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Class	10th	Chapter	13
Subject	Physics	Board	Federal

CHAPTER 13: SOUND

MULTIPLE CHOICE QUESTIONS

Q1. Choose the best possible option in the following questions:

1. What are the three main parts of the human ear?

- **A.** Outer ear, Middle ear, Inner ear
- **B.** Inner ear, Cochlea, Eardrum
- **C.** Middle ear, Eardrum, Auditory nerve
- **D.** Outer ear, Auditory nerve, Cochlea
- **Answer: A. Outer ear, Middle ear, Inner ear**

2. Sound produced by piano and violin gives _____ waveform on oscilloscope.

- **A.** Simple
- **B.** Harmonic
- **C.** Complex
- **D.** Symmetric
- **Answer: C. Complex**

3. Which is NOT true for sound?

- **A.** Sound is produced by vibrating body
- **B.** Sound travels due to variation of pressure in air
- **C.** Sound transfer energy along with matter of medium
- **D.** Sound is compressional and longitudinal wave
- **Answer: C. Sound transfer energy along with matter of medium** (Sound waves transfer energy without transferring matter)

4. Sound travels faster in:

- **A.** rubber
- **B.** air
- **C.** water
- **D.** steel
- **Answer: D. steel** (Sound travels fastest in solids due to higher elasticity and density characteristics)

5. Speed of sound in air is $332\ ms^{-1}$. What is its speed in vacuum?

- **A.** Equal to $332\ ms^{-1}$

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- **B.** Greater than $332\ ms^{-1}$
- **C.** Less than $332\ ms^{-1}$
- **D.** Zero
- **Answer: D. Zero** (Sound requires a material medium to propagate and cannot travel through a vacuum)

6. The sound travels from water to an iron rod and then into air and back into water. The speed of sound will successively:

- **A.** Increase, decrease, increase
- **B.** decrease, increase, decrease
- **C.** Increase, increase, increase
- **D.** decrease, decrease, decrease
- **Answer: A. Increase, decrease, increase** (Water to iron increases speed, iron to air decreases speed, air to water increases speed)

7. What will happen to speed of sound, if frequency is doubled? It will become:

- **A.** half
- **B.** double
- **C.** four times
- **D.** remain same
- **Answer: D. remain same** (The speed of sound depends on the medium's properties, not on frequency)

8. Infrasonic waves have frequency:

- **A.** greater than 20 Hz
- **B.** less than 20 Hz
- **C.** of 20 Hz
- **D.** of 20 kHz
- **Answer: B. less than** 20 Hz

9. For echo, the minimum distance of a person from obstacle is:

- **A.** 17 m
- **B.** 34 m
- **C.** 0.1 m
- **D.** any distance above 50 m
- **Answer: A.** 17 m

10. The property of waves which is directly related with loudness of sound is

- **A.** Frequency
- **B.** Wavelength
- **C.** Speed
- **D.** Amplitude
- **Answer: D. Amplitude**

11. Sound entered in ear is amplified by:

- **A.** Ossicles
- **B.** Cochlea
- **C.** Eardrum
- **D.** Brain
- **Answer: A. Ossicles**

12. Silent whistle is used to train dog. When trainer blows the whistle, human beings do not hear it but dog do listen. Its possible frequency is:

- **A.** > 20 Hz
- **B.** $= 20$ Hz
- **C.** < 20000 Hz
- **D.** > 20000 Hz
- **Answer: D.** > 20000 Hz (Ultrasonic range above human hearing threshold)

13. The pitch of sound depends upon:

- **A.** frequency
- **B.** amplitude
- **C.** quality
- **D.** displacement
- **Answer: A. frequency**

14. Two sound waves having same loudness and pitch can be distinguished by one of the characteristics of sound called:

- **A.** loudness
- **B.** pitch
- **C.** quality
- **D.** intensity
- **Answer: C. quality** (or timbre)

15. The sensation of sound persists in our brain for about

- **A.** 10 s
- **B.** 1 s
- **C.** 0.1 s
- **D.** 0.01 s
- **Answer: C.** 0.1 s

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CONSTRUCTED RESPONSE QUESTIONS

QII. Follow the directions to respond to the following questions:

1. Mark the frequency region for Infrasonic, Human Audible Frequency and Ultrasound.

0 Hz	**10 Hz**	**20 Hz**	**1000 Hz**	**3500 Hz**	**13,000 Hz**	**20,000 Hz**	**40,000 Hz**	**55,000 Hz**	**80,000 Hz**
Infrasonic	Infrasonic	Audible	Audible	Audible	Audible	Audible	Ultrasound	Ultrasound	Ultrasound

- **Infrasonic Region:** 0 Hz up to below 20 Hz (0 Hz to 10 Hz)
- **Human Audible Frequency Region:** 20 Hz to 20,000 Hz (20 Hz, 1000 Hz, 3500 Hz, 13,000 Hz, 20,000 Hz)
- **Ultrasound Region:** Above 20,000 Hz (40,000 Hz, 55,000 Hz, 80,000 Hz)

2. Label the major parts of Human Hearing System.

- **Outer Ear:** Pinna, Auditory canal (Ear canal)
- **Middle Ear:** Eardrum (Tympanic membrane), Ear ossicles (Malleus, Incus, Stapes), Eustachian tube
- **Inner Ear:** Cochlea, Semicircular canals, Auditory nerve.

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SHORT RESPONSE QUESTIONS

QIII. Give a short response to the following questions.

1. Analyse the process of sound transmission from outer ear to brain.

Sound waves collected by the outer ear vibrate the eardrum, which amplifies vibrations via ossicles (malleus, incus, stapes). The cochlea converts mechanical vibrations into nerve impulses, sending them via the auditory nerve to the brain.

2. What are common sources of harmful noise, assess their impact on human health?

Common sources include heavy traffic, industrial machinery, construction tools, and loud music. Prolonged exposure causes hearing impairment, chronic stress, hypertension, sleep disruption, and decreased productivity.

3. How do animals use infrasound for communication? Compare this with human communication methods.

Elephants and whales use low-frequency infrasound (< 20 Hz) for long-distance communication through air and water. Humans rely on audible vocal cords (20 Hz–20 kHz) and technology like radio waves.

4. Evaluate the advantages and limitations of ultrasonic cleaning.

Advantages: Reaches micro-crevices without scrubbing and cleans delicate jewelry or medical instruments safely.

Limitations: Requires specialized fluids, cannot clean soft materials, and involves higher initial equipment costs.

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

Solids have much higher elastic moduli and tightly packed molecules, allowing disturbance forces to transmit rapidly. Consequently, speed ($v = \sqrt{E/\rho}$) is highest in solids compared to liquids or gases.

6. How two plastic glasses with a string stretched between them could be better way to communicate than merely shouting through the air?

Sound travels significantly faster and loses less energy through a taut solid string than spreading spherically in open air. The mechanical vibrations transfer efficiently between cups with minimal dissipation.

7. How can we distinguish between two sounds having same loudness?

We distinguish them by their **quality (timbre)** or **pitch (frequency)**. Quality depends on the waveform and overtones produced by the instrument, allowing us to tell a violin apart from a piano.

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?

Light travels extremely fast ($\approx 3 \times 10^8$ m/s), reaching our eyes almost instantaneously. Sound travels much slower (≈ 340 m/s in air), creating a noticeable delay over stadium distances.

9. When a pendulum vibrates, we do not hear its sound. Why?

A vibrating pendulum moves at a frequency well below 20 Hz (infrasonic region). Since the human audible range is 20 Hz to 20 kHz, the human ear cannot detect these vibrations.

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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 have long wavelengths comparable to doorway dimensions, allowing them to **diffract** (bend) around corners. Light waves have extremely short wavelengths, traveling only in straight lines.

11. What steps would you take to stop echo and reverberation effects in a large room?

Install sound-absorbing materials such as thick carpets, heavy curtains, acoustic foam panels, and upholstered furniture. Soft, porous, and irregular surfaces reduce unwanted reflections and sound prolongation.

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LONG RESPONSE QUESTIONS

QIV. Give a detailed response to the following questions.

1. Explain the production of sound waves with examples.

Definition & Mechanism

Sound is a form of energy produced by **vibrating bodies**. When an object vibrates back and forth, it disturbs the surrounding air molecules, creating periodic pressure variations (compressions and rarefactions) that travel through the medium as longitudinal mechanical waves.

Examples of Sound Production

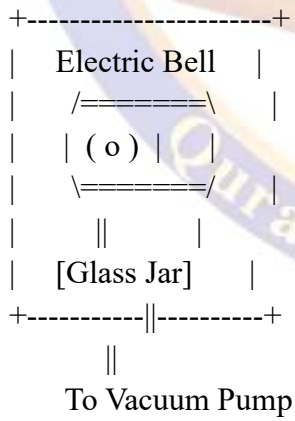
- **Tuning Fork:** Striking a tuning fork causes its tines to move rapidly back and forth. As a tine moves outward, it compresses the adjacent air (high pressure); as it moves inward, it creates a rarefaction (low pressure).
- **Vocal Cords:** Air forced from the lungs passes through the vocal cords in the larynx, causing them to vibrate and produce speech sounds.
- **Stretched String (Guitar/Violin):** Plucking a tight string creates transverse vibrations along the string, which compress and rarefy air molecules in contact with the instrument's sound box.
- **Drums (Membranes):** Striking a drum skin causes the membrane to flex up and down, generating longitudinal pressure waves in the surrounding air.

2. Justify why sound waves cannot travel in a vacuum. Design an experiment that demonstrates this principle.

Theoretical Justification

Sound is a **mechanical wave**, meaning it relies on particle-to-particle interactions (elastic collisions) to propagate energy. In a vacuum, space is completely devoid of matter (atoms or molecules); thus, there are no particles to transfer pressure oscillations.

Bell-Jar Experiment



- **Apparatus:** Electric bell, glass bell jar, vacuum pump, battery, and connecting wires.
- **Procedure:**
    1. Suspend the electric bell inside an airtight glass bell jar connected to a vacuum pump.

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2. Turn on the bell circuit. The hammer strikes the gong, and the ringing sound is clearly audible outside.
3. Start the vacuum pump to gradually evacuate air from inside the jar.

- **Observation:** As air is pumped out, the intensity of the sound diminishes. Eventually, when a near-total vacuum is created, no sound is heard despite seeing the hammer strike the gong. When air is allowed back in, the sound becomes audible again.
- **Conclusion:** Sound requires a material medium to propagate.

3. What is nature of sound waves? How is sound propagated? Explain.

Nature of Sound Waves

- **Mechanical:** Requires a material medium (solid, liquid, or gas) to travel.
- **Longitudinal:** The particles of the medium oscillate parallel to the direction of wave propagation.
- **Pressure Waves:** Composed of alternating high-density regions (**compressions**) and low-density regions (**rarefactions**).

Direction of Wave Propagation ---->

||||||| | | | | ||||||| | | | | ||||||| | | | | |||||||

Compressions Rarefactions Compressions

Propagation Process

1. **Source Vibration:** A vibrating object moves forward, pushing air molecules together to form a **compression** zone of high pressure and density.
2. **Restoring Motion:** When the object swings back, it creates a **rarefaction** zone of low pressure.
3. **Chain Reaction:** Air molecules do not travel from source to listener; they oscillate locally around their equilibrium positions, transmitting energy continuously to adjacent molecules.

4. Discuss how changes in amplitude and frequency affect the loudness and pitch of sound waves.

Amplitude and Loudness

- **Loudness:** The degree of auditory sensation produced by a sound wave, directly linked to the wave's **amplitude**.
- **Relationship:** Loudness is proportional to the square of amplitude (Loudness $\propto A^2$).
    - **High Amplitude:** Larger energy, greater air displacement → **Loud sound**.
    - **Low Amplitude:** Smaller energy, minor air displacement → **Faint sound**.

Frequency and Pitch

- **Pitch:** The sensation that allows a sound to be perceived as high or low, directly dependent on **frequency**.
- **Relationship:** Pitch increases proportionally with frequency (Pitch $\propto f$).
    - **High Frequency (f):** Short wavelength, rapid vibrations → **High pitch / Shrilled sound** (e.g., whistle, woman's voice).

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- **Low Frequency (f):** Long wavelength, slow vibrations → **Low pitch / Grave sound** (e.g., bass drum, man's voice).

5. What is quality of sound? How do the shape and material of a sound source influence the waveform of the sound it produces?

Quality (Timbre)

Quality is the characteristic feature of sound that enables a listener to distinguish between two sounds having the **same loudness and pitch** emitted by different instruments.

Influence of Shape and Material on Waveform

- **Fundamental and Overtones:** Pure tones are simple sine waves (like a tuning fork). Instruments produce a fundamental frequency along with multiple secondary frequencies called **harmonics** or **overtones**.
- **Material Influence:** Wood, metal, and plastic vibrate differently due to variations in elasticity and internal damping. For example, a wooden acoustic guitar absorbs higher harmonics faster than a brass trumpet.
- **Shape/Geometry:** The resonant cavity shape (e.g., violin body vs. piano soundboard) dictates which harmonic frequencies are amplified or attenuated.
- **Resulting Waveform:** The superposition of fundamental and overtone waves yields a unique **complex waveform** signature.

6. Explain the speed of sound in different media. How does the speed of sound differ in solids, liquids, and gases? Explain why, and discuss real-world implications.

Speed of Sound Formula

The velocity of a mechanical wave depends on elastic properties (E) and density (ρ):

$$v = \sqrt{\frac{E}{\rho}}$$

Comparison Across Phases

Phase	Speed Range (approx.)	Explanation
Solids	3000 m/s $- 6000$ m/s	Strongest intermolecular forces, high bulk/Young's modulus (E).
Liquids	1400 m/s $- 1600$ m/s	Moderately bound molecules; less elastic than solids.
Gases	330 m/s $- 350$ m/s	Weak intermolecular forces, easily compressible.

Real-World Implications

- **Railway Track Detection:** Hearing an oncoming train by placing an ear against steel rails long before hearing it through the air.

- **SONAR & Marine Life:** Submarines use high-speed underwater sound propagation (≈ 1500 m/s) for navigation and target tracking.
- **Acoustic Design:** Sound travel delay must be compensated in large outdoor public address (PA) systems.

7. What is reflection of sound? Differentiate between echo and reverberation.

Reflection of Sound

When a sound wave encounters the boundary of a different medium, it bounces back into the original medium following the law of reflection (angle of incidence = angle of reflection).

Difference Between Echo and Reverberation

Feature	Echo	Reverberation
Definition	Clear, distinct repetition of sound after reflection from a distant surface.	Prolonged sound caused by multiple overlapping reflections in an enclosed space.
Minimum Distance	At least 17 meters (in air at 20°C).	Less than 17 meters.
Time Delay	Reflection arrives ≥ 0.1 s after the original sound.	Reflections arrive < 0.1 s after the original sound.
Perception	Heard as a separate, distinct repetition of the sound.	Heard as a continuous, blurry extension of sound.

8. Explain the phenomenon of an echo as the reflection of sound waves. Design an experiment to measure the time delay of an echo, and discuss how this can be used to determine distances in various applications, such as sonar.

Phenomenon of Echo

An echo occurs when a sound wave strikes a hard obstacle (e.g., cliff, wall) and reflects back to the observer. Human persistence of hearing is 0.1 s. For a distinct echo, the reflected sound must reach the ear at least 0.1 s after the original sound.

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

Experiment: Measuring Time Delay of Echo

1. Stand at a known distance $S = 50$ m from a large flat vertical wall.
2. Use a stopwatch and clap two wooden blocks together sharp and loudly.
3. Start the timer upon clapping and stop it when the reflected echo is heard. Let total time be t.
4. Speed of sound can be verified as $v = \frac{2S}{t}$.

Applications (SONAR & Depth Detection)

- **SONAR (Sound Navigation and Ranging):** A transmitter on a ship emits ultrasonic pulses down into the ocean floor.
- **Calculation:** The receiver detects the echo after time t. With sound speed in ocean water $v \approx 1500$ m/s, seabed depth is given by:

$$d = \frac{v \cdot t}{2}$$

9. Differentiate between noise and music? Explain that how is noise nuisance?

Differences

Feature	Music	Noise
Waveform	Regular, periodic, continuous vibrations.	Irregular, non-periodic, abrupt vibrations.
Auditory Perception	Pleasant and soothing to human ears.	Unpleasant, jarring, and irritating to ears.
Frequency Pattern	Defined musical frequencies (harmonics).	Random mixtures of frequencies with no order.
Examples	Flute, violin, singing.	Heavy traffic, drilling machine, explosion.

Why Noise is a Nuisance

Excessive noise disrupts physiological and psychological balance. It causes sleep disturbance, stress, elevated blood pressure, severe headaches, lack of concentration, and permanent noise-induced hearing loss (NIHL).

10. Justify the importance of acoustic protection in environments such as schools and hospitals. How can design elements and materials contribute to creating sound-friendly spaces?

Importance in Critical Spaces

- **Schools:** High noise levels interfere with speech clarity, causing student fatigue and impaired learning performance.
- **Hospitals:** Quiet environments are vital for patient healing, blood pressure stabilization, and restful recovery.

Design Elements & Materials

- **Absorptive Surface Linings:** Acoustic ceiling tiles, porous plaster, and wall panels absorb incident sound energy.
- **Soft Interior Furnishings:** Carpeting, heavy drapes, and upholstered chairs minimize reverberation.

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- **Structural Isolation:** Double-glazed windows, cavity walls, and rubberized door gaskets block exterior noise transmission.

11. Analyze the effects of noise pollution on the environment and human health. What strategies can be implemented to mitigate these effects, and how can communities balance development with acoustic quality?

Impact on Environment & Health

- **Human Health:** Cardiovascular diseases, chronic anxiety, sleep disorders, hearing loss, and diminished cognitive performance.
- **Environment/Wildlife:** Disrupts animal navigation, mating calls, and hunting behaviors (e.g., songbirds, marine mammals using SONAR/echolocation).

Mitigation Strategies & Community Balancing

- **Engineering Controls:** Installing sound barriers along highways, using mufflers on exhausts, and designing quiet machinery.
- **Urban Zoning:** Isolating industrial zones and airports away from residential areas.
- **Green Buffers:** Planting dense belts of trees along roadways to naturally absorb sound waves.

12. Humans can hear frequencies from approximately 20 Hz to $20,000$ Hz. Analyze how sounds outside this range (infrasound and ultrasound) are utilized in nature and technology. What are the implications of these frequencies for human hearing?

Utilization of Infrasound (< 20 Hz)

- **Nature:** Elephants, whales, and rhinos communicate over vast miles; animals detect early seismic waves preceding earthquakes.
- **Technology:** Monitoring volcanic eruptions, nuclear test detection, and studying atmospheric phenomena.

Utilization of Ultrasound ($> 20,000$ Hz)

- **Nature:** Bats navigate and hunt insects via echolocation; dolphins explore underwater environments.
- **Technology:** Medical ultrasonography (imaging fetuses/organs), non-destructive flaw detection in metals, ultrasonic cleaning, and SONAR depth measurement.

Implications for Human Hearing

Although inaudible, extremely high-intensity infrasound can cause dizziness or resonance in internal organs, while high-intensity ultrasound can cause localized thermal heating in tissues.

15. Explain how sound waves are converted into electrical signals by the eardrum and auditory nerves.

Step-by-Step Transduction Process

Sound Waves ---> Eardrum (Mechanical Vibration)

|

v

Ossicles (Amplification)

|

v
Oval Window / Cochlea Fluid
|
v
Hair Cells in Organ of Corti
|
v
Electrical Impulses (Auditory Nerve) ---> Brain

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1. **Collection & Mechanical Vibration:** Sound waves pass through the ear canal and strike the **eardrum (tympanic membrane)**, causing it to vibrate in sync with pressure variations.
2. **Mechanical Amplification:** Three small bones—**malleus, incus, stapes (ossicles)**—amplify these mechanical vibrations and push against the oval window of the inner ear.
3. **Fluid Movement & Hair Cell Deflection:** Vibrations enter the fluid-filled **cochlea**, generating fluid waves that displace microscopic hair cells in the Organ of Corti.
4. **Bioelectric Conversion & Nerve Transmission:** Bending of hair cells triggers membrane depolarization, converting mechanical movement into **electrical nerve impulses** sent via the **auditory nerve** to the brain for interpretation.

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NUMERICAL RESPONSE QUESTIONS

QV. Solve the questions given below.

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 the sound is taken as 344 m/s?

Given:

- Time interval for echo, $t = 5$ s
- Speed of sound, $v = 344$ m/s

Formula:

Since the sound wave travels to the cliff and back, total distance traveled is $2d$:

$$2d = v \times t \Longrightarrow d = \frac{v \times t}{2}$$

Calculation:

$$d = \frac{344 \times 5}{2}$$

$$d = \frac{1720}{2} = 860 \text{ m}$$

Result:

The distance of the cliff is 860 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:

- Speed of sound, $v = 1500$ m/s
- Wavelength, $\lambda = 45 \text{ cm} = \frac{45}{100} \text{ m} = 0.45 \text{ m}$

Formula:

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

Calculation:

$$f = \frac{1500}{0.45} = \frac{1500}{\frac{45}{100}} = \frac{150000}{45}$$

$$f = 3333.33 \text{ Hz}$$

Result:

The frequency of the sound waves is 3,333.3 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:

- Speed of sound in seawater, $v = 1500$ m/s
- Total time taken, $t = 8.5$ s

Formula:

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$$\text{Depth } d = \frac{v \times t}{2}$$

Calculation:

$$d = \frac{1500 \times 8.5}{2}$$

$$d = 750 \times 8.5 = 6375 \text{ m}$$

Result:

The distance from the surface to the bottom of the sea is 6,375 m.

4. A physician counts 69 heartbeats in 1 min. Calculate the frequency and period of the heartbeats.

Given:

- Number of heartbeats, $N = 69$
- Time taken, $t = 1 \text{ min} = 60 \text{ s}$

Formulae:

1. Frequency, $f = \frac{N}{t}$
2. Time Period, $T = \frac{1}{f}$

Calculation:

- **Frequency (f):**

$$f = \frac{69}{60} = 1.15 \text{ Hz}$$

- **Time Period (T):**

$$T = \frac{1}{1.15} \approx 0.869565 \text{ s} \approx 0.8696 \text{ s}$$

Result:

- Frequency: 1.15 Hz
- Period: 0.8696 s

5. Find the range of wavelengths at speed 343 m/s for audible frequency range (20 Hz to 20 kHz).

Given:

- Speed of sound, $v = 343$ m/s
- Lower frequency limit, $f_1 = 20$ Hz
- Upper frequency limit, $f_2 = 20$ kHz $= 20{,}000$ Hz

Formula:

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

Calculation:

- **For $f_1 = 20$ Hz:**

$$\lambda_1 = \frac{343}{20} = 17.15 \text{ m}$$

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- **For $f_2 = 20{,}000$ Hz:**

$$\lambda_2 = \frac{343}{20000} = 0.01715 \text{ m}$$

Result:

The range of wavelengths is from 17.15 m **to** 0.01715 m.

6. During thunder storm, thunder sound is heard after 3 second of lightning flash. Find the distance of clouds from ground. (Speed of sound = 340 m/s).

Given:

- Time delay, $t = 3$ s
- Speed of sound, $v = 340$ m/s

Formula:

$$d = v \times t$$

Calculation:

$$d = 340 \times 3 = 1020 \text{ m}$$

Result:

The distance of the clouds from the ground is 1020 m.

7. SONAR (sound navigation and ranging system) sends ultrasound signal towards sea bed. It is received back after 5.3 s. If speed of sound in sea water is 1550 m/s. Find the depth of sea there.

Given:

- Total time taken, $t = 5.3$ s
- Speed of ultrasound in seawater, $v = 1550$ m/s

Formula:

$$\text{Depth } d = \frac{v \times t}{2}$$

Calculation:

$$d = \frac{1550 \times 5.3}{2}$$

$$d = \frac{1550 \times 5.3}{2}$$

Result:

The depth of the sea is 4107.5 m

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