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Chapter 13: Sound

Class 10th FBISE - SLO Based Notes

Physicist Hammad Shaukat

SLO-Based Notes: Chapter 13 - Sound

1 13.1 Source of Sound

Question (Short): What is meant by the source of sound?

Answer: The object which vibrates and produces sound is called the source of sound. For example: clapping hands, ringing bell, chirping birds, thunder, etc.

- Clapping hands
- Bird chirping
- Thunder
- Ringing cellphone
- Musical instruments
- School bell
- Footsteps
- Car horn

2 13.1.1 How Sound is Produced?

Question (Short): How is sound produced?

Answer: Sound is produced when an object vibrates. These vibrations transfer energy to the surrounding medium (like air), creating longitudinal waves that travel to our ears and are interpreted as sound.

Question (Long): Describe the process of sound production with an experiment.

Answer: Vibrating objects produce sound. When an object vibrates, it disturbs nearby particles, causing them to oscillate back and forth. This to-and-fro motion produces longitudinal waves that travel through a medium and are detected by our ears.

Experiment:

1. Take a glass of water, a rubber pad, and a tuning fork.
2. Hit the tuning fork on the rubber pad and bring it near your ear to hear the sound.
3. Now dip the vibrating tuning fork into the glass of water.

Observation: You will see ripples in water and hear the sound, showing that vibration is necessary for sound production.

3 13.1.2 Medium for Propagation of Sound

Question (Short): Can sound travel in a vacuum?

Answer: No, sound cannot travel in a vacuum. It requires a medium (like air, water, or solids) to propagate.

Question (Long): Describe an experiment to prove that sound needs a medium.

Answer: Take an electric bell inside a vacuum jar.

1. When air is present, you can hear the bell sound.
2. As the air is removed using a vacuum pump, the sound becomes faint.
3. When all air is removed, the sound stops completely.

This proves that sound needs a medium to travel.

Mini Lab: String Telephone

- Take two paper cups and a long string.
- Make a small hole in each cup and pass the string through.
- Tie a paper clip inside each cup to secure the string.
- Pull the string tight and talk into one cup while another person listens from the other.

Result: The sound travels through the string by vibrations, proving that a medium is required.

4 13.2 Nature of Sound Waves

Question (Short): What are sound waves?

Answer: Sound waves are mechanical longitudinal waves. They are also called pressure waves and travel through a medium by forming compressions and rarefactions due to vibration of the source object.

Question (Long): Explain how sound travels through a medium.

Answer: When an object vibrates, it causes the surrounding molecules to vibrate as well. These vibrations are transferred from one molecule to another, forming compressions (high pressure) and rarefactions (low pressure) that move through the medium as sound waves.

5 13.2.1 Compression and Rarefaction

Question (Short): What is compression and rarefaction?

Answer:

- **Compression:** A region in a sound wave where particles are close together and pressure is high.
- **Rarefaction:** A region where particles are far apart and pressure is low.

6 13.2.2 Related Terms of Sound Waves

A. Wavelength: The distance between two consecutive compressions or rarefactions. Represented by λ. SI unit: meter.

B. Amplitude: Maximum displacement of particles from their rest position due to a sound wave. It indicates energy—higher amplitude means more energy.

C. Frequency: Number of sound waves produced in one second. Represented by f. SI unit: hertz (Hz).

D. Time Period: Time taken by a wave to complete one full cycle. Represented by T. SI unit: second.

7 13.2.3 Types of Sound Waves

Question (Short): What are the types of sound waves?

Answer: Sound waves can be categorized as:

- **Rhythmic (Musical):** Pleasant and regular, like music.
- **Non-Rhythmic (Noise):** Unpleasant and irregular.
- **Infrasonic Waves:** Below 20 Hz, not audible to humans. Used by animals like whales and elephants.
- **Audible Waves:** From 20 Hz to 20,000 Hz, audible to humans.
- **Ultrasonic Waves:** Above 20,000 Hz, used in medical and industrial applications.

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8 13.3 Ultrasound

Question (Short): What is ultrasound?

Answer: Ultrasound refers to sound waves with frequencies above 20,000 Hz, which is higher than the human hearing range. These waves are not audible to humans.

Question (Long): Write a note on ultrasound and its applications.

Answer: Ultrasound has many applications in medical and industrial fields. In medicine, it is used for imaging internal organs and monitoring fetal development during pregnancy. In industries, it is used to detect flaws in materials, clean delicate objects, and in underwater navigation systems like sonar.

9 13.3.1 Uses of Ultrasound

A. Cleaning: High-frequency waves create small bubbles in liquid. These bubbles collapse and generate shock waves that clean objects.

Applications: Cleaning jewelry, electronic parts, surgical tools.

B. Medical Scanning (Including Prenatal): A transducer sends ultrasound into the body. The waves reflect from tissues and return to create images.

Applications: Monitoring fetus, checking heart function (echocardiography), observing blood flow (Doppler ultrasound).

C. Sonar (Sound Navigation and Ranging): A sonar device sends sound waves underwater. These waves reflect off objects and return to the device to detect location and distance.

Applications: Mapping ocean floor, locating shipwrecks, measuring depth.

10 13.3.2 Calculating Depth or Distance

Question (Short): How can ultrasound be used to calculate depth or distance?

Answer: Ultrasound can be used to measure the depth of water or the distance of an object by sending sound pulses and recording the time it takes for the echo to return. The distance is calculated using the following formula:

$$\text{Depth or Distance (d)} = \frac{v \times t}{2}$$

Where:

- v is the speed of sound in the medium (e.g., water)
- t is the total time taken for the pulse to travel to the object and back (echo)

Example:

If the time taken for the sound to return is 2 seconds and the speed of sound in water is 1500 m/s, then:

$$d = \frac{1500 \times 2}{2} = 1500 \text{ m}$$

Conclusion: The object is located at a depth of 1500 meters. This technique is widely used in sonar systems for underwater exploration and oceanographic research.

11 13.4 Infrasound

Question (Short): What is infrasound?

Answer: Infrasound refers to sound waves that have frequencies lower than 20 Hz, which is below the limit of human hearing. These low-frequency sounds are used in various natural and artificial applications.

13.4.1 Communication by Animals

Question (Long): How do animals use infrasound for communication?

Answer: Many large animals, like elephants and giraffes, use infrasound to communicate over long distances. These sounds are produced at very low frequencies, making them difficult for humans to hear. Larger animals produce lower frequency sounds, while smaller animals generate higher ones. Infrasound allows animals to send messages even in areas with poor visibility, such as dense forests. Elephants, for instance, use infrasound to warn others of threats and coordinate movement, helping them stay connected over several kilometers. This advanced form of communication demonstrates their intelligence and adaptability to their natural environment.

13.4.2 Seismic Activity

Question (Long): How is infrasound related to seismic activity?

Answer: Infrasound is also produced by natural disasters such as earthquakes, volcanic eruptions, and explosions. Specialized infrasound sensors can detect these low-frequency waves and help monitor seismic activity. These instruments are valuable in predicting natural events like earthquakes and volcanoes. For example, sensors placed around volcanoes can detect low-frequency rumblings before an eruption, allowing early warnings and evacuation. This technology helps in disaster preparedness and provides insights into the Earth's internal processes.

12 13.5 Characteristics of Sound Wave

Sound waves have three basic characteristics:

- Pitch
- Loudness
- Quality (Timbre)

13.5.1 Pitch

Question (Short): What is pitch in sound?

Answer: Pitch is the characteristic of sound that helps distinguish between grave (low) and shrill (high) sounds. It is directly related to the frequency of the sound wave. Higher frequency means higher pitch, and lower frequency means lower pitch.

Relation:

$$\text{Pitch} \propto \text{Frequency of sound wave}$$

Example: Birds produce high-pitched sounds, while the roar of a lion is low-pitched. A woman's voice generally has a higher pitch than a man's.

13.5.2 Loudness

Question (Short): What is loudness in sound?

Answer: Loudness is the characteristic of sound that enables us to distinguish between loud and faint sounds. It depends on the amplitude of the sound wave and is measured in decibels (dB).

Relation:

$$\text{Loudness} \propto \text{Amplitude of sound wave}$$

Factors Affecting Loudness:

- **A. Vibrational Amplitude:** Larger vibration amplitude produces louder sound.
- **B. Distance from Source:** Loudness decreases as distance increases.
- **C. Surface Area of Source:** Bigger vibrating surfaces produce louder sounds.
- **D. Sensitivity of Ears:** More sensitive ears can detect lower sound levels.

13.5.3 Quality of Sound or Timbre

Question (Short): What is quality or timbre of sound?

Answer: Quality or timbre is the property of sound that helps us distinguish between two sounds of same pitch and loudness. It depends on the wave shape and harmonic content.

Comparison of Pitch and Loudness

- Pitch depends on frequency; loudness depends on amplitude.
- Pitch is independent of energy received by the ear; loudness is dependent on it.
- Pitch distinguishes between flat and sharp sounds; loudness distinguishes between loud and faint sounds.

13 13.6 Analyzing Sound Waves

Question (Short): What is the role of an oscilloscope in analyzing sound waves?

Answer: An oscilloscope is a device used to visualize sound waves. It shows sound waves as waveforms (traces) on a screen, helping us understand their shape and timbre. Different instruments or sound sources produce different waveforms.

Explanation: Some sound waves have smooth and regular waveforms, like those produced by a tuning fork—called pure tones or sine waves. Others have complex waveforms produced by musical instruments like piano, violin, or flute. These complex waves contain multiple frequencies and overtones, which give each instrument its unique timbre. The oscilloscope can display the fundamental frequency and its overtones, helping analyze the sound's quality.

14 13.7 Speed of Sound

Question (Short): How is the speed of sound calculated?

Answer: Speed of sound is calculated using the formula:

$$\text{Speed (v)} = \frac{\text{Distance}}{\text{Time}} \quad \text{or} \quad v = \frac{d}{t}$$

Question (Long): What factors affect the speed of sound and how does it vary in different media?

Answer: The speed of sound depends on the temperature and the medium through which it travels. It moves faster in warmer air because particles have more energy. In colder air, sound travels slower.

- **Speed in Air:** Around 330–350 m/s depending on temperature. For example, it is slower on a cold winter day and faster on a hot summer day.
- **Speed in Solids:** Fastest among all states of matter. Sound travels efficiently due to tightly packed particles. For example, in steel it can exceed 5000 m/s.
- **Speed in Liquids:** Faster than in gases, but slower than in solids. Approximate speed in water is 1500 m/s.

- **Speed in Gases:** Slowest due to widely spaced particles, e.g., 340 m/s in air at room temperature.

Additional Example: During a thunderstorm, we often see lightning before hearing thunder due to the slower speed of sound compared to light. This delay helps estimate the distance of the storm.

15 13.8 Noise

Question (Short): What is noise in physics?

Answer: In physics, noise refers to unpleasant, non-rhythmic, and irregular sound waves. These waves have:

- Non-rhythmic behavior
- Irregular time intervals for vibrations
- Variable energy states
- Irregular intensities

Explanation: Sound waves can be classified as periodic (musical) and non-periodic (noise). Human ears are designed to receive periodic sound waves, which feel pleasant. Non-periodic waves are irritating and sometimes painful. Noise pollution is common in:

- Industrial buildings (machinery, air-conditioning)
- Construction sites (excavation, demolition)
- Transportation (trains, aircraft, road vehicles)
- Public places (markets, streets, parks)

Control Measures: Use earplugs, turn off unused appliances, maintain machines, lower volume, and plant more trees to reduce noise pollution.

16 13.9 Reflection, Refraction and Diffraction of Sound

Question (Short): What are the main behaviors of sound waves?

Answer: Sound waves can reflect, refract, and diffract depending on the surfaces and materials they interact with. These behaviors help explain how sound travels and is heard in various environments.

13.9.1 Reflection

Question (Short): What is reflection of sound?

Answer: Reflection occurs when a sound wave hits a surface and bounces back, just like light. It is used in sonar to measure ocean depth and can be experienced in small rooms where sound reflects off walls.

13.9.2 Refraction

Question (Short): What is refraction of sound?

Answer: Refraction occurs when sound changes direction due to a change in speed as it passes through materials or air layers of different temperatures or densities. For example, sound is clearer at night due to cooler ground and warmer upper air.

13.9.3 Diffraction

Question (Short): What is diffraction of sound?

Answer: Diffraction is the bending or spreading of sound waves around obstacles or through small openings. For instance, hearing someone call you from behind a wall or hearing music through a partially closed door is due to diffraction.

17 13.10 Echo

Question (Short): What is an echo?

Answer: An echo is the reflection of a sound wave that returns to the listener after striking a hard surface such as a wall or cliff. It follows the wave-reflection phenomenon.

Explanation: When a sound wave reflects from a surface and travels back to the ear, it is heard as a distinct sound separate from the original. The surface must be hard enough to reflect sound efficiently. Echoes can be used to measure distances, including underwater.

13.10.1 Necessary Condition for Human Hearing of Echo

Question (Short): What is the minimum time gap required to hear an echo?

Answer: The human ear can detect an echo if the reflected sound reaches after a time gap of at least 0.1 seconds.

Formula to calculate distance using echo:

$$\text{Distance (d)} = \frac{v \times t}{2}$$

Where:

- v = speed of sound
- t = time taken for echo to return

Minimum distance to hear an echo:

$$d = \frac{v}{20}$$

Example: If speed of sound in air is 340 m/s, then the minimum distance required to hear an echo is:

$$d = \frac{340}{20} = 17 \text{ m}$$

13.10.2 Applications of Echo

Question (Short): Mention some common applications of echo.

Answer: Echo is used in:

- Measuring the speed of sound
- Ultrasonography in medical diagnostics
- Echolocation by animals like bats
- Locating submarines and measuring sea depth

Explanation: Animals such as bats use echolocation to navigate and identify obstacles. Ships use echo techniques to detect objects underwater and measure ocean depth.

18 13.11 Acoustics

Question (Short): What is acoustics?

Answer: Acoustics is the branch of physics that studies sound, including its production, transmission, effects, and control. It covers various types such as environmental noise, musical acoustics, ultrasound, infrasound, and vibrations.

Environmental Noise: Undesirable or harmful sound caused by human activities like traffic, industrial operations, and air travel.

13.11.1 Acoustic Protection

Question (Short): What is acoustic protection?

Answer: Acoustic protection involves using soft and porous materials to absorb unwanted noise and reduce its impact. Materials like curtains, carpets, and foam panels help soften echoes and lower noise pollution.

Concept of Reverberation: Reverberation is the overlapping of multiple reflected sound waves that are heard as noise when the time gap is too short to distinguish them.

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13.11.2 Importance of Acoustic Protection

Acoustic protection is important for the following reasons:

- **A. Health and Well-being**
  - **Hearing Protection:** Prevents hearing damage from loud environments.
  - **Mental Health:** Reduces stress, anxiety, and sleep disturbances caused by noise.
- **B. Productivity and Performance**
  - **Workplace Efficiency:** Enhances focus, reduces errors, and minimizes distractions.
  - **Learning Environments:** Helps students concentrate and retain information.
- **C. Environmental and Community Impact**
  - **Wildlife Preservation:** Protects animals that depend on sound for survival.
  - **Quality of Life:** Creates quieter, more pleasant surroundings.
  - **Regulatory Compliance:** Assists in meeting noise safety laws and standards.

13.11.3 Applying Acoustics in Building Design

Question (Long): How can knowledge of sound be applied in building design?

Answer: Understanding the properties of sound helps in designing buildings with better acoustics. Several methods are used:

- **A. Sound Absorption:** Soft materials like carpets, acoustic panels, and curtains absorb sound waves and reduce echoes.
- **B. Sound Reflection:** Walls and ceilings are designed to reflect sound effectively using materials like glass and concrete.
- **C. Sound Transmission:** Dense materials and thick walls block sound between rooms. Double-glazed windows and insulated doors also reduce transmission.
- **D. Sound Diffusion:** Elements like rough or irregular surfaces scatter sound evenly, preventing harsh reflections.
- **E. Resonance Control:** Room size and shape are adjusted to prevent amplification. Bass traps are used in studios to control low-frequency noise.

- **F. Noise Control:** Proper sealing of doors and windows, along with fences and landscaping, helps reduce external noise.
- **G. Vibration Control:** Rubber mounts and floating floors reduce vibrations in machines and instruments.

Practical Examples: Concert halls, classrooms, offices, libraries, and homes use a mix of absorption, reflection, and diffusion techniques to create quieter, more comfortable environments.

19 13.12 Human Hearing System

Question (Long): Describe the process of hearing in the human ear.

Answer: The human hearing process converts sound vibrations into electrical signals that are interpreted by the brain. The steps involved are:

1. **Sound Waves Enter the Ear:** Vibrations travel through the ear canal.
2. **Eardrum Vibration:** The eardrum vibrates in response to the sound waves.
3. **Ossicles Amplify Vibrations:** Vibrations pass through three tiny bones (malleus, incus, stapes) in the middle ear, amplifying the sound.
4. **Vibrations Enter the Cochlea:** The stapes transfers vibrations to the cochlea (inner ear).
5. **Fluid Waves in the Cochlea:** Vibrations create waves in the cochlear fluid.
6. **Hair Cells Detect Vibrations:** Waves stimulate hair cells inside the cochlea, which generate electrical signals.
7. **Electrical Signals Travel to the Brain:** Signals are transmitted via the auditory nerve.
8. **Brain Interprets Signals:** The brain processes and recognizes them as sound (speech, music, etc.).

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Multiple Choice Questions with Explanations

Q1. What are the three main parts of the human ear?
Correct Option: A. Outer ear, Middle ear, Inner ear
The human ear is divided into three main parts that help in collecting and interpreting sound.

Q2. Sound produced by piano and violin gives ________ waveform on oscilloscope.
Correct Option: C. Complex
Musical instruments produce complex waveforms containing multiple frequencies.

Q3. Which is NOT true for sound?
Correct Option: C. Sound transfer energy along with matter of medium
Sound only transfers energy, not matter.

Q4. Sound travels faster in:
Correct Option: D. Steel
Sound travels fastest in solids due to closely packed particles.

Q5. Speed of sound in air is 332 m/s. What is its speed in vacuum?
Correct Option: D. Zero
Sound needs a medium to travel and cannot propagate in vacuum.

Q6. The sound travels from water to an iron rod and then into air and back into water. The speed of sound will successively:
Correct Option: A. Increase, decrease, increase
Sound travels fastest in solids, slower in liquids, and slowest in gases.

Q7. What will happen to speed of sound, if frequency is doubled? It will become:
Correct Option: D. Remain same
Speed of sound is independent of frequency and depends on medium.

Q8. Infrasonic waves have frequency:
Correct Option: B. Less than 20Hz
Infrasonic sounds are below the audible range of human hearing.

Q9. For echo, the minimum distance of a person from obstacle is:
Correct Option: A. 17 m
The minimum distance required for echo is 17 meters.

Q10. The property of waves which is directly related with loudness of sound is:
Correct Option: D. Amplitude
Loudness is directly proportional to amplitude of the wave.

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Q11. Sound entered in ear is amplified by:
Correct Option: A. Ossicles
Ossicles in the middle ear amplify the sound vibrations.

Q12. Silent whistle is used to train dog. When trainer blows the whistle, human beings do not hear it but dog does. Its possible frequency is:
Correct Option: D. ¿ 20000 Hz
Dogs can hear ultrasonic sounds above 20000 Hz which are inaudible to humans.

Q13. The pitch of sound depends upon:
Correct Option: A. Frequency
Higher frequency means higher pitch.

Q14. Two sound waves having same loudness and pitch can be distinguished by one of the characteristics of sound called:
Correct Option: C. Quality
Quality (timbre) helps distinguish between sounds having same pitch and loudness.

Q15. The sensation of sound persists in our brain for about:
Correct Option: C. 0.1 s
This persistence is called the persistence of hearing.

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Short Response Questions

1. **Analyse the process of sound transmission from outer ear to brain.**
   Sound waves enter the outer ear and travel through the ear canal to the eardrum, causing it to vibrate. These vibrations pass through the ossicles in the middle ear and enter the cochlea in the inner ear. Hair cells convert vibrations into electrical signals, which are sent to the brain via the auditory nerve for interpretation.

2. **What are common sources of harmful noise, assess their impact on human health?**
   Common noise sources include traffic, machinery, loudspeakers, and industrial equipment. Prolonged exposure can cause stress, hearing loss, disturbed sleep, and increased blood pressure. Controlling noise pollution is essential for maintaining mental and physical health.

3. **How do animals use infrasound for communication? Compare this with human communication methods.**
   Animals such as elephants and whales use infrasound (below 20 Hz) to communicate over long distances. Humans communicate using audible sound (20–20,000 Hz) through speech and hearing, which is limited to shorter ranges.

4. **Evaluate the advantages and limitations of ultrasonic cleaning.**
   Ultrasonic cleaning removes dirt and debris from delicate items using high-frequency sound waves. It is effective for deep cleaning but may not work on porous surfaces and can damage sensitive materials if used improperly.

5. **Why does sound travel faster in solids than liquids and gases?**
   Sound travels fastest in solids because particles are tightly packed, allowing vibrations to transfer more efficiently. In liquids and gases, the particles are less dense, which slows down sound propagation.

6. **How two plastic glasses with a string stretched between them could be better way to communicate than merely shouting through the air?**
   In the string telephone, vibrations travel directly through the taut string, which reduces sound loss. This method is more efficient over short distances than shouting, where sound dissipates in air.

7. **How can we distinguish between two sounds having same loudness?**
   Sounds with the same loudness can be distinguished by their pitch and quality. Pitch depends on frequency, while quality (timbre) depends on waveform and harmonics.

8. **During a match in cricket stadium, you see a batsman striking the ball but we hear stroke sound slightly later. Explain this time difference.**

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Light travels much faster than sound. We see the action almost instantly, but the sound takes longer to reach us, causing the time lag.

9. **When a pendulum vibrates, we do not hear its sound. Why?**
   A vibrating pendulum produces sound, but its frequency is often too low (infrasonic) or the sound is too weak to be heard by human ears.

10. **Two students are talking in the corridor of your school, you can hear them in your class room but you cannot see them. How?**
    Sound waves can bend around corners (diffraction) and pass through openings. Light travels in straight lines and gets blocked, so we cannot see them but can still hear.

11. **What steps would you take to stop echo and reverberation effects in a large room?**
    Use soft, porous materials like carpets, curtains, and acoustic panels to absorb sound. These reduce reflections and control reverberation, improving sound clarity.

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Numerical Response Questions

1. **A tourist clapped his hands near a cliff and heard the echo after 5 s. What is the distance of the cliff from the student if the speed of sound is taken as 344 m/s?**
   Given: Time = 5 s (to and fro), Speed = 344 m/s
   Formula: Distance = Speed × Time / 2
   Distance = $\frac{344\times5}{2} = 860\,\text{m}$

2. **Speed of sound in seawater is 1500 m/s. If its wavelength is 45 cm, find the frequency of these sound waves.**
   Given: $v = 1500\,\text{m/s}, \lambda = 0.45\,\text{m}$
   Formula: $f = \frac{v}{\lambda}$
   $f = \frac{1500}{0.45} = 3333.3\,\text{Hz}$

3. **A sound wave in seawater travels at speed of 1500 m/s. It is sent and detected back after reflection from seabed in 8.5 s. Find the distance from surface to the bottom of the sea.**
   Given: Total Time = 8.5 s, Speed = 1500 m/s
   Formula: Distance = Speed × Time / 2
   Distance = $\frac{1500\times8.5}{2} = 6375\,\text{m}$

4. **A physician counts 69 heartbeats in 1 minute. Calculate the frequency and period of the heartbeats.**
   Given: No. of beats = 69, Time = 60 s
   Formula: Frequency $f = \frac{n}{t} = \frac{69}{60} = 1.15\,\text{Hz}$
   Period: $T = \frac{1}{f} = \frac{1}{1.15} = 0.8696\,\text{s}$

5. **Find the range of wavelengths at speed 343 m/s for audible frequency range (20 Hz to 20 kHz).**
   Given: $v = 343\,\text{m/s}$
   Formula: $\lambda = \frac{v}{f}$
   Max wavelength = $\frac{343}{20} = 17.15\,\text{m}$
   Min wavelength = $\frac{343}{20000} = 0.01715\,\text{m}$

6. **During thunder storm, thunder sound is heard after 3 seconds of lightning flash. Find the distance of clouds from ground. (Speed of sound = 340 m/s)**
   Given: Time = 3 s, Speed = 340 m/s
   Formula: Distance = Speed × Time
   Distance = $340 \times 3 = 1020\,\text{m}$

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7. **SONAR sends ultrasound signal towards sea bed. It is received back after 5.3 s. Speed of sound in sea water is 1550 m/s. Find depth of sea.**
   Given: Total Time = 5.3 s, Speed = 1550 m/s
   Formula: Distance = Speed × Time / 2
   Depth $= \frac{1550\times5.3}{2} = 4107.5\,\text{m}$

Summary Section

List of Important Formulas

- **Speed of sound:** $v = \frac{d}{t}$
- **Wavelength:** $\lambda = \frac{v}{f}$
- **Echo distance:** $d = \frac{v \times t}{2}$
- **Frequency:** $f = \frac{1}{T}$
- **Time Period:** $T = \frac{1}{f}$

List of Main Definitions

- **Sound:** A form of energy produced by vibrating objects and transmitted as longitudinal waves.
- **Echo:** Reflection of sound that is heard after it bounces off a distant object.
- **Amplitude:** Maximum displacement of a wave from its rest position.
- **Frequency:** Number of vibrations or waves produced per second.
- **Ultrasonic waves:** Sound waves with frequency above 20,000 Hz, inaudible to humans.

Fascinating Quotes About Sound and Science

- "Science is a way of thinking much more than it is a body of knowledge." – Carl Sagan
- "If you want to find the secrets of the universe, think in terms of energy, frequency, and vibration." – Nikola Tesla
- "Where words fail, music speaks." – Hans Christian Andersen
- "Sound is the vocabulary of nature." – Pierre Schaeffer

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