

Class – IX (Science)

Chapter – Sound Waves: Characteristics and Applications

Revise, Reflect, Refine Solution

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

Solution:

A mechanical wave is a wave that requires a material medium (solid, liquid, or gas) for its propagation. Sound cannot travel through a vacuum, which shows that it needs a medium to travel. This characteristic distinguishes mechanical waves from electromagnetic waves.

(ii) Sound needs a medium to propagate

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

Solution:

- Frequency is the number of vibrations (or compressions) produced per second.
- Therefore, increasing the frequency increases the number of compressions per second.

For a given medium:

$$v = f\lambda$$

where v is the speed, f is the frequency, and λ is the wavelength.

- Speed v remains constant in the same medium.



- As frequency increases, wavelength decreases.
- Time period $T = \frac{1}{f}$, so it decreases.

Hence, the correct option is

(iii) number of compressions per second

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

- (i) 80 HZ
- (ii) 5 Hz
- (iii) 10 Hz
- (iv) 0.2 Hz

Solution:

Frequency is the number of compressions passing a point per second.

$$f = \frac{\text{Number of compressions}}{\text{Time}}$$

$$f = \frac{20}{4}$$

$$f = 5 \text{ Hz}$$

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

Solution:

For a person to hear a distinct echo, the reflected sound must reach the ear at least 0.1 s after the original sound.

Given:

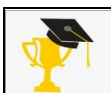
$$\text{Time delay} = 0.05 \text{ s}$$

Since

$$0.05 \text{ s} < 0.1 \text{ s}$$

the reflected sound reaches the ear too quickly to be heard as a separate sound.

Therefore, the reflected sound will mix with the original sound and produce reverberation rather than an echo.



5. Graphs representing two sound waves are given in Fig. 10.30. If the scales on the X and Y axes of the two graphs are the same, which of the two sound waves has
- greater wavelength, and
 - smaller amplitude?

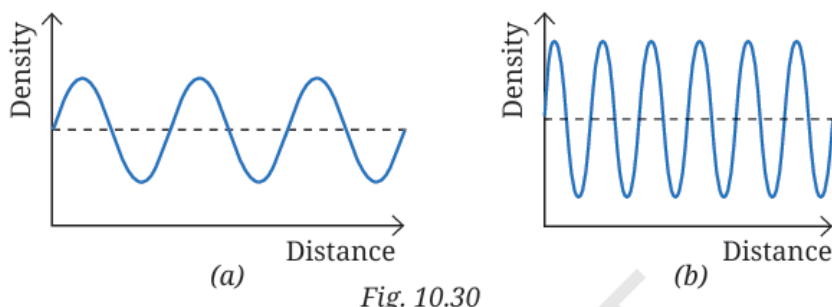


Fig. 10.30

Solution:

The wavelength of a wave is the distance between two successive compressions (or rarefactions).

Since the scales on both graphs are the same:

- Graph (a) shows **fewer waves** in the same horizontal distance.
- Graph (b) shows **more waves** in the same horizontal distance.

Therefore, the wavelength is **greater in graph (a)**.

(i) Greater wavelength: Graph (a)

The amplitude is the maximum displacement from the mean position (dashed line).

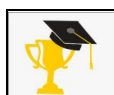
Comparing the heights of the crests and depths of the troughs from the mean line:

- Graph (b) has larger amplitude.
- Graph (a) has smaller amplitude.

Therefore,

(ii) Smaller amplitude: Graph (a)

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.



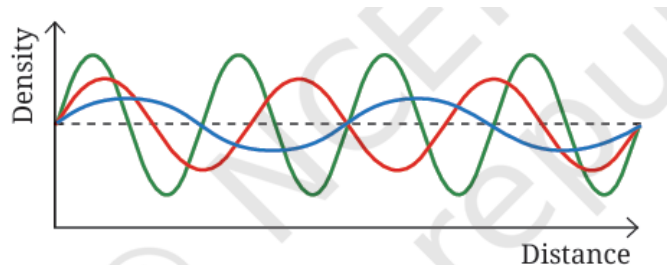


Fig. 10.31

Solution:

The **frequency** of a sound wave is proportional to the number of complete waves present in a given distance.

- More cycles in the same distance \Rightarrow **higher frequency**
- Fewer cycles in the same distance \Rightarrow **lower frequency**

From Fig. 10.31:

- The **green curve** has the maximum number of oscillations \Rightarrow **maximum frequency**
- The **blue curve** has the minimum number of oscillations \Rightarrow **minimum frequency**
- The **red curve** has an intermediate number of oscillations \Rightarrow **intermediate frequency**

Therefore:

A = Green curve

B = Red curve

C = Blue curve

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

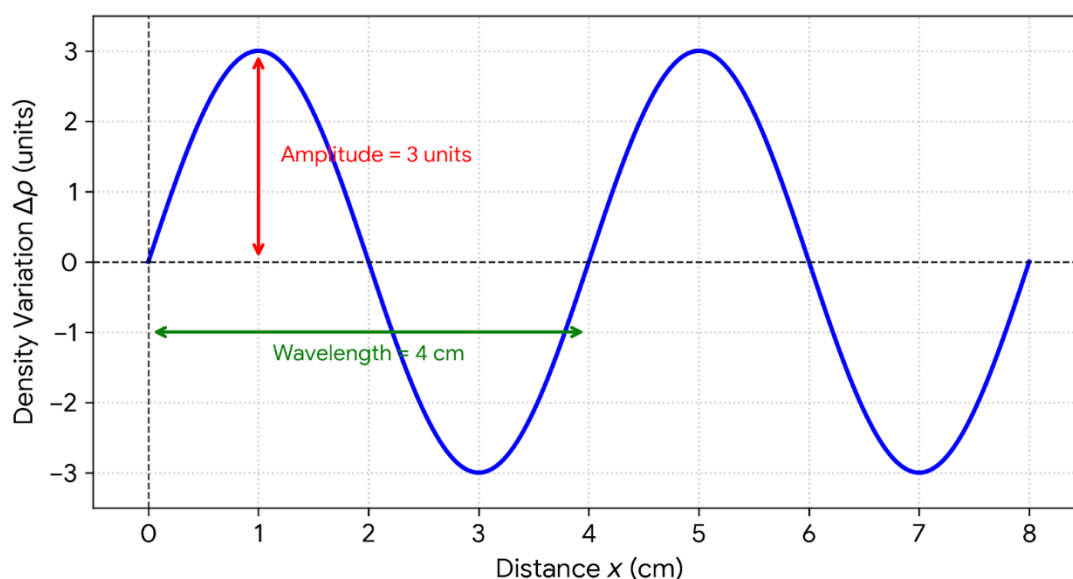
Solution:

To draw the graph:

- Take **Distance (cm)** on the X-axis.
- Take **Density** on the Y-axis.
- Amplitude = 3 units, so the maximum density is +3 and the minimum density is -3 .
- Wavelength = 4 cm, so one complete wave occupies 4 cm along the X-axis.

A suitable representation is:

Sound Wave: Density Variation vs Distance



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?

Solution:

There are two errors in this depiction:

1. **Sound cannot travel in space.**

Sound is a mechanical wave and requires a material medium for propagation. Since space is nearly a vacuum, the sound of the explosion cannot be heard.

2. **Light and sound cannot reach an observer at the same time.**

Even if sound could travel, light travels much faster than sound. Therefore, the flash of light would be seen before the sound is heard.

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.

Solution:

Given:

- Wavelength, $\lambda = 3.44 \text{ m}$
- Speed of sound, $v = 344 \text{ m s}^{-1}$

Using the relation,



$$v = f\lambda$$

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

$$f = \frac{344}{3.44}$$

$$f = 100 \text{ Hz}$$

The time period is

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

$$T = \frac{1}{100}$$

$$T = 0.01 \text{ s}$$

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

Solution:

Given:

- Speed of ultrasonic wave, $v = 1525 \text{ m s}^{-1}$
- Time for echo to return, $t = 5 \text{ s}$

The 5 s is the **total time** for the sound wave to travel to the wreckage and back.

Therefore, the time taken for one-way travel is

$$t_1 = \frac{5}{2} = 2.5 \text{ s}$$

Distance of the wreckage below the ship:

$$d = vt_1$$

$$d = 1525 \times 2.5$$

$$d = 3812.5 \text{ m}$$

11. A vehicle is fitted with an ultrasonic distance sensor as part of a parking assistance system which provides echolocation, while the driver is reversing the vehicle. It emits ultrasonic wave (about 40 kHz) which is reflected by the obstacle. When the warning beep starts sounding at a distance of 1.2 m from the obstacle, how much time is taken by the ultrasonic wave to travel to the obstacle and come back? Assume the speed of ultrasonic wave in air to be 345 m s^{-1} .



Solution:

Given:

- Distance to obstacle, $d = 1.2$ m
- Speed of ultrasonic wave, $v = 345$ m s⁻¹

The ultrasonic wave travels to the obstacle and back, so the total distance travelled is

$$2d = 2 \times 1.2 = 2.4 \text{ m}$$

Using

$$t = \frac{\text{Distance}}{\text{Speed}}$$
$$t = \frac{2.4}{345}$$
$$t = 0.00696 \text{ s}$$
$$t \approx \mathbf{0.007 \text{ s}}$$

12. The speed of sound in air is about 331 m s⁻¹ at 0°C and nearly 344 m s⁻¹ at 22°C. Roughly how much extra time will the sound of thunder take to travel a distance of 1720 m, if the air temperature changes from 22°C to 0°C? Assume that all other conditions remain unchanged.

Solution:

Given:

- Distance, $d = 1720$ m
- Speed of sound at 22°C, $v_1 = 344$ m s⁻¹
- Speed of sound at 0°C, $v_2 = 331$ m s⁻¹

Time taken at 22°C

$$t_1 = \frac{d}{v_1}$$
$$t_1 = \frac{1720}{344}$$
$$t_1 = 5 \text{ s}$$

Time taken at 0°C



$$t_2 = \frac{d}{v_2}$$

$$t_2 = \frac{1720}{331}$$

$$t_2 \approx 5.20 \text{ s}$$

Extra time taken

$$\Delta t = t_2 - t_1$$

$$\Delta t = 5.20 - 5.00$$

$$\Delta t \approx 0.20 \text{ s}$$

13. The variation of density of medium for a sound wave propagating with a speed of 340 m s^{-1} is shown in Fig. 10.32. Calculate the wavelength and frequency of the sound wave.

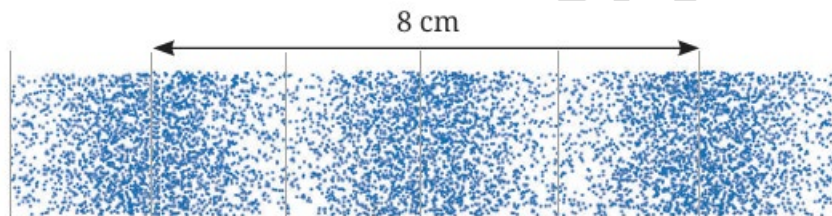


Fig. 10.32

Solution:

Given:

- Speed of sound, $v = 340 \text{ m s}^{-1}$

From Fig. 10.32, the distance between two successive compressions is the wavelength.

The marked distance of **8 cm** extends from the first compression to the third compression, i.e., it contains **2 wavelengths**.

Therefore,

$$2\lambda = 8 \text{ cm}$$

$$\lambda = 4 \text{ cm}$$

$$\lambda = 0.04 \text{ m}$$

Using the relation

$$v = f\lambda$$

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



$$f = \frac{340}{0.04}$$

$$f = 8500 \text{ Hz}$$

14. The graphical representation of two sound waves A and B propagating at the same speed of 345 m s^{-1} is shown in Fig. 10.33. What is the wavelength of each of them? Also, calculate their frequencies.

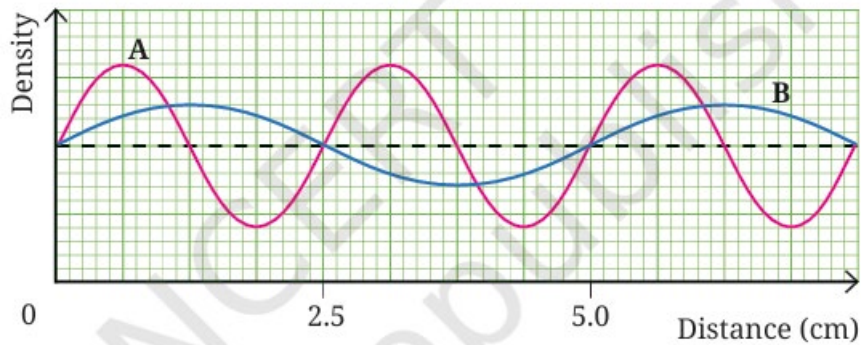


Fig. 10.33

Solution:

Given:

- Speed of both sound waves,

$$v = 345 \text{ m s}^{-1}$$

From the graph:

- Wave A completes **3 full waves** in a distance of **7.5 cm**.
- Wave B completes **1.5 full waves** in the same distance of **7.5 cm**.

Wavelength of Wave A

$$\lambda_A = \frac{7.5}{3}$$

$$\lambda_A = 2.5 \text{ cm}$$

$$\lambda_A = 0.025 \text{ m}$$

Wavelength of Wave B

$$\lambda_B = \frac{7.5}{1.5}$$

$$\lambda_B = 5.0 \text{ cm}$$

$$\lambda_B = 0.05 \text{ m}$$



Frequency of Wave A

Using

$$f = \frac{v}{\lambda}$$
$$f_A = \frac{345}{0.025}$$
$$f_A = 13800 \text{ Hz}$$

Frequency of Wave B

$$f_B = \frac{345}{0.05}$$
$$f_B = 6900 \text{ Hz}$$

15. Two identical sound sources are placed at A and B—one in air and one submerged in water (Fig. 10.34). Both produce sounds at the same time, which travel horizontally to the vertical side of the cliff and come back. If the time taken by the sound to return to A is 4.5 times that of B, what is the ratio between the speeds of sound in air and water?

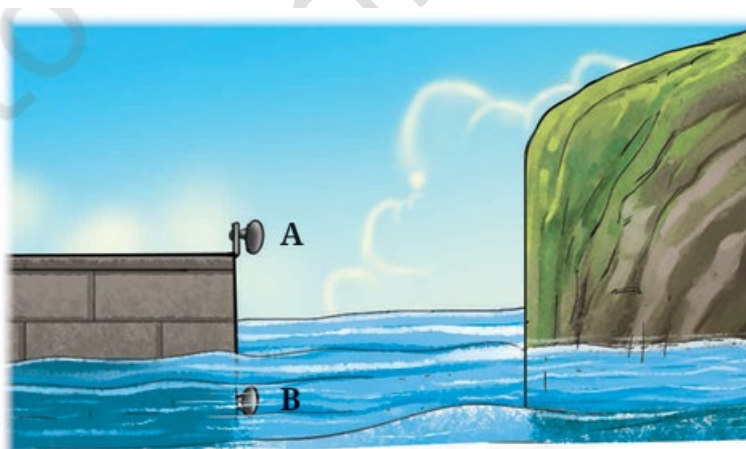


Fig. 10.34

Solution:

From Fig. 10.34, the sound in air (source A) and the sound in water (source B) travel to the same cliff and return. Therefore, both travel the **same total distance**.

Using

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



Let:

- v_a = speed of sound in air
- v_w = speed of sound in water
- d = total distance travelled (same for both)

Then,

$$v_a = \frac{d}{t_a}$$
$$v_w = \frac{d}{t_b}$$

Given:

$$t_a = 4.5 t_b$$

Therefore,

$$\frac{v_a}{v_w} = \frac{d/t_a}{d/t_b} = \frac{t_b}{t_a} = \frac{1}{4.5} = \frac{2}{9}$$

Hence,

$$\boxed{v_a : v_w = 2 : 9}$$

