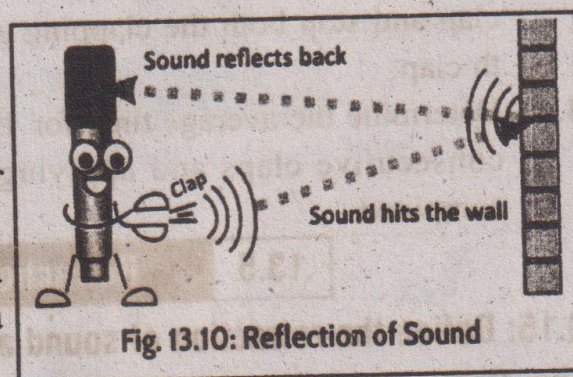
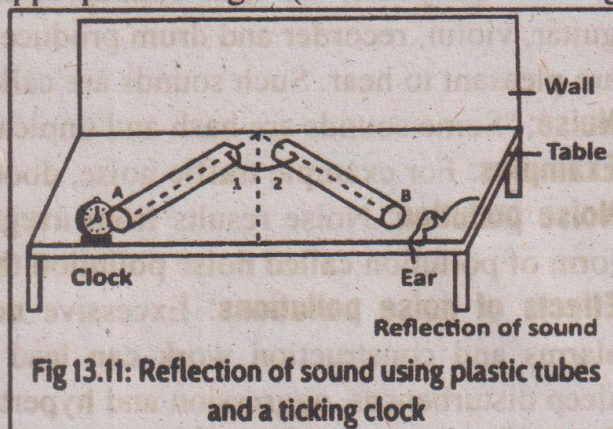


Fig. 13.10: Reflection of Sound

34 meters (total distance travelled by sound) meaning the reflecting surface must be at least 17 meters away. Echoes can also repeat multiple times due to successive reflections.

Activity: Take two identical plastic tubes of appropriate length (or create them using chart paper). 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.



Q.14: Measure the speed of sound with the help of Echo method.

Ans. 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 10th 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.

13.5

Refraction and Diffraction of Sound

Q.15: Define the refraction of sound and explain why it occurs. Also give examples.

Ans. Refraction of sound:

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

Cause of Refraction:

The primary reason for this change in direction is that the speed of sound differs in various mediums. When a sound waves lift the boundary of a new medium at an angle, one part of the wave changes speed before the rest, causing the entire wave front to bend.

Examples:

- 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 under water sounds, while someone above the surface may struggle to hear them.
- A spoon in a glass of water looks bent or broken.
- A coin in a bowl of water appears raised when water is added.

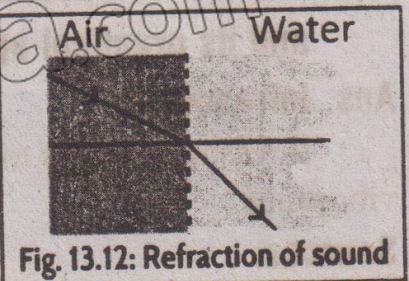


Fig. 13.12: Refraction of sound

Q.16: Define the diffraction of sound and explain why it occurs. Also give examples.

Ans. Diffraction of sound:

"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."

Occurrence: Diffraction occurs when sound waves bend around obstacles or spread out after passing through narrow slits. This properly allows sound to be heard when the source is not in direct view.

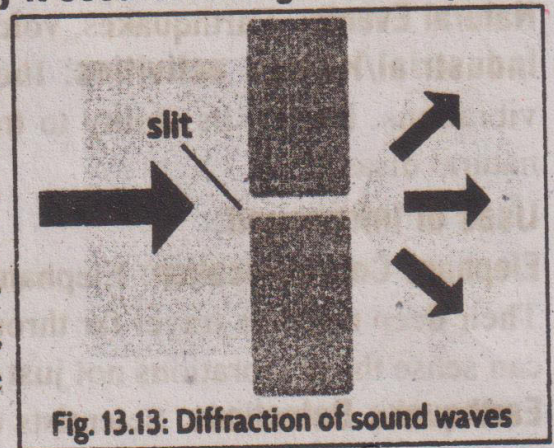


Fig. 13.13: Diffraction of sound waves

Examples:

- If someone is speaking from behind a wall, his voice can still be heard because the sound waves bend around the barrier.
- Sound can travel through 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 spreading even if he is around a corner or behind a wall. This is because sound waves diffract around the obstacle and reach our ears.

13.6

Audible Frequency

Q.17: Define the audible frequency range for humans and discuss how this range changes with age?

Ans. Audible frequency range:

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

Inaudible sounds:

Sounds below 20Hz or above 20,000Hz are inaudible to humans called inaudible sounds.

Impact of age on hearing: Hearing ability declines with age.

Young children: Young children can hear up to 20,000 Hz.

Olders: Older Individuals may struggle with sounds above 15,000 Hz.

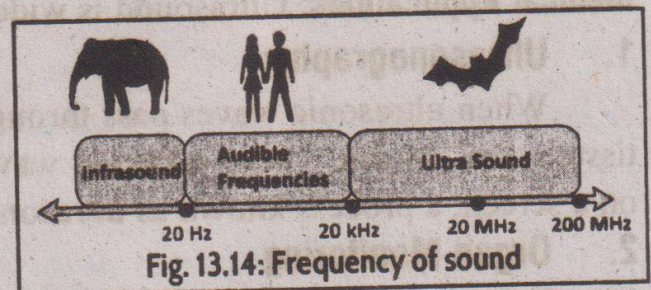


Fig. 13.14: Frequency of sound

Q.18: Define infrasound. Discuss its characteristics, natural and industrial sources, and its practical application in communication and disaster monitoring?

Ans. Infrasound:

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

Sources:

Biological Source: Many animals like elephants and whales, use infrasound to communicate over distance of several kilometers.

Natural Events: Earthquakes, volcanic eruptions, avalanches and tsunamis.

Industrial/Human activities: Industrial machinery, large explosions and structural vibrations. 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 Detections: Scientists use infrasound to detect earthquakes before the strong shaking starts. These low frequency waves act as an early warning system.

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.

Q.19: Define ultrasound and explain its various applications?

Ans. 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.

1. Ultrasonography:

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.

2. Organ Monitoring

It is used to visualize organs such as the heart, liver, and kidneys, as well as in monitoring pregnancies.

Examples:

1. Parental scanning uses ultrasound to observe the fetus inside the womb, assess its development, and detect any potential issues.
2. 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.

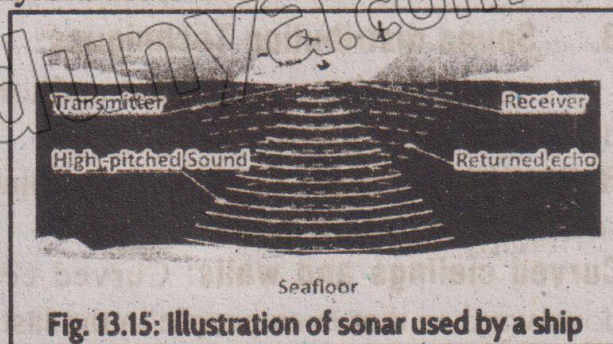


Fig. 13.15: Illustration of sonar used by a ship

- **Calculating Distance in SONAR:**

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

$$\text{Distance} = \frac{\text{Speed of sound in water} \times \text{time}}{2}$$

where speed of sound in water is approximately 1500 ms^{-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:**

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

13.7 Acoustic protection of Buildings

Q.20: What is acoustic protection of buildings and how does building design affect the quality and clarity of sound inside a hall or auditorium?

Ans. The acoustics of a building refers to the management of sound to ensure clarity and reduce noise. This is achieved by balancing two main techniques.

- Acoustic protection (Absorption)
- Sound Distribution (Reflection)

1. **Acoustic Protection and Absorption:**

To reduce unwanted noise and minimize echoes, buildings use soft and porous materials.

- **Materials used:** Carpets and curtains.
- **Purpose:** These materials absorb sound waves rather than reflecting them.
- **The Balance:** While absorption is necessary, excessive absorption can weaken audibility in class rooms and halls. Therefore, a balance must be struck to prevent sound from becoming too faint.

2. **Managing Reverberation**

Multiple reflections of sound in a large room can cause reverberation, which distorts the original sound. Architects design spaces to ensure that reflections do not

overlap in a way that makes speech or music unclear.

3. Sound distribution Techniques:

In large halls, theaters and auditoriums, specific architectural features are used to direct sound toward the audience.

Reflective Surfaces: Hard surfaces placed behind a stage (sound boards) help direct sound waves toward the listeners.

Curved ceilings and walls: Curved ceilings are engineered to reflect sound waves downward so that even people in the last row can hear clearly.

Sound boards: These are placed behind the sound source to ensure even sound distribution throughout the hall.

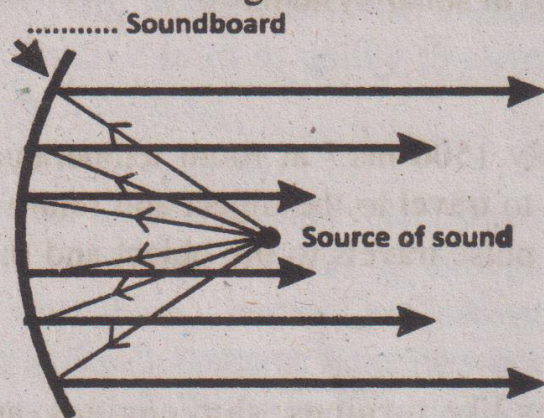


Fig. 13.16(a): Soundboard used in a big hall

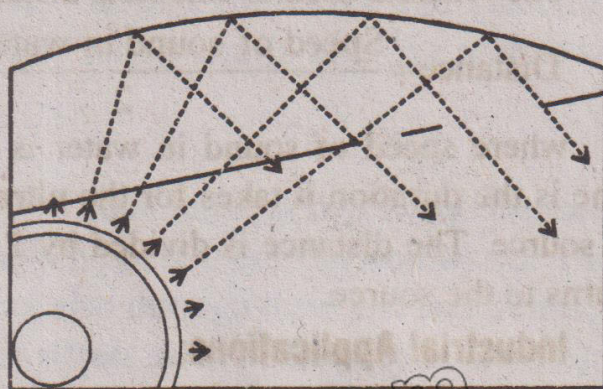
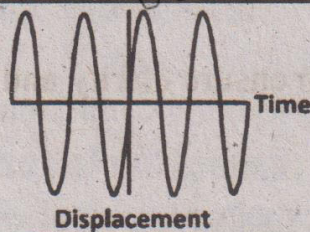


Fig. 13.16(b): Curved ceiling of a conference hall

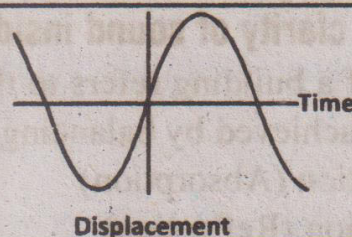
DO YOU KNOW?

Sound is a **MECHANICAL WAVE**

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



Sound waves that are squished together have a high frequency and high pitch



Sound waves that are stretched out have a low frequency and a low pitch

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.

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.

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.

Tidbits

1. Why is it impossible for sound waves to travel through a vacuum, such as outer space?

Ans. 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. Because there are no particles available to vibrate and transmit the energy.

2. **How is the shape of a sound wave displayed on an oscilloscope affected by an instrument's unique construction and the way it produces vibrations?**

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

3. **Why does sound travel farther and appear clearer on cool mornings, and how does refraction of sound in air layers of different temperature cause this effect?**

Ans. 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.

4. **How are infrared sensors used to monitor volcanic eruptions, earthquakes and tsunami and how do low-frequency waves help scientists give early warnings?**

Ans. 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!

5. **How do curved ceilings, soft walls, carpets, curtains and reflections in concert halls and theaters improve sound quality and ensure clear music reaches the entire audience?**

Ans. In concert halls and theaters, 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.

Brain Teaser

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

Ans. Air particles vibrate back and forth about their fixed positions, creating compressions and rarefaction that carry the sound energy through the air.

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

Ans. No, loudness does not affect the time of an echo, time depends only on the distance and the speed of sound.

3. **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?**

Ans. We hear our voice echoing because sound waves reflect off distant surface like walls or mountains and return to our ears after a short delay.

The air particles vibrate back and forth, passing the sound energy from the source to the reflecting surface and then back to us, allowing us to hear the echo.

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

Ans. No, sound cannot travel in space because there is no air or medium, so we cannot hear someone scream there.

Examples

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

Solution:

Given that;

Speed of wave: $v = 340 \text{ ms}^{-1}$

Wavelength: $\lambda = 2.0 \text{ m}$

To find; $f = ?$

Using the formula;

$$v = f\lambda$$

or

$$f = \frac{v}{\lambda}$$

Substituting the values

$$\begin{aligned} f &= \frac{340 \text{ ms}^{-1}}{2.0 \text{ m}} \\ &= 170 \text{ Hz} \end{aligned}$$

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 ms^{-1})

Solution:

Given that;

Time: $t = 2 \text{ s}$

Speed of sound: $v = 332 \text{ ms}^{-1}$

To find;

Distance: $S = ?$

As distance of the cloud; $S = vt$

$$S = 332 \text{ ms}^{-1} \times 2 \text{ s}$$

$$S = 664 \text{ m.}$$

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 ms^{-1} , what is the distance from the ship to the seafloor?

Solution:

Given that;

Time for the sound pulse to return $t = 3.2 \text{ seconds}$

Speed of sound in water: $v = 1600 \text{ ms}^{-1}$

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

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

$$d = 5120 \text{ m}$$

Since the distance covered is twice the actual distance to the seafloor, we divide by 2 to find the distance.

$$d = \frac{5120 \text{ m}}{2}$$

$$d = 2560 \text{ m}$$

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

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

13.1

Production and Propagation of Sound

1. Sound is produced by:
(a) Stationary objects (b) Vibrating objects
(c) Heating objects (d) Light waves
2. Sound waves are classified as:
(a) Transverse waves (b) Electromagnetic waves
(c) Longitudinal waves (d) Light waves
3. In air, sound travels at approximately what speed?
(a) $3 \times 10^8 \text{ m s}^{-1}$ (b) 1500 m s^{-1} (c) $330 - 350 \text{ m s}^{-1}$ (d) 100 m s^{-1}
4. The regions in a sound wave where air molecules are pushed together are called:
(a) Rarefactions (b) Compressions (c) Crests (d) Troughs
5. Which of the following is required for sound to travel?
(a) A vacuum (b) A medium (Solid, liquid, Gas)
(c) Darkness (d) Magnetic field
6. Why can sound NOT travel in a vacuum?
(a) It is too cold (b) There are no particles to vibrate
(c) Light blocks it (d) Gravity is too low
7. Which instrument is used to produce a specific sound in a Lab?
(a) Guitar (b) Stethoscope (c) Tuning fork (d) Bell jar

13.2

Speed of Sound

8. Sound travels fastest in which medium?
(a) Gases (b) Liquids (c) Solids (d) Vacuum
9. The speed of sound in air increases with an increase in:
(a) Humidity and temperature (b) Gravity
(c) Atmospheric Pressure (d) Darkness
10. What is the mathematical formula for the speed of sound?
(a) $v = f + \lambda$ (b) $v = f/\lambda$ (c) $v = f\lambda$ (d) $v = \lambda/f$
11. The speed of sound in steel is approximately:
(a) 346 m s^{-1} (b) 1498 m s^{-1} (c) 5960 m s^{-1} (d) 317 m s^{-1}
12. If a wave has a frequency of 170 Hz and a wavelength of 2.0 m , its speed is:
(a) 85 m s^{-1} (b) 170 m s^{-1} (c) 340 m s^{-1} (d) 680 m s^{-1}

13. Which property allows us to distinguish between loud and faint sounds?
(a) Pitch (b) Quality (c) Loudness (d) Speed
14. Loudness is primarily determined by the _____ of the vibrating body.
(a) Frequency (b) Wavelength (c) Amplitude (d) Speed
15. Pitch is the characteristic that differentiates between:
(a) Loud and soft sounds (b) Shrill and deep (grave) sounds
(c) Music and noise (d) Reflections and rarefactions
16. A high frequency sound corresponds to a:
(a) Low pitch (b) High pitch (c) Faint sound (d) Quality
17. Quality allows us to distinguish between two sounds that have the same:
(a) Speed and direction (b) Source and medium
(c) Loudness and pitch (d) Reflection and rarefaction
18. Irregular and sudden vibrations produce:
(a) Musical sounds (b) Echoes (c) Noise (d) Ultrasound
19. The recommended safe noise level for an 8-hour work day is:
(a) 20 - 30 dB (b) 50 - 60 dB (c) 85 - 90 dB (d) 120 - 150 dB

13.4

Reflection of Sound (Echo)

20. The phenomenon where sound bounces back from a surface is called:
(a) Refraction (b) Diffraction (c) Echo (d) Absorption
21. To hear a distinct echo, the reflecting surface must be at least how many meters away?
(a) 5 meters (b) 10 meters (c) 17 meters (d) 34 meters
22. The human brain retains sound for approximately:
(a) 0.1 seconds (b) 1.0 seconds (c) 0.01 seconds (d) 2.0 seconds
23. Which animal uses echoes to find food?
(a) Elephant (b) Whale (c) Bat (d) Both b and c
24. What happens to the sound of the clock when the tubes are properly aligned?
(a) It disappears (b) It becomes distorted
(c) It is heard distinctly due to reflection (d) It changes pitch

13.5

Refraction and Diffraction of Sound

25. Refraction occurs when sound waves change direction due to a change in:
(a) Volume (b) Medium properties (density/temperature)
(c) Pitch (d) The listener's position
26. Why can submerged person hear underwater sounds clearly while someone above the surface cannot?
(a) Diffraction (b) Reflection (c) Refraction (d) Loudness

27. The bending of sound waves around obstacles or through narrow openings is called:

- (a) Diffraction (b) Reflection (c) Echo (d) Infrasound

13.6 Audible Frequency

28. The range of audible frequencies for the human ear is:

- (a) 0 Hz to 20 Hz (b) 20 Hz to 20,000 Hz
(c) 20,000 Hz to 200,000 Hz (d) Above 1,000,000 Hz

29. Infrasound refers to sound waves with frequencies:

- (a) Below 20 Hz (b) Above 20,000 Hz
(c) Exactly 1,000 Hz (d) Between 20 and 100 Hz

30. Which of the following is the use of infrasound?

- (a) Cleaning jewelry (b) Monitoring natural disasters like volcanoes
(c) find cracks in machinery (d) To find depth of sea

31. At human age, their ability to hear frequencies typically declines:

- (a) Low (b) Infrasonic (c) High (d) Mid-range

32. Which animal is known to communicate using infrasound that can travel hundreds of kilometers across oceans?

- (a) Bats (b) Blue whales (c) Elephants (d) Dolphins

33. Ultrasound is defined as sound with frequencies above:

- (a) 20 Hz (b) 2,000 Hz (c) 20,000 Hz (d) 100,000 Hz

34. In medical diagnostics, the process of capturing reflected ultrasonic waves to create images of internal organs is known as:

- (a) Radiography (b) Ultrasonography (c) Infrasonic (d) Echo-location

35. SONAR (Sound Navigation and Ranging) is primarily used for:

- (a) Detecting cracks in machine turbines
(b) Measuring ocean depth and locating underwater objects
(c) Improving hearing in the elderly (d) Cleaning delicate jewelry

36. If a sonar pulse returns from the seafloor in 4 seconds and the speed of sound in water is 1500 m s^{-1} . What is the depth of the water?

- (a) 6000 m (b) 3000 m (c) 1500 m (d) 750 m

13.7 Acoustics Protection of Buildings

37. Multiple reflections of sound that can distort clarity in a large hall are known as:

- (a) Rarefactions (b) Refractions (c) Reverberation (d) Diffraction

38. Why are curved ceilings and sound boards often used in large conference halls and theaters?

- (a) To absorb unwanted noise
(b) To ensure even sound distribution by reflecting sound toward the audience
(c) To create echoes for a dramatic effect
(d) To block sound from reaching the back rows

Answers

- | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|
| 1. (b) | 2. (c) | 3. (c) | 4. (b) | 5. (b) | 6. (b) | 7. (c) |
| 8. (c) | 9. (a) | 10. (c) | 11. (c) | 12. (c) | 13. (c) | 14. (c) |
| 15. (b) | 16. (b) | 17. (c) | 18. (c) | 19. (c) | 20. (c) | 21. (c) |
| 22. (a) | 23. (d) | 24. (c) | 25. (b) | 26. (c) | 27. (a) | 28. (b) |
| 29. (a) | 30. (b) | 31. (c) | 32. (b) | 33. (c) | 34. (b) | 35. (b) |
| 36. (b) | 37. (c) | 38. (b) | | | | |

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

13.1

Production and Propagation of Sound

13.2

Speed of Sound

1. How is sound produced?

Ans. Sound is generated specifically 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.

2. Describe the classification of sound waves?

Ans. Sound waves are classified as longitudinal waves because the particles of the medium move back and forth along the direction of the wave's travel.

3. What are two main regions created in a longitudinal sound wave?

Ans. The wave consists of "compressions" where air molecules are pushed together, and "rarefactions" where they are spread apart.

4. Why is a medium essential for sound propagation?

Ans. Sound requires a solid, liquid or gas medium because it relies on the vibration of particles to transfer energy, without particles, such as in a vacuum, sound cannot travel.

5. What is the typical speed of sound in air?

Ans. In air, sound travels at an appropriate speed of 330 to 350 meters per second.

6. How does the speed of sound vary across different states of matter?

Ans. Sound travels fastest in solids, followed by liquids, and is slowest in gases.

7. What factors influence the speed of sound in air?

Ans. The speed increases with lighter humidity and higher temperature.

8. What is the formula used to calculate the speed of a wave?

Ans. The mathematical formula is:

$$v = f\lambda$$

Where, v is speed, f is frequency and λ is wavelength.

9. What is the speed of sound in steel, Iron, Nickel?

Ans. Steel 5960 m s⁻¹
Iron 5950 m s⁻¹
Nickel 6040 m s⁻¹

13.3 Characteristics of Sound

13.4 Reflection of Sound (Echo)

10. How do we distinguish between a loud and a faint sound?

Ans. This is determined by the 'Loudness' property'. Which is physically tied to the amplitude of the vibration.

11. Explain the characteristic of "Pitch"?

Ans. Pitch allows us to differentiate between shrill sounds and grave (deep) sounds, and it is directly related to the frequency of the vibration.

12. What happens to pitch as frequency increases?

Ans. A high frequency sound corresponds to high pitch, while low frequency results in a low pitch.

13. What is Quality of sound?

Ans. It is the characteristic that allows us to distinguish between two sounds that have the exact same loudness and pitch.

14. How noise is produced?

Ans. Noise is produced by irregular and sudden vibrations.

15. What is the recommended safe limit for noise exposure?

Ans. For an 8-hour workday, the recommended safe noise level is 85-90 dB.

16. Define an echo?

Ans. An echo is the phenomenon where sound bounces back (reflects) from a distant surface.

17. What are the requirements for the humans ear to hear a distinct echo?

Ans. The reflecting surface must be atleast 17 meters away, and the time interval must be at least 0.1 seconds, as the brain retains sound for that duration.

18. Name animals that use echoes to find food?

Ans. Bats and whales are examples of animals that use echolocation (echoes) for hunting.

13.5

Refraction and Diffraction of Sound

19. What causes the refraction of sound waves?

Ans. Refraction is the change in direction of sound waves when they pass through different medium properties, such as changes in density or temperature.

20. Explain why sound travels farther on a cool morning?

Ans. On a cool morning, sound bends back toward the ground due to refraction, allowing it to travel further distances.

21. What is "Diffraction" of sound?

Ans. It is the bending of sound waves as they move around obstacles or pass through narrow openings.

22. What is the range of human hearing?

Ans. The audible frequency range for a healthy human ear is between 20 Hz and 20,000 Hz.

23. Why do sound waves bend when traveling from air into water?

Ans. This happens due to refraction. When sound waves enter a medium with a different density, their speed changes (sound travels faster in water than in air), causing the waves to bend.

24. What is diffraction of sound, and what is a common example of it?

Ans. Diffraction is the bending of sound waves around obstacles or through narrow openings. An example is being able to hear someone speaking from behind a wall or around a corner even when you cannot see them.

13.6 Audible Frequency

25. What is "infrasound" and how is it used?

Ans. Infrasound consists of frequencies below 20 Hz, it is used by blue whales for long-distance communication and by scientists to monitor volcanoes or earthquakes.

26. How does SONAR calculate the depth of the ocean?

Ans. SONAR sends ultrasonic waves into the water and measures the time it takes for the echo to return. The depth is calculated using the formula:

$$\text{Distance} = \frac{\text{Speed} \times \text{Time}}{2}$$

27. What is the audible frequency range for a healthy human ear?

Ans. The standard audible range for humans is between 20 Hz and 20,000 Hz. This range often declines with age, with older individuals sometimes struggling to hear frequencies above 15,000 Hz.

28. What is ultrasound and how is it used in medical?

Ans. Ultrasound consists of frequencies above 20,000 Hz. In medicine, it is used for ultrasonography to visualize internal organs (like the heart or kidneys) and to monitor the development of a fetus during pregnancy without surgery.

13.7 Acoustics Protection of Buildings

29. What are the acoustic benefits of curved ceiling in theatres?

Ans. Curved ceilings act as sound boards, reflecting sound waves toward the audience to ensure even sound distribution throughout the hall.

30. What is "reverberation" and how can it be controlled in a hall?

Ans. Reverberation is the result of multiple reflections of sound that can distort clarity. It is controlled by using acoustic protection, such as soft, porous materials (carpets and curtains) that absorb unwanted sound waves.

Exercise Questions (Solved)

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) $330\text{-}350 \text{ m s}^{-1}$
- (c) 500 m s^{-1}
- (d) $1,000 \text{ m s}^{-1}$

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) $10 \text{ Hz} - 10 \text{ kHz}$
- (b) $20 \text{ Hz} - 20 \text{ kHz}$
- (c) $25 \text{ Hz} - 25 \text{ kHz}$
- (d) $30 \text{ Hz} - 30 \text{ kHz}$

Answers

13.1 (b) 13.2 (b) 13.3 (c) 13.4 (c) 13.5 (b) 13.6 (b) 13.7 (b)

B. Short Answer Questions

13.1 How does the medium affect the speed of sound?

Ans. The medium affects the speed of sound through its density, elasticity and temperature. Sound generally travels faster in denser, more elastic and warmer media.

13.2 Does sound waves show reflection?

Ans. Yes, sound waves exhibit reflection.

13.3 What factors influence the loudness of sound?

Ans. The loudness of sound is influenced by the amplitude, area and the distance from the sound source.

13.4 Why do we hear an echo when we clap near a building?

Ans. We hear an echo when we clap near a building because the sound waves from the clap reflect off the building's surface and return to our ears with a delay.

13.5 What is ultrasound, how is it used in medical?

Ans. Ultrasound consists of frequencies above 20 kHz. In medical, it is used for imaging internal organs (sonography) and breaking kidney stones (lithotripsy).

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?

Ans. The table has a larger surface area than the tuning fork when placed on the table, it forces a large volume of air to vibrate, increasing the loudness. This tells us that loudness is directly proportional to the vibrating surface area.

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?

Ans. When a bell rings inside a jar and the air is gradually removed by a vacuum pump, the sound fades until it disappears. This proves sound cannot travel through a vacuum, it requires a material medium.

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?

Ans. The human brain retains a sound for about 0.1 seconds to hear a clear echo, the reflected sound must arrive after this interval. At a speed of roughly 340 ms^{-1} , sound travels 34 meters in 0.1 seconds, meaning the reflecting surface must be half that distance (17 meters) away for the sound to go and return.

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.

Ans. Men generally have larger and thicker vocal cords, which vibrate at a lower frequency, resulting in a deeper (lower pitch) voice. Women and children have shorter, thinner vocal cords that vibrate faster, creating a higher 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?

Ans. Soft materials like carpets and curtains are porous and absorb sound energy instead of reflecting it. This reduces unwanted echoes and reverberations, making the sound in a room clearer and less "boomy".

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?

Ans. Distance can be calculated by using the formula $d = \frac{v \times t}{2}$ where v is the speed of sound and t is the total time taken for the echo to return. This uses the principle of reflection of sound.

D. Comprehensive Questions

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

Ans. The approximate speed of sound in air at room temperature (around 20°C) is 343 meters per second (m/s).

Factors affecting the speed of sound in air:

- (i) **Temperature:** The speed of sound increases with temperature. Higher temperature means air molecules have more kinetic energy, allowing sound waves to travel faster.
- (ii) **Humidity:** Humidity can slightly increase the speed of sound because water vapour is lighter than the average mass of the gases in the air.
- (iii) **Wind:** Wind speed can affect the speed of sound relative to an observer. Sound travels faster in the direction of the wind and slower against it.

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

Ans. Sound travels faster in solids because of the arrangement and interaction of molecules. In solids, molecules are closely packed together and are held by strong intermolecular forces. This close proximity and strong bonding allow vibrations (sound waves) to be transmitted more quickly and efficiently from one molecule to the next. In liquids, molecules are more loosely packed than in solids, and the intermolecular forces are weaker. In gases, molecules are widely dispersed with very weak intermolecular forces. The denser packing and stronger forces in solids facilitate faster transmission of sound waves compared to liquids and gases.

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

Ans. Amplitude affects the loudness (intensity) of the sound. Higher amplitude means the sound wave carries more energy, resulting in a louder sound. Lower amplitude corresponds to a quieter sound.

Frequency affects the pitch of the sound. Higher frequency means more cycles per second, resulting in a higher-pitched sound. Lower frequency corresponds to a lower-pitched sound. The quality of sound is affected by the combination of different frequencies and their respective amplitudes, which determine the harmonic content of the sound.

13.4 How does echo occur? Explain.

Ans. An echo occurs when a sound wave encounters a surface and bounces back to the source or listener. This phenomenon is a form of sound reflection. For an echo to be distinct, there must be a sufficient time delay between the original sound and the reflected sound. This delay is determined by the distance to the reflecting surface and the speed of sound. The sound wave travels to the surface, reflects, and then travels back. The time it takes for this round trip determines whether an echo is perceived.

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

Ans. Reflection: Sound waves bounce off surfaces, changing direction. This is used in

acoustics to control sound distribution in rooms.

Refraction: Sound waves bend when they pass from one medium to another or through a medium with varying properties (e.g., temperature gradients in air). This can cause sound to travel further or be distorted.

Diffraction: Sound waves bend around obstacles or spread out through openings. This allows sound to be heard even when there is an obstruction in the direct path.

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

Ans. For answer see Q # 18

E. Numerical Problems

13.1 At a particular temperature, the speed of sound in air is 333 ms^{-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?

Sol. Given:

Speed of sound = $v = 333 \text{ ms}^{-1}$

Wavelength = $\lambda = 3 \text{ cm} = 0.03 \text{ m}$

Required:

frequency = $f = ?$

Formula: $v = f\lambda$

Rearrange,

$$f = \frac{v}{\lambda}$$

Solution: Substitute the values,

$$f = \frac{333 \text{ ms}^{-1}}{0.03 \text{ m}}$$

$$f = 11,100 \text{ Hz} = 11 \text{ kHz}$$

Result: Since the human hearing range is 20 Hz to 20,000 Hz, this frequency is audible.

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

Sol. Given:

Number of chimes = 48

Time (t) = 1 minute = 60 seconds

Required:

frequency = $(f) = ?$

Time Period = $(T) = ?$

Formula:

$$f = \frac{\text{Number of vibrations}}{\text{Total time}}$$

$$\text{Period (T)} = \frac{1}{f}$$

Solution: For frequency,

$$f = \frac{\text{Number of vibrations}}{\text{Total time}}$$

$$f = \frac{48}{60}$$

$$f = 0.8 \text{ Hz}$$

For Period,

$$T = \frac{1}{f}$$

$$T = \frac{1}{0.8}$$

$$T = 1.25 \text{ s}$$

Result: The frequency and period of the chimes is 0.8 Hz and 1.25 seconds.

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

Sol. Given:

Wavelength (λ) = 0.5 m

Speed of sound (v) = 340 ms^{-1}

Required:

Frequency (f) = ?

Formula:

$$v = f\lambda$$

Re arrange,

$$f = \frac{v}{\lambda}$$

Solution: Substitute the values,

$$f = \frac{340 \text{ ms}^{-1}}{0.5 \text{ m}}$$
$$f = 680 \text{ Hz}$$

Result: The frequency produced by the car horn is 680 Hz.

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

Sol. Given:

Speed of sound = $v = 500 \text{ ms}^{-1}$

Wavelength = $\lambda = 2 \text{ m}$

Required:

$$T = ?$$

Formula:

$$T = \frac{1}{f}$$

Solution:

First, find the frequency (f).

using $v = f\lambda$

$$f = \frac{v}{\lambda}$$
$$f = \frac{500 \text{ ms}^{-1}}{2 \text{ m}}$$

$$f = 250 \text{ Hz}$$

Now, find time period (T)

$$T = \frac{1}{f}$$

By substituting values,

$$T = \frac{1}{250 \text{ Hz}}$$

$$T = 0.004 \text{ s}$$

Result: The time period of the wave is 0.004 seconds.

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 ms^{-1} . Find the depth of the

sea at this position.

Sol. Given:

Speed of sound in sea water (v) = 1600 ms^{-1}

Total time for echo (t) = 2 s

Required:

depth = ?

Formula:

$$d = v \times t$$

Solution: By Substituting values,

$$d = 1600 \text{ ms}^{-1} \times 2 \text{ s}$$

$$d = 3200 \text{ m}$$

Since the sound wave travels to the seabed and back, the depth of the sea is half the total distance.

$$\text{Depth} = \frac{3200 \text{ m}}{2} = 1600 \text{ m}$$

Result:

The depth of the sea is 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 ms^{-1} , what is the distance of the mountain from the person?

Sol. Given:

Speed of sound (v) = 343 ms^{-1}

Time for echo (t) = 6 seconds

Required:

distance (d) = ?

Formula:

$$d = v \times t$$

Solution: Substitute the values,

$$d = 343 \text{ ms}^{-1} \times 6 \text{ s}$$

$$d = 2058 \text{ m}$$

Since the sound wave travels to the mountain and back, the distance of the mountain from the person is half the total distance.

$$\text{Distance} = \frac{2058 \text{ m}}{2} = 1029 \text{ m}$$

Result: The distance of the mountain from the person is 1029 m.

