CLASS 9 SCIENCE

CHAPTER 10

SOUND WAVES: CHARACTERISTICS AND APPLICATIONS

NCERT QUESTIONS & ANSWERS

Chapter coverage: Sound is produced by vibrations; sound is a longitudinal mechanical wave requiring a medium; compressions and rarefactions; wavelength, frequency, time period, amplitude, intensity and speed; human hearing; reflection, echo and reverberation; infrasonic and ultrasonic waves; echolocation and sonar.

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CHAPTER-END QUESTIONS & ANSWERS

Revise • Reflect • Refine — Chapter 10

1. Which observation best supports the idea that sound is a mechanical wave? (i) Sound shows reflection (ii) Sound needs a medium to propagate (iii) Sound has frequency (iv) Sound carries energy.

Answer: (ii) Sound needs a medium to propagate.
Mechanical waves require a material medium for propagation. Sound cannot travel through vacuum.

2. For a sound wave propagating in a medium, increasing its frequency will increase its: (i) wavelength (ii) speed (iii) number of compressions per second (iv) time period.

Answer: (iii) number of compressions per second.
Frequency is the number of complete density oscillations, or compressions and rarefactions, passing a point per second. Therefore, increasing frequency increases the number of compressions per second.

3. If 20 compressions pass a point in 4 seconds, find the frequency.

Answer: 5 Hz.
Frequency = number of oscillations / time = 20 / 4 = **5 Hz**.

4. In a room, the reflected sound reaches the ear 0.05 s after its production. Will it produce an echo or reverberation? Justify.

Answer: Reverberation.
A separate echo is heard when the time gap is at least 0.1 s. Here the reflected sound arrives after only 0.05 s, so the original and reflected sounds are not distinctly separated. The result is **reverberation**.

5. Graphs representing two sound waves are given in Fig. 10.30. If the scales on the X and Y axes are the same, which wave has (i) greater wavelength and (ii) smaller amplitude?

Answer:
(i) Greater wavelength: **Wave (a)**.
(ii) Smaller amplitude: **Wave (a)**.
Wavelength is the distance between successive corresponding points such as compressions/crests. Amplitude is the maximum departure from average density. With identical graph scales, the supplied answer key identifies wave (a) for both.

Exam Tip: For sound numericals, first identify whether the time is one-way or round-trip. Use $\nu = 1/T$ and $v = \lambda\nu$. For echoes and sonar, divide the total travel distance/time by 2 to obtain the one-way distance/time.

6. The sound waves emitted by three sources A, B and C are represented in Fig. 10.31. If the frequency of A is maximum and C is minimum, identify the corresponding curves and mark A, B and C on them.

Answer:
A → **Green curve** (maximum frequency)
B → **Red curve**
C → **Blue curve** (minimum frequency)
A higher frequency has more oscillations/compressions over the same distance, while a lower frequency has fewer.

7. Draw a graph to represent a sound wave for which the density amplitude is 3 units and wavelength is 4 cm.

Answer: Draw a sinusoidal density-versus-distance graph with the average density as the central line. The maximum density should be **3 units above** the average line and the minimum density **3 units below** it. The horizontal distance between two successive crests (or two successive troughs) should be **4 cm**. Label the vertical axis **Density** and the horizontal axis **Distance (cm)**.

8. In a movie, while showing the explosion of a spacecraft in space, a flash of light is shown along with sound at the same time. What are the errors in this depiction?

Answer: There are two errors. First, outer space is nearly a vacuum, so **sound cannot propagate directly through space** because it needs a medium. Second, even when sound travels through a medium, it travels much slower than light, so a real observer would see the flash before hearing the sound.

9. A source produces a sound wave of wavelength 3.44 m. If the wave travels with a speed of 344 m s^{-1}, find its time period.

Given: λ = 3.44 m, v = 344 m s^{-1}.
Using $v = \lambda\nu$:
ν = 344 / 3.44 = **100 Hz**.
Time period T = $1/\nu$ = 1/100 = **0.01 s**.

10. A ship searching for a sunken ship sends a sonar signal and detects an echo after 5 s. If the ultrasonic wave travels at 1525 m s^{-1} in seawater, approximately how far down is the wreckage?

Given: total echo time = 5 s; speed = 1525 m s^{-1}.
The 5 s is for the journey down and back, so one-way time = 5/2 = 2.5 s.
Depth = 1525 × 2.5 = **3812.5 m**.

Exam Tip: For sound numericals, first identify whether the time is one-way or round-trip. Use ν = 1/T and v = λν. For echoes and sonar, divide the total travel distance/time by 2 to obtain the one-way distance/time.

11. A vehicle uses an ultrasonic distance sensor. The warning begins when the obstacle is 1.2 m away. How much time does the ultrasonic wave take to travel to the obstacle and return? Take speed = 345 m s■^{1}.

Round-trip distance = 2 × 1.2 = 2.4 m.
Time = distance / speed = 2.4 / 345 = 0.006956... s.
Answer: approximately 0.007 s.

12. Speed of sound in air is about 331 m s■^{1} at 0 °C and 344 m s■^{1} at 22 °C. Roughly how much extra time will thunder take to travel 1720 m if temperature changes from 22 °C to 0 °C?

At 22 °C: t■ = 1720/344 = 5.00 s.
At 0 °C: t■ = 1720/331 ≈ 5.196 s.
Extra time = 5.196 – 5.00 ≈ **0.196 s** (about 0.20 s).
Answer: approximately 0.20 s extra.

13. The variation of density for a sound wave travelling at 340 m s■^{1} is shown in Fig. 10.32. Calculate the wavelength and frequency.

From the graph: wavelength λ = **0.04 m**.
Using v = λν:
ν = 340 / 0.04 = **8500 Hz**.
Answer: wavelength = 0.04 m; frequency = 8500 Hz.

14. Two sound waves A and B travel at the same speed of 345 m s■^{1}. The graphical representation in Fig. 10.33 is given. Find the wavelength of each and their frequencies.

Wave A: λ = **0.025 m** = 2.5 cm. Frequency ν = 345/0.025 = **13,800 Hz**.
Wave B: λ = **0.05 m** = 5.0 cm. Frequency ν = 345/0.05 = **6,900 Hz**.
Answer: A → 0.025 m, 13,800 Hz; B → 0.05 m, 6,900 Hz.

15. Two identical sound sources are placed at A and B—one in air and one submerged in water. Both sounds travel to a cliff and return. If the time taken by sound to return to A is 4.5 times that taken to return to B, what is the ratio between the speeds of sound in air and water?

Answer: 2 : 9 (air : water).
The distances travelled are the same, so time is inversely proportional to speed. If t_{air} = 4.5 t_{water}, then v_{water}/v_{air} = 4.5 = 9/2. Hence **v_{air} : v_{water} = 2 : 9**.

Exam Tip: For sound numericals, first identify whether the time is one-way or round-trip. Use ν = 1/T and v = λν. For echoes and sonar, divide the total travel distance/time by 2 to obtain the one-way distance/time.

QUICK REVISION — CHAPTER 10

High-priority concepts, definitions and formulas

Sound: Sound is produced by vibrating objects. It is a **longitudinal mechanical wave** and needs a material medium. It can travel through solids, liquids and gases but not through vacuum.

Wave quantities: Wavelength (λ) = distance between consecutive corresponding points; frequency (ν) = oscillations per second; time period (T) = time for one oscillation. ν **= 1/T**.

Speed: $v = \lambda\nu = \lambda/T$. Sound travels fastest in solids, slower in liquids and slowest in gases. In air, speed also varies with temperature and humidity.

Amplitude & intensity: Greater amplitude means greater energy carried by the wave. Intensity is the sound energy passing through unit area per unit time. Loudness is the human perception associated with amplitude.

Human hearing: Approximate audible range = **20 Hz to 20 kHz**. Below 20 Hz = infrasonic; above 20 kHz = ultrasonic. Pitch is related mainly to frequency; loudness is related mainly to amplitude.

Reflection: Echo is a distinct reflected sound heard when the time gap is at least 0.1 s. With sound speed 340 m s^{-1}, the minimum echo distance is about 17 m. Reverberation results from multiple reflections arriving in very short intervals.

Applications: Ultrasound is used in ultrasonography, breaking kidney stones, industrial cleaning and detecting defects. Echolocation uses reflected sound to locate objects; sonar applies the same principle underwater.

Key answers: Q1 (ii) • Q2 (iii) • Q3 5 Hz • Q4 reverberation • Q5 (a),(a) • Q6 A-Green, B-Red, C-Blue • Q9 0.01 s • Q10 3812.5 m • Q11 0.007 s • Q12 ≈0.20 s extra • Q13 0.04 m, 8500 Hz • Q14 0.025 m/13,800 Hz and 0.05 m/6,900 Hz • Q15 2:9.