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SOLUTIONS BOOK

CLASS 9

Science · Exploration

CHAPTER 10

Sound Waves: Characteristics and Applications

Complete Questions, Examples and Activities Solutions

In-text Questions | Examples | Revise, Reflect, Refine | The Journey Beyond

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Every question is followed by its answer. Question numbers above are clickable and the PDF bookmarks panel lets you jump to any exercise set or question. Figures are reproduced from the NCERT textbook (© NCERT) for educational use.

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10.1

CLASS 9 SCIENCE · CHAPTER 10

In-text Questions

Solutions · 25 questions

Directions (Questions 1–25): These are the questions that appear inside the chapter (Think It Over, Activities 10.1–10.8, Pause and Ponder and What if ...), numbered in the order in which they appear. Where an activity needs a classroom or a device, the expected result and the reasoning are given.

QUESTION 1 *Think It Over · p. 184*

Two astronauts are repairing the arm of a space station together during a spacewalk. Can they talk to each other and hear the sounds of metal clanking as they do on the Earth?



ANSWER

No, not directly. Sound needs a material medium to travel, and in outer space there is a near vacuum.

a **Reason**

- Sound is produced by vibrating objects and travels through a medium (a solid, a liquid or a gas).

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- In the vacuum bell jar experiment, almost no sound is heard once most of the air is removed, even though the bell can be seen ringing.
- In outer space there is almost no medium between the astronauts, so the sound cannot propagate.

b How do they communicate?

Astronauts in spacesuits cannot directly hear each other speak or hear metal objects clanking together. They communicate through special devices fitted into their spacesuits.

Therefore, the astronauts cannot talk or hear clanking directly in space, because sound cannot propagate in a vacuum; they use special devices in their suits.

QUESTION 2 *Think It Over · p. 184*

How do most bats use sound to locate their prey in the dark at night?

ANSWER

Most bats use echolocation: they send out sound waves and listen to the echoes that come back.

a How echolocation works

- Most bats emit short bursts of ultrasonic waves (frequency above 20 kHz, which humans cannot hear).
- The waves are reflected from nearby objects, such as obstacles and prey.
- By sensing the echoes, the bat determines the position of the obstacles and the prey.

This ability to locate objects using reflected sound waves is called echolocation (Section 10.8.1). It lets bats fly and hunt in the dark without colliding with objects.

Therefore, bats emit ultrasonic waves and use the echoes reflected from objects to locate obstacles and prey in the dark.

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QUESTION 3 *Activity 10.1 · p. 185*

Activity 10.1: Let us explore. A cardboard box with one side open has a rubber band stretched across the open side (Fig. 10.2).
3. Holding the box steady with one hand, pluck the rubber band with a finger. Do you hear any sound?
4. Pluck the rubber band again and watch it carefully. Is it vibrating?
5. Wait till the rubber band stops vibrating. Do you still hear the sound?
6. Change the tension in the rubber band by stretching it more or loosening it slightly and plucking it each time. Does the sound change? What changes do you notice?
7. Remove the rubber band from the box. Stretch it between two fingers and pluck it near your ear. Is the sound still produced? Is it as loud as before?



Fig. 10.2: Vibrating rubber band produces sound

ANSWER

Expected observations are given step by step. They lead to the conclusion that sound is produced by vibrations.

a Observations

Step	Observation
3	Yes, a sound is heard when the band is plucked.
4	Yes, the band moves rapidly to and fro (it looks blurred): it is vibrating.
5	No. When the vibration stops, the sound stops.
6	Yes. A tighter band gives a higher (shriller) sound and a looser band gives a lower sound; plucking harder makes the sound louder.
7	Yes, sound is still produced by the vibrating band, but it is not as loud; the box and the air in it help to make the sound louder.

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b Conclusion

As long as the rubber band is stretched and vibrating, sound is produced. Once the vibration stops, so does the sound. Vibration is the periodic to and fro motion (oscillation) of an object.

Therefore, sound is produced by vibrations.

QUESTION 4 *Activity 10.2 · p. 186*

Activity 10.2: Let us explore (tuning fork and rubber pad, Fig. 10.4).
3. Strike one of the prongs of the tuning fork gently against the rubber pad (Fig. 10.4b) and bring it close to your ear. Do you hear a sound?
4. Now, gently touch a water surface with one of the vibrating prongs of the tuning fork. Do you see waves forming on the surface of water?
5. Repeat step 3 a few times while bringing the prongs of the tuning fork near your ear in different orientations. Do you hear the sound?

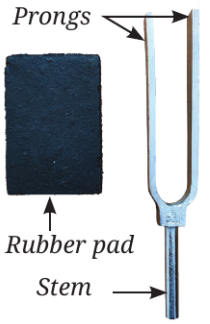


Fig. 10.4: (a) A tuning fork and a rubber pad


Fig. 10.4: (b) Striking a tuning fork against a rubber pad


Fig. 10.4: (c) A prong of vibrating tuning fork touching the surface of water

ANSWER

The tuning fork is a vibrating source. Each step gives evidence that its prongs vibrate and that sound spreads in different directions.

a Observations

Step	Observation	What it shows
3	Yes, a clear sound is heard near the ear.	The struck fork produces sound.
4	Yes, waves (ripples) form on the water surface where the prong touches it.	The prongs are vibrating.
5	Yes, the sound is heard in every orientation.	Sound propagates in many directions from the source.

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Therefore, these observations support the idea that sound is produced by vibrating objects.

QUESTION 5 *Pause and Ponder · p. 186*

1. Explore various ways of producing sound.

ANSWER

Sound is produced whenever an object (or the air) vibrates. Some ways of producing it are listed below.

a Ways of producing sound

- Plucking a stretched string or a rubber band.
- Striking a metal object, a taal or a tuning fork.
- Blowing through a bansuri (flute), which makes the air column inside the pipe vibrate.
- Striking a drum or tabla, whose stretched membrane vibrates.
- Vocal cords vibrating in humans and some animals when we talk or sing.
- Rubbing body parts, as grasshoppers and crickets rub their wings or legs.

Therefore, striking, plucking, blowing, rubbing and vibrating vocal cords are all ways of producing sound; in every case something vibrates.

QUESTION 6 *Pause and Ponder · p. 186*

2. Make a list of different types of musical instruments and identify their vibrating parts which produce sound.

ANSWER

Musical instruments can be grouped by the part that vibrates. In most instruments more than one part vibrates.

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a Instruments and their vibrating parts

Type	Examples	Vibrating part
String instruments	Sitar, sarangi, veena, tanpura, ektara	Stretched strings
Wind instruments	Bansuri (flute)	Air column inside the hollow pipe
Drums	Tabla, mridangam	Stretched membrane (drum head)
Metal instruments	Taal	The metal struck with an object

Therefore, strings, air columns, membranes and metal bodies are the vibrating parts that produce sound in musical instruments.

QUESTION 7 *Activity 10.3 · p. 186*

Activity 10.3: Let us investigate.
1. You and your friend stand on opposite sides of a desk in the classroom. Let your friend gently knock or scratch on the desk. Listen carefully to the sound produced with your ear in the air.
2. Now, place your ear against the desk, close your other ear and listen again, as shown in Fig. 10.5. Are you able to hear the sound through the table?

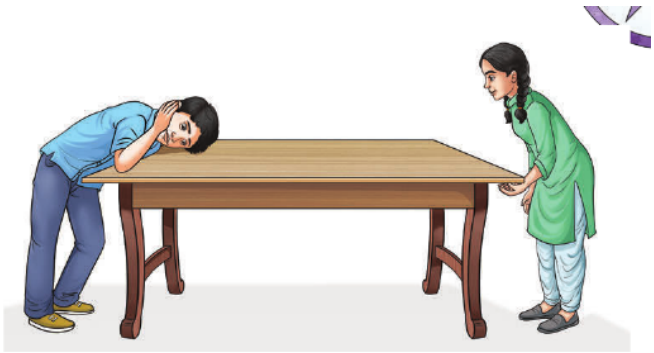


Fig. 10.5: Investigating if sound travels through solid objects

ANSWER

The sound is heard in both cases, and it is heard clearly through the desk.

a Observations

- Step 1: the knock or scratch is heard through the air.

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- Step 2: with the ear against the desk the sound is heard clearly through the table.

Therefore, sound can also travel through solids.

QUESTION 8 *Activity 10.4 · p. 187*

Activity 10.4: Let us investigate.
1. Take a large tub or bucket of water filled to the brim and two metal spoons.
2. Tap the spoons against one another and listen to the sound produced (Fig. 10.6a).
3. Now, submerge the two metal spoons in water without touching the sides or bottom of the bucket and tap them against one another again (Fig. 10.6b). Do you again hear the sound produced?


(a)


(b)

Fig. 10.6: Tapping two poons against each other in (a) air, and (b) water

ANSWER

Yes. The sound of the submerged spoons is heard.

a **Explanation**

The sound has reached you after travelling through water and air. If sound did not travel through liquids, the sound of the submerged spoons would not have been heard.

Therefore, sound can travel through liquids (water) as well as air; sound can propagate through solids, liquids and gases.

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QUESTION 9 *Pause and Ponder · p. 188*

3. Assertion (A): We cannot hear the sound of a bell ringing in a closed jar after most of the air is pumped out.
Reason (R): Sound requires a medium to travel.
Choose the correct statement:
(i) Both A and R are true, but R is not the correct explanation of A.
(ii) Both A and R are true, and R is the correct explanation of A.
(iii) A is true, but R is false.
(iv) A is false, but R is true.

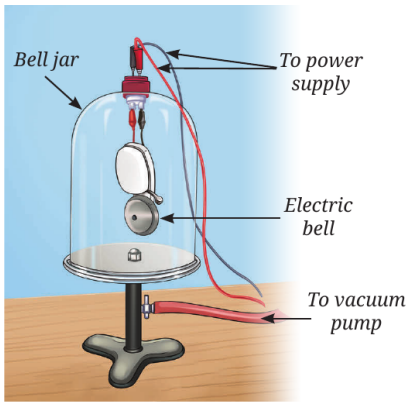


Fig. 10.7: Illustration of a vacuum bell jar

ANSWER

Option (ii) is correct.

a Checking A and R

- A is true: in the vacuum bell jar experiment the sound becomes fainter as air is pumped out and almost no sound is heard near a vacuum.
- R is true: sound needs a medium (solid, liquid or gas) to propagate.
- R explains A: when most of the air (the medium) is removed, the sound cannot reach us.

Therefore, option (ii) is correct: both A and R are true, and R is the correct explanation of A.

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QUESTION 10 *Activity 10.5 · p. 188*

Activity 10.5: Let us observe (slinky and a marked turn, Fig. 10.8).
4. Give the slinky at your end a sharp push towards your friend and then quickly pull it back again (Fig. 10.8). Do you observe a disturbance created in the slinky which moves towards your friend?
5. Now, push and pull the slinky end multiple times in quick succession. Are a series of disturbances produced in the slinky? Do these disturbances move across the length of slinky? Does the mark on the slinky move back and forth parallel to the direction of the disturbance?

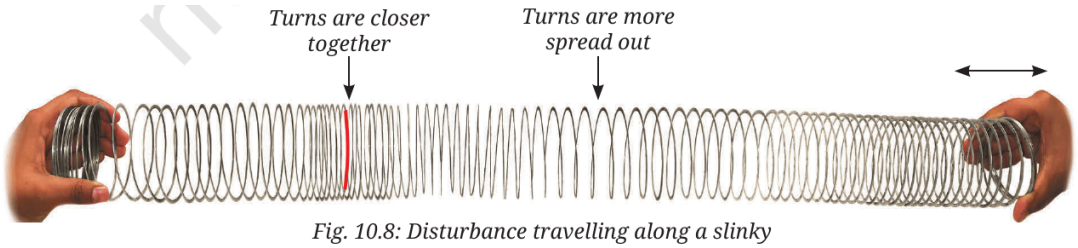


Fig. 10.8: Disturbance travelling along a slinky

ANSWER

The answer to each question is yes. The slinky is an analogy for a medium through which sound travels.

a Observations

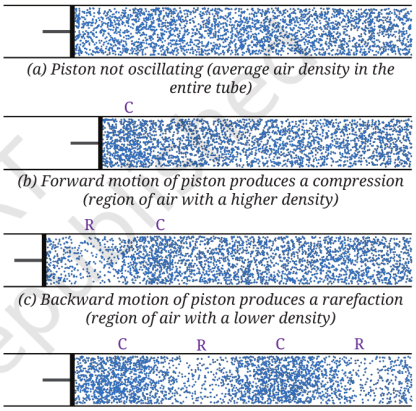
- Yes, a disturbance is created and moves along the slinky towards your friend.
- Yes, repeated pushing and pulling produces a series of disturbances.
- Yes, the regions where the turns are closer together and the regions where they are more spread out appear to travel along the slinky.
- Yes, the mark does not travel along the slinky. It only moves back and forth about its position of rest, parallel to the direction of the disturbance.

Therefore, the disturbance travels along the slinky while each turn only oscillates about its own position; sound moves through a medium in a similar way.

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QUESTION 11 *Pause and Ponder · p. 191*

4. Assertion (A): Compressions and rarefactions move through the medium.
Reason (R): Individual particles of the medium continuously move forward with the wave.
Choose the correct statement:
(i) Both A and R are true, but R is not the correct explanation of A.
(ii) Both A and R are true, and R is the correct explanation of A.
(iii) A is true, but R is false.
(iv) A is false, but R is true.



(a) Piston not oscillating (average air density in the entire tube)
(b) Forward motion of piston produces a compression (region of air with a higher density)
(c) Backward motion of piston produces a rarefaction (region of air with a lower density)
(d) Oscillating piston produces alternate compressions and rarefactions
Fig. 10.9: Density of air in a tube with a piston

ANSWER

Option (iii) is correct.

a Checking A and R

- A is true: the compressions and rarefactions travel away from the source through the medium.
- R is false: the particles of the medium do not travel with the wave. They only vibrate about their mean positions.

Therefore, option (iii) is correct: A is true, but R is false.

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QUESTION 12 *Activity 10.6 · p. 191*

Activity 10.6: Let us experiment. A sheet (cellophane or balloon rubber) is stretched tightly over a wide-mouthed container and grains (rice, semolina, salt, chalk powder) are sprinkled on it (Fig. 10.14).
4. Produce a loud sound near the bowl without touching it. Observe the grains on the sheet. Does the sound have any effect on the grains?
5. Repeat step 4 with different sources of sounds and observe the effect on the grains. You can try increasing or reducing the volume of sound. Try with different grains.

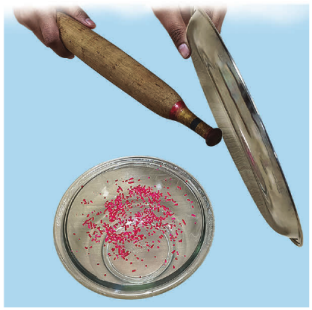


Fig. 10.14: Sound moving grains (coloured)

ANSWER

Yes. The grains move or jump even though the source is not touching the sheet.

a Why do the grains move?

As the sound propagates through air, it reaches the sheet and makes it vibrate. This vibration causes the grains to move.

b Different sounds and volumes

A louder sound (larger amplitude) carries more energy, so the sheet vibrates with a larger displacement and the grains jump higher. A softer sound makes them move less.

Therefore, sound is a form of energy: the vibrating source transfers energy to the medium, and this energy reaches the sheet and moves the grains.

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QUESTION 13 *Pause and Ponder · p. 192*

5. When sound travels from a tuning fork to your ear, which of the following actually reaches your ear?
(i) Air particles near the tuning fork
(ii) Energy carried by sound waves
(iii) The tuning fork material
(iv) A continuous stream of compressed air

ANSWER

Option (ii) is correct.

a Reasoning

- In a sound wave the particles of the medium do not travel with the wave; they only vibrate about their mean positions.
- What travels is the disturbance (compressions and rarefactions) and the energy it carries.
- The material of the tuning fork stays in the fork, and no continuous stream of air flows from the fork to the ear.

Therefore, only the energy carried by the sound waves reaches the ear: option (ii).

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QUESTION 14 *Pause and Ponder · p. 193*

6. The variation of density of the medium for two sound waves is shown in Fig. 10.17 (a) and (b). Label compression and rarefaction by C and R on it. In the graph given in Fig. 10.17 (c) and (d), label the axes and draw the curves corresponding to Fig. 10.17 (a) and (b).

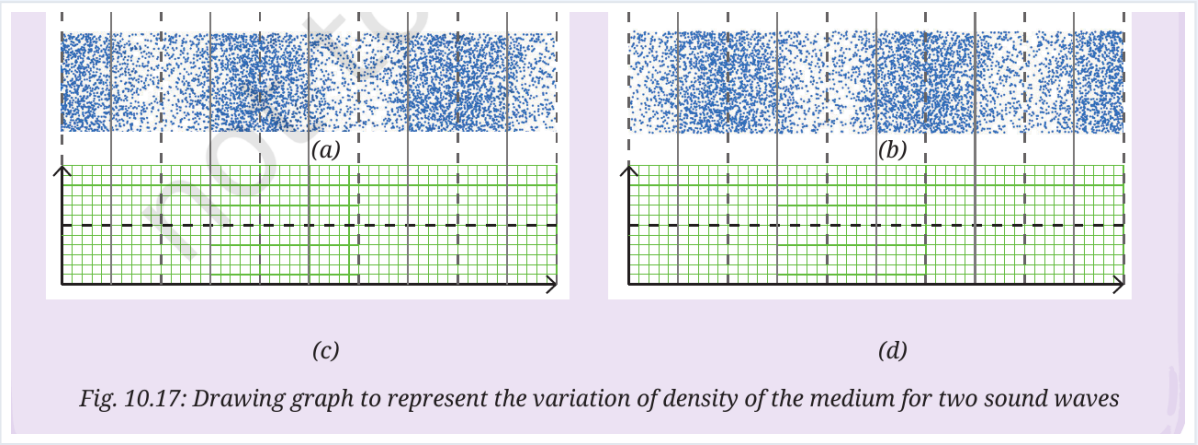


Fig. 10.17: Drawing graph to represent the variation of density of the medium for two sound waves

ANSWER

Regions where the dots are crowded together have higher than average density: compressions (C). Regions where the dots are spread out have lower density: rarefactions (R). The graph is drawn with a crest at each C and a trough at each R.

a Labelling

In (a) and (b), dense regions are labelled C and sparse regions R, alternately along the distance. They are marked in the completed figure below.

b Drawing the graphs

- X-axis: Distance. Y-axis: Density. The dashed line is the average density.
- Draw the curve above the dashed line (a crest) under every compression C and below it (a trough) under every rarefaction R.
- The curve crosses the dashed line between a compression and the next rarefaction.

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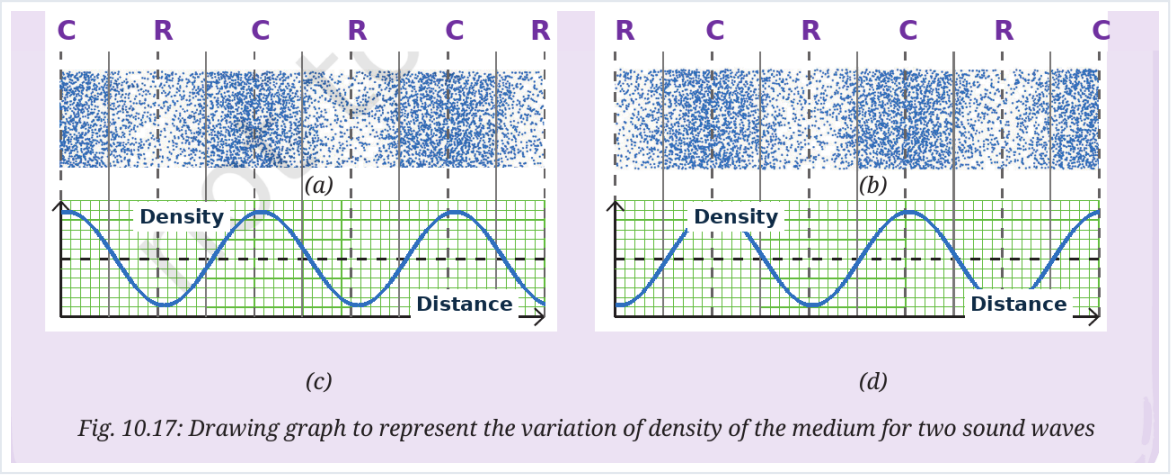


Fig. 10.17: Drawing graph to represent the variation of density of the medium for two sound waves

Fig. 10.17 completed: C and R marked and the curves drawn in (c) and (d)

Therefore, crowded regions are compressions (crests of the density graph) and spread-out regions are rarefactions (troughs).

QUESTION 15 *Activity 10.7 · p. 194*

Activity 10.7: Let us experiment (demonstration activity). Use a mobile app, such as Phyphox that can identify frequencies of sounds ('Audio Spectrum').
2. Try to sing the musical notes 'Sa, Re, Ga, Ma, Pa, Dha, Ni, Sa' one after another, or use a music or tone generating app. Observe how the frequency changes as each note is produced.
3. Record the approximate frequency values for each musical note.
4. Compare the musical notes by taking the ratio of each frequency with respect to the 'Sa'. Do you observe any pattern?
5. If both voice and mobile-generated notes are used, compare their frequencies for the same musical notes.

ANSWER

This is a demonstration with a phone app, so the frequency values come from your own readings. The pattern to expect is described below.

a What to expect

- The frequency is lowest for the first 'Sa' and gradually increases for the other notes. Each note has a distinct frequency, which makes it sound different.
- The last 'Sa' has about twice the frequency of the first 'Sa' (an octave, Section 10.6.4).

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- The ratios of the notes' frequencies to the 'Sa' are roughly the same whatever the base 'Sa' is. A common set of ratios is about 1, 1.12, 1.25, 1.33, 1.5, 1.67, 1.88 and 2 (they vary slightly with the tuning system).
- Voice and app notes for the same note have nearly equal frequencies, but the sung values are less steady.

b Method

Record the frequency of each note, then ratio = frequency of the note / frequency of the first 'Sa'. Tabulate the values and compare them for different singers.

Therefore, each note has its own frequency, the frequency rises from Sa to the next Sa, and the frequency ratios show a pattern.

QUESTION 16 *Pause and Ponder · p. 195*

7. Conduct Activity 10.1 once again with a thick rubber band and then with a thin rubber band. Does the thin rubber band vibrate faster than the thick rubber band? If yes, how do the frequency and time period of the sound produced by the thin rubber band differ from that of the thick rubber band?

ANSWER

Expected result: the thin band vibrates faster than the thick band and gives a higher-pitched sound.

a Comparison

Quantity	Thin rubber band	Thick rubber band
Vibrations per second	More (vibrates faster)	Fewer
Frequency (ν)	Higher	Lower
Time period (T = 1/ν)	Smaller	Larger
Sound heard	Higher pitch (shriller)	Lower pitch

b Illustration (assumed values)

If the thin band vibrates 200 times per second, its time period is 1/200 = 0.005 s; if the thick band vibrates 100 times per second, its time period is 1/100 = 0.01 s. The frequency and time period are inversely related (ν = 1/T).

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Therefore, the thin band has a higher frequency and a smaller time period than the thick band.

QUESTION 17 *Pause and Ponder · p. 195*

8. If the frequency of a sound wave produced by an oscillating piston of a long tube filled with air is 20 Hz, then how many oscillations does the piston complete per minute?

ANSWER

Frequency is the number of oscillations per second. The piston makes 20 oscillations every second.

a Given

Frequency ν = 20 Hz = 20 oscillations per second; 1 minute = 60 s.

b Calculation

Oscillations per minute = 20 × 60 = 1200

Therefore, the piston completes 1200 oscillations per minute.

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QUESTION 18 *Pause and Ponder · p. 195*

9. For the sound wave represented by the graph shown in Fig. 10.19, what is half of its wavelength?

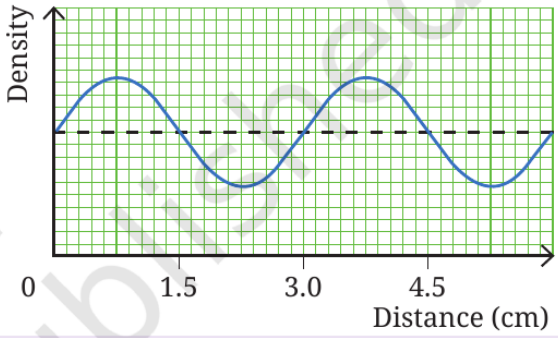


Fig. 10.19: Graphical representation of a sound wave

ANSWER

The wavelength is the distance between two consecutive crests (or two consecutive troughs). In Fig. 10.19 the curve starts on the average-density line at 0 and crosses it again at 1.5 cm, 3.0 cm and 4.5 cm.

a Reading the graph

- The two crests are at about 0.75 cm and 3.75 cm: the distance between them is 3.75 − 0.75 = 3.0 cm.
- The curve completes one full cycle (up, down and back to the start) between 0 and 3.0 cm.

b Calculation

Wavelength λ = 3.0 cm

Half of the wavelength = 3.0 cm / 2 = 1.5 cm

Therefore, the wavelength is 3.0 cm and half of it is 1.5 cm.

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QUESTION 19 *What if ... · p. 196*

What if … the speed of sound in air depended on its frequency? Would music still sound pleasant when a singer performs with instruments? Why or why not?

ANSWER

No, it would not sound pleasant. The notes of a song or a chord would not reach the listener together.

a **Reasoning**

- In most media, such as air, the speed of sound does not depend on the frequency, so all notes travel at the same speed and reach the listener together.
- If the speed depended on frequency, sounds of different frequencies produced at the same instant (by the singer and the instruments) would arrive at different times.
- The listener, particularly at a distance, would hear the notes out of step, so the music would sound jumbled.

Therefore, music would not sound pleasant, because the different frequencies would reach the ear at different times.

QUESTION 20 *Pause and Ponder · p. 197*

10. Table 10.1 shows the speed of sound in a few media at atmospheric pressure. Table 10.1: Speed of sound in different media at 15 °C: Steel (solid) 5000 m s^{-1}, Water (liquid) 1500 m s^{-1}, Air (gas) 340 m s^{-1}. Compare the speeds in different media by finding the ratio of
(i) the speed of sound in water with respect to the speed in the air.
(ii) the speed of sound in steel with respect to the speed in the water.

ANSWER

The ratio of two speeds is one speed divided by the other.

a **(i) Water with respect to air**

Ratio = 1500 / 340 = 4.4 (approximately)

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b **(ii) Steel with respect to water**

Ratio = 5000 / 1500 = 3.3 (approximately)

Therefore, sound travels about 4.4 times faster in water than in air, and about 3.3 times faster in steel than in water.

QUESTION 21 *Pause and Ponder · p. 198*

11. Two friends are standing along a steel fence at a distance of 340 m from each other (Fig. 10.23). Gunjan places her ear over the fence and her friend knocks the fence with a metal object. Using the values of the speed of sound in steel and air given in Table 10.1, calculate the time difference between the sound that reached Gunjan through the air and the steel. Would it have been possible for her to distinguish between the two sounds? (The time interval between two sounds must be at least 0.1 s to be heard separately.)

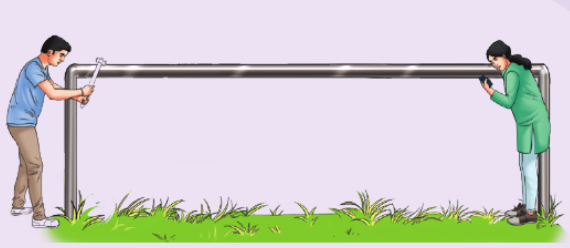


Fig. 10.23: Time difference between the sound reaching through air and steel

ANSWER

Find the time taken by the sound in each medium using time = distance / speed, then compare the difference with 0.1 s.

a **Given**

Distance = 340 m; speed in air = 340 m s^{-1}; speed in steel = 5000 m s^{-1}

b **Time taken**

Through air: t_{air} = 340 / 340 = 1 s
Through steel: t_{steel} = 340 / 5000 = 0.068 s

c **Time difference**

Difference = 1 s − 0.068 s = 0.932 s ≈ 0.93 s

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The difference (0.93 s) is much more than 0.1 s.

Therefore, the time difference is about 0.93 s, so Gunjan can hear the two sounds separately: first the sound through the steel and later through the air.

QUESTION 22 *Activity 10.8 · p. 198*

Activity 10.8: Let us experiment (demonstration activity). Open a mobile app that can generate sounds.
2. Set the frequency to 100 Hz, tap 'play', and listen carefully.
3. Increase the frequency in steps of 100 Hz up to 1000 Hz and describe how the sound changes.
4. Next, set the frequency to 50 Hz. Reduce the frequency till about 20 Hz or the point where you cannot hear the sound anymore.

ANSWER

This is a demonstration with a sound-generating app. The expected observations are given below.

a Expected observations

- At 100 Hz a low, deep sound is heard.
- As the frequency increases in steps of 100 Hz up to 1000 Hz, the sound becomes higher in pitch (more shrill).
- Reducing the frequency from 50 Hz towards 20 Hz makes the sound lower and softer, until it can no longer be heard near the lower end of the hearing range (the phone speaker may stop producing it even earlier).

b What it shows

Higher frequency is perceived as higher pitch. The human hearing range is about 20 Hz to 20,000 Hz (20 kHz); sounds below 20 Hz are infrasonic and those above 20 kHz are ultrasonic.

Therefore, pitch increases with frequency, and we cannot hear sounds below about 20 Hz.

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QUESTION 23 *Pause and Ponder · p. 201*

12. An experiment is being set up that requires echoes to arrive at least 0.2 s after the emission of sound. What minimum distance should a reflecting surface be placed at? Assume the speed of sound to be 343 m s^{-1}.

ANSWER

The sound travels to the reflecting surface and back, so the total distance covered in 0.2 s is twice the distance of the surface.

a Given

Time t = 0.2 s, speed v = 343 m s^{-1}.

b Calculation

Total distance = v × t = 343 × 0.2 = 68.6 m

Distance of the surface = 68.6 / 2 = 34.3 m

Therefore, the reflecting surface should be placed at least 34.3 m away.

QUESTION 24 *What if … · p. 202*

What if … humans could detect ultrasonic waves like dogs can? What would be the advantages and disadvantages?

ANSWER

Humans would sense sounds above 20 kHz, which they cannot hear now. This would bring both uses and problems.

a Possible advantages

- We could hear ultrasonic sounds from animals such as bats and dolphins.
- We could locate obstacles and objects by echoes, as bats do, even in the dark.
- We could detect some machine and equipment sounds that are above the audible range.

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b **Possible disadvantages**

- We would hear ultrasonic sounds from devices all the time, which could be irritating and add to noise pollution.
- Exposure to very loud ultrasonic sound could affect sleep and hearing.
- Concentrating on ordinary sounds, like speech, might be harder.

Therefore, detecting ultrasound would help in locating objects and sensing more of nature, but extra noise could be a nuisance and a hazard.

QUESTION 25 *Pause and Ponder · p. 203*

13. Sound travels much farther in water than light, and thus, is used for various underwater applications. A sonar signal sent to find the depth of ocean takes 4 s to return. What is the depth of the ocean at that location if the speed of sound in seawater is 1500 m s^{-1}?

ANSWER

The signal goes down to the ocean floor and comes back, so the time to reach the bottom is half of 4 s.

a **Given**

Total time = 4 s, speed = 1500 m s^{-1}.

b **Calculation**

Time to reach the bottom = 4 / 2 = 2 s

Depth = speed × time = 1500 × 2 = 3000 m

Therefore, the depth of the ocean at that location is 3000 m (3 km).

NCERT ARCHIVE

10.2

CLASS 9 SCIENCE · CHAPTER 10

Examples

Solutions · 6 examples

Directions (Questions 1–6): These are Examples 10.1 to 10.6 worked in the chapter. Each example is restated and solved step by step, and every result has been checked.

QUESTION 1 *Example 10.1 · p. 195*

If there are 10 density oscillations in 2 seconds at a given position, then calculate the (i) frequency of sound wave, and (ii) its time period.

ANSWER

Frequency is the number of oscillations per unit time. The time period is the time for one oscillation.

a **(i) Frequency**

ν = number of oscillations / time taken = 10 / 2 s = 5 Hz

b **(ii) Time period**

T = 2 s / 10 = 0.2 s

Check: $T = 1/\nu = 1/5 = 0.2$ s

Therefore, the frequency is 5 Hz and the time period is 0.2 s.

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QUESTION 2 *Example 10.2 · p. 196*

Human hearing roughly spans 20 Hz to 20 kHz. What are the corresponding wavelengths in air for these two frequencies? Use the speed of sound in air as 344 m s^{-1}.

ANSWER

Use Eq. (10.2): speed = wavelength × frequency, so wavelength λ = v / ν.

a **(i) For ν = 20 Hz**

λ = 344 / 20 = 17.2 m

b **(ii) For ν = 20 kHz = 20000 Hz**

λ = 344 / 20000 = 0.0172 m = 1.72 cm

Therefore, the wavelengths in air are 17.2 m for 20 Hz and 1.72 cm for 20 kHz.

QUESTION 3 *Example 10.3 · p. 197*

During a thunderstorm, lightning is seen before thunder is heard because sound travels much slower than light. If the time delay between seeing the lightning flash and hearing the thunder is measured to be 5 s, estimate the distance to the lightning strike. Use the speed of sound in air as 340 m s^{-1}. Assume that light (speed = 300000 km s^{-1}) reaches you almost instantaneously.

ANSWER

Light reaches us almost instantly, so the delay of 5 s is the time taken by the sound.

a **Calculation**

Distance = v × t = 340 × 5 = 1700 m = 1.7 km

Therefore, the lightning struck about 1.7 km away.

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QUESTION 4 *Example 10.4 · p. 197*

From the graphical representation of a sound wave propagating in steel (Fig. 10.22), find its wavelength. Calculate its frequency and time period if the speed of sound in steel is 5000 m s^{-1}.

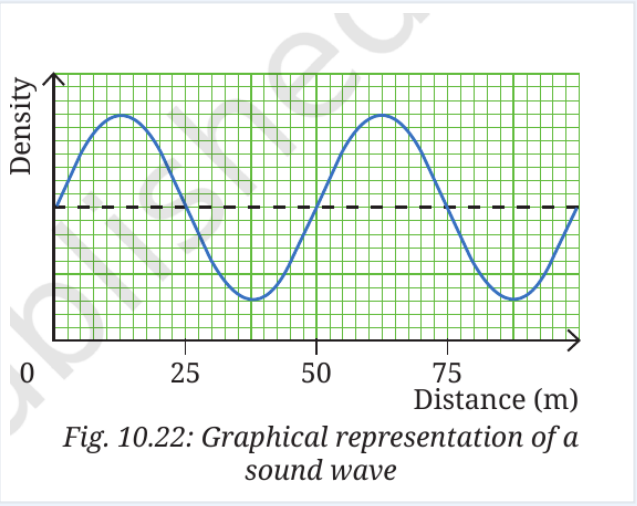


Fig. 10.22: Graphical representation of a sound wave

ANSWER

Read the wavelength from the graph as the distance between two consecutive crests, then use $\nu = v / \lambda$ and $T = 1/\nu$.

a Wavelength from the graph

The crests are at about 12.5 m and 62.5 m, so $\lambda = 62.5 - 12.5 = 50$ m (the curve completes one cycle between 0 and 50 m).

b Frequency

$\nu = v / \lambda = 5000 / 50 = 100$ Hz

c Time period

$T = 1/\nu = 1 / 100$ Hz $= 0.01$ s

Therefore, $\lambda = 50$ m, $\nu = 100$ Hz and $T = 0.01$ s.

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QUESTION 5 *Example 10.5 · p. 201*

You clap in an empty corridor and hear an echo after 0.5 s. If the speed of sound in air is 340 m s^{-1}, calculate your distance from the wall.

ANSWER

The sound travels to the wall and back, so the distance travelled is twice the distance from the wall.

a **Calculation**

2 × distance = v × t = 340 × 0.5 = 170 m

Distance from the wall = 170 / 2 = 85 m

Therefore, you are 85 m from the wall.

QUESTION 6 *Example 10.6 · p. 203*

A naval sonar signal sent into seawater returns after 0.90 s. The speed of sound in seawater is 1530 m s^{-1}. How far is the object?

ANSWER

The signal travels to the object and back in 0.90 s.

a **Calculation**

Time to reach the object = 0.90 / 2 = 0.45 s

Distance = speed × time = 1530 × 0.45 = 688.5 m

Therefore, the object is 688.5 m away.

NCERT ARCHIVE

10.3

CLASS 9 SCIENCE · CHAPTER 10

Revise, Reflect, Refine

Solutions · 15 questions

Directions (Questions 1–15): These are the questions at the end of the chapter (pages 204–206). Each answer lists the data, the formula, the working and the final result. Where a value is read from a graph, the reading is stated.

QUESTION 1 *Revise, Reflect, Refine · p. 204*

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

Option (ii) is correct. A mechanical wave is a wave that needs a material medium to propagate.

a **Why the other options do not decide it**

- Reflection, frequency and carrying energy are properties of other waves too, including light, which is not a mechanical wave.
- Needing a medium is what makes a wave mechanical: the vacuum bell jar shows sound cannot propagate without one.

Therefore, option (ii): sound needs a medium to propagate.

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QUESTION 2 *Revise, Reflect, Refine · p. 204*

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

Option (iii) is correct.

a **Reasoning**

- Frequency is the number of oscillations (so the number of compressions) passing a point per second. Increasing it increases this number.
- The speed depends on the medium, so it stays constant.
- Since $v = \lambda\nu$, with v fixed, a larger ν gives a smaller wavelength.
- The time period $T = 1/\nu$ becomes smaller.

Therefore, option (iii): the number of compressions per second increases.

QUESTION 3 *Revise, Reflect, Refine · p. 205*

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

ANSWER

One compression passing a point corresponds to one complete oscillation, so frequency = number of compressions / time.

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a Calculation

$\nu = 20 / 4 \text{ s} = 5 \text{ Hz}$

Therefore, the frequency is 5 Hz: option (ii).

QUESTION 4 *Revise, Reflect, Refine · p. 205*

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.

ANSWER

It will produce reverberation, not an echo.

a Justification

- An echo is heard only when the time gap between the original and reflected sounds is at least 0.1 s. Here the gap is 0.05 s, which is less than 0.1 s, so the two sounds cannot be heard separately.
- In a room, the reflections from the walls arrive within about this very short time and merge with the original sound, making the sound persist after the source stops (reverberation, with reflections arriving less than about 0.05 s apart).

Therefore, a gap of 0.05 s is too short for an echo; the reflected sound merges with the original sound and produces reverberation.

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QUESTION 5 *Revise, Reflect, Refine · p. 205*

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 (i) greater wavelength, and (ii) smaller amplitude?

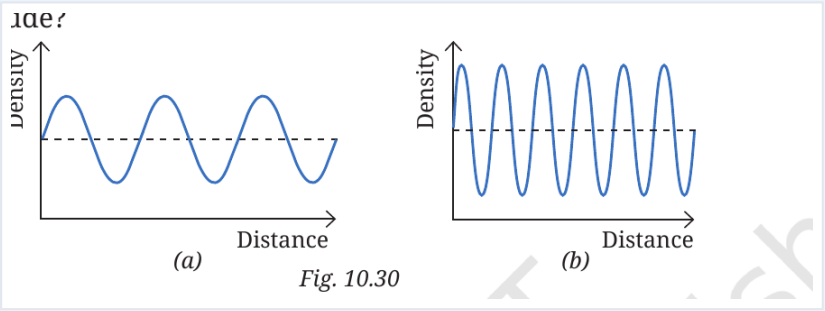


Fig. 10.30

ANSWER

Wavelength is the distance between two consecutive crests; amplitude is the maximum height of the curve above (or depth below) the average-density line.

a (i) Greater wavelength

In the same length of the X-axis, graph (a) has fewer waves than graph (b), so its crests are farther apart. Graph (a) has the greater wavelength.

b (ii) Smaller amplitude

The crests and troughs of graph (a) are closer to the dashed average line than those of graph (b), so (a) has the smaller amplitude.

Therefore, wave (a) has the greater wavelength and also the smaller amplitude.

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QUESTION 6 *Revise, Reflect, Refine · p. 205*

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.

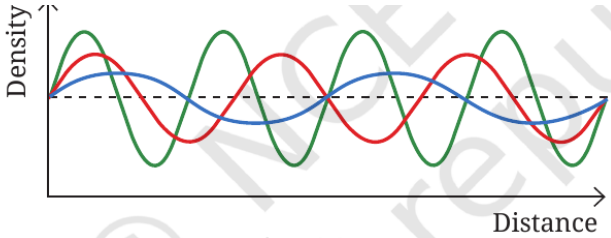


Fig. 10.31

ANSWER

A wave with a higher frequency has more crests in the same distance (a shorter wavelength). Count the crests of the three curves.

a Identifying the curves

Curve	Crests in the same distance	Frequency	Source
Green	Most (4)	Maximum	A
Red	Fewer than green	In between	B
Blue	Fewest	Minimum	C

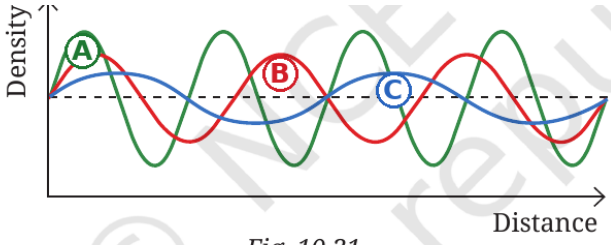


Fig. 10.31

Fig. 10.31 with the curves marked A, B and C

Therefore, A is the green curve (maximum frequency), B is the red curve and C is the blue curve (minimum frequency).

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QUESTION 7 *Revise, Reflect, Refine · p. 205*

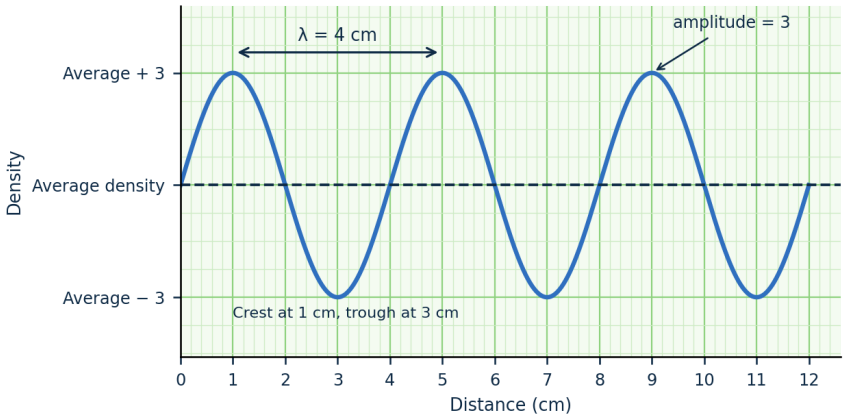
7. Draw a graph to represent a sound wave for which the density amplitude is 3 units and wavelength is 4 cm.

ANSWER

Plot density against distance. The curve swings 3 units above and 3 units below the average density, and repeats every 4 cm.

a Steps

- Draw the X-axis (Distance, cm) and Y-axis (Density) and mark the average density as a dashed horizontal line.
- Amplitude 3 units: crests at average + 3 and troughs at average − 3.
- Wavelength 4 cm: crests 4 cm apart (at 1 cm, 5 cm, 9 cm, …) and troughs at 3 cm, 7 cm, 11 cm, …; the curve crosses the average line at 0, 2, 4, 6 cm and so on.



Graph of the sound wave: amplitude 3 units, wavelength 4 cm

Therefore, the graph is a wave of height 3 units above and below the average line, repeating every 4 cm.

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QUESTION 8 *Revise, Reflect, Refine · p. 205*

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, one about the sound and one about the timing.

a The errors

- Sound cannot propagate in space because there is a near vacuum and no medium, so no explosion sound could be heard.
- Even where sound can travel (for example in air), light travels much faster than sound, so the flash is seen first and the sound is heard later; they are not perceived at the same time.

Therefore, the errors are showing sound in space (where there is no medium) and showing the sound and light together, although light reaches us much earlier.

QUESTION 9 *Revise, Reflect, Refine · p. 205*

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.

ANSWER

Use $v = \lambda \nu$ and $T = 1/\nu$, so $T = \lambda / v$.

a Given

$\lambda = 3.44$ m, $v = 344$ m s^{-1}.

b Calculation

$\nu = v / \lambda = 344 / 3.44 = 100$ Hz

$T = 1/\nu = 1/100 = 0.01$ s

Therefore, the time period is 0.01 s.

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QUESTION 10 *Revise, Reflect, Refine · p. 205*

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?

ANSWER

The signal travels down and back in 5 s, so the one-way time is half of it.

a **Calculation**

One-way time = 5 / 2 = 2.5 s

Distance = 1525 × 2.5 = 3812.5 m

Therefore, the wreckage is about 3800 m (approximately 3.8 km) down in the ocean.

QUESTION 11 *Revise, Reflect, Refine · p. 205*

11. A vehicle is fitted with an ultrasonic distance sensor as part of 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 ultrasonic wave to travel to the obstacle and come back? Assume the speed of ultrasonic wave in air to be 345 m s^{-1}.

ANSWER

The wave covers the distance to the obstacle twice, once going and once coming back.

a **Calculation**

Total distance = 2 × 1.2 = 2.4 m

Time = distance / speed = 2.4 / 345 = 0.00696 s ≈ 7×10^{-3} s

Therefore, the ultrasonic wave takes about 0.007 s (7 ms) to go to the obstacle and come back.

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QUESTION 12 *Revise, Reflect, Refine · p. 206*

12. The speed of sound in air is about 331 m s^{-1} at 0 ºC and nearly 344 m s^{-1} at 22 ºC. 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 ºC to 0 ºC? Assume that all other conditions remain unchanged.

ANSWER

Find the time for 1720 m at each speed using time = distance / speed and take the difference.

a **Time at the two temperatures**

At 22 ºC: $t_1 = 1720 / 344 = 5$ s
At 0 ºC: $t_2 = 1720 / 331 \approx 5.20$ s

b **Extra time**

$t_2 - t_1 = 5.196 - 5 \approx 0.2$ s

Therefore, the thunder takes roughly 0.2 s longer to arrive at 0 ºC.

QUESTION 13 *Revise, Reflect, Refine · p. 206*

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.

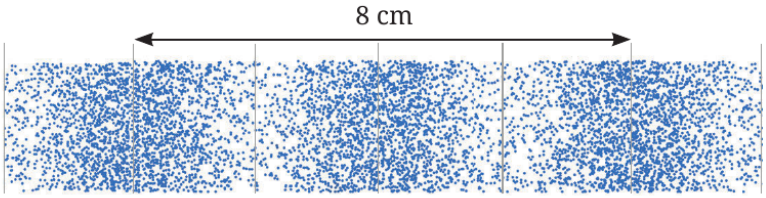


Fig. 10.32

ANSWER

In Fig. 10.32 the arrow marked 8 cm covers two complete wavelengths (two compressions and the two rarefactions between and after them).

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a Wavelength

The vertical lines in the figure are half a wavelength apart. The arrow marked 8 cm spans four of these gaps, which is two complete wavelengths.

$2\lambda = 8 \text{ cm} \Rightarrow \lambda = 4 \text{ cm} = 0.04 \text{ m}$

b Frequency

$\nu = v / \lambda = 340 / 0.04 = 8500 \text{ Hz} = 8.5 \text{ kHz}$

Therefore, the wavelength is 4 cm (0.04 m) and the frequency is 8500 Hz.

QUESTION 14 *Revise, Reflect, Refine · p. 206*

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.

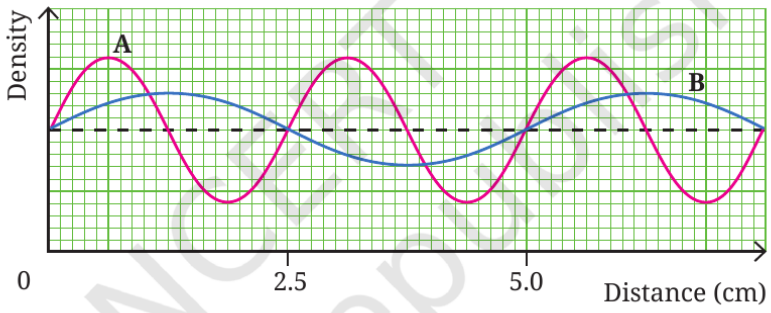


Fig. 10.33

ANSWER

Read each wavelength from the graph (one complete cycle), then use $\nu = v / \lambda$.

a Wavelengths

- Wave A (pink): the crests are 2.5 cm apart (one cycle between 0 and 2.5 cm), so $\lambda_A = 2.5 \text{ cm} = 0.025 \text{ m}$.
- Wave B (blue): it crosses the average line at 0, 2.5 cm and 5.0 cm, which are half-wavelength steps, so one cycle is 5.0 cm and $\lambda_B = 5.0 \text{ cm} = 0.05 \text{ m}$.

b Frequencies

$\nu_A = 345 / 0.025 = 13800 \text{ Hz} = 13.8 \text{ kHz}$
$\nu_B = 345 / 0.05 = 6900 \text{ Hz} = 6.9 \text{ kHz}$

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Therefore, A: λ = 2.5 cm, ν = 13800 Hz; B: λ = 5.0 cm, ν = 6900 Hz. Wave A has half the wavelength and twice the frequency of B.

QUESTION 15 *Revise, Reflect, Refine · p. 206*

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 than that of B, what is the ratio between the speeds of sound in air and water?

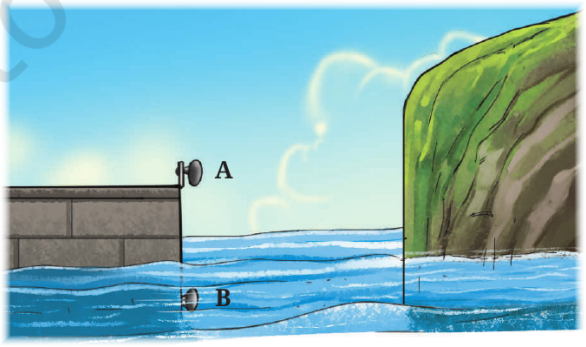


Fig. 10.34

ANSWER

Both sounds travel the same distance, 2d (to the cliff and back), where d is the distance to the cliff. The time is inversely proportional to the speed.

a Setting up

$t_A = 2d / v_{air}$ and $t_B = 2d / v_{water}$
Given $t_A = 4.5\ t_B$

b Ratio

$t_A / t_B = v_{water} / v_{air} = 4.5$
$v_{air} / v_{water} = 1 / 4.5 = 2 / 9 \approx 0.22$

This agrees with Section 10.6.3: sound travels about 4 to 5 times faster in water than in air.

Therefore, $v_{air} : v_{water} = 1 : 4.5 = 2 : 9$.

NCERT ARCHIVE

10.4

CLASS 9 SCIENCE · CHAPTER 10

The Journey Beyond

Solutions · 5 questions

Directions (Questions 1–5): These are the tasks at the end of the chapter (page 207). Where a task is a hands-on activity or a project, the expected result and the reasoning are given.

QUESTION 1 *The Journey Beyond · p. 207*

Many people use earphones extensively these days. Find out the research studies that might have been done to understand the impact of excessive use of earphones on hearing (if any). Also, find out how hearing is tested and what are the decibel ranges for defining mild, moderate and severe hearing loss. What are the government schemes for purchasing or fitting of aids or appliances and free cochlear implants? Write an article on your findings.

ANSWER

This is a research and writing task. The facts below can be used as a starting point; check the latest details from official websites before writing your article.

a Earphones and hearing

Prolonged exposure to loud sound can lead to hearing loss (Bridging Science and Society, p. 199). Listening to loud music through earphones for long durations is such an exposure. For your article, search for studies on this by health organisations and audiology researchers, and quote their findings with the source.

b How hearing is tested

Hearing is tested by an audiologist with an audiogram: sounds of different frequencies are played at different loudness levels and the quietest level that the person can hear is recorded in decibels hearing level (dB HL).

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c Decibel ranges (WHO grading, better-ear average)

Grade	Hearing loss (dB HL)
Normal	25 dB or less
Mild	26 – 40 dB
Moderate	41 – 60 dB
Severe	61 – 80 dB
Profound	81 dB or more

Other systems use slightly different limits, so quote the system you use.

d Government support

The ADIP Scheme (Assistance to Disabled Persons for Purchase/Fitting of Aids/Appliances) of the Government of India supports the purchase and fitting of aids and appliances, including hearing aids, for eligible persons with disabilities, and also provides for cochlear implants for hearing-impaired children. Conditions such as age and family income apply, so check the current guidelines with the District Social Security or disability office.

Therefore, a good article gives study findings with sources, how hearing is tested, the decibel grades of hearing loss and the schemes available.

QUESTION 2 *The Journey Beyond · p. 207*

Make a cone using a poster paper or cardboard and adhesive tape. Cover a mobile phone that is playing music with the cone. Compare the loudness of the sound with and without the cone. You can also use another mobile phone with an app to measure the characteristics of the sound in both cases. Try experimenting with different shapes and record your observations. (This activity is to be facilitated by the teacher.)

ANSWER

This is a hands-on activity, so you record your own observations. The expected result and its explanation are given below.

a Expected observation

In front of the open end of the cone the sound is louder than without the cone; behind or beside the cone it is softer. A wider mouth and a smooth shape work better.

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b Explanation

- Without the cone, the sound spreads out in all directions and the intensity falls quickly with distance (Section 10.6.2).
- The cone reflects the sound and guides it in one direction, so more energy reaches the listener in front of it, as in a megaphone.
- A measuring app will show a larger loudness (dB) in front of the cone.

Therefore, the cone makes the sound louder in the direction it points by confining the sound energy instead of letting it spread in all directions.

QUESTION 3 *The Journey Beyond · p. 207*

How does the curved design of ceilings and walls behind the stage in concert and conference halls improve the quality of sound for the audience compared to flat surfaces? You may consult an architect or search it on the internet.

ANSWER

Sound waves are reflected by walls and ceilings and follow the laws of reflection (Section 10.7). A curved surface can direct the reflected sound towards the audience.

a Curved surfaces

- A curved wall or ceiling behind the stage reflects the sound coming from the stage towards the audience.
- This spreads the sound more evenly through the hall, so listeners in all parts hear clearly, including those far from the stage.
- Less sound is lost or sent in random directions.

b Flat surfaces

A flat surface reflects the sound in only one direction by the laws of reflection, which can leave some parts of the audience with weak sound and can cause echoes or garbled sound.

Therefore, curved ceilings and walls direct and spread the reflected sound over the audience, giving clearer and louder sound than flat surfaces.

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QUESTION 4 *The Journey Beyond · p. 207*

Carry out a simple activity to measure the speed of sound, along with a friend in a large open ground of size 200 m or more. (This activity is to be facilitated by the teacher.)
(i) Your friend stands at one end of the open ground with the balloons, while you stand at the other end with the stopwatch.
(ii) Signal your friend to burst one balloon. When you see the balloon burst, start the stopwatch. As soon as you hear the 'pop' sound of the bursting balloon, stop the timer and note down the reading.
(iii) Repeat this experiment multiple times and take the average value of the times noted.
(iv) Note the approximate distance between you and your friend using a map application on a mobile phone.
(v) Divide the distance measured with the average time to get the average speed of sound. What value of speed did you get from the experiment? Compare it with the speed of sound in air, which is typically about 346 m s^{-1} at 25 °C.
(vi) Why did you measure the time between 'seeing' and 'hearing' the balloon burst?

ANSWER

This is an experiment, so the numbers come from your measurements. The method and a sample calculation (assumed values) are given below.

a Method and formula

Average speed of sound = distance between the two of you / average time

b Sample calculation (assumed values)

If the distance is 200 m and the average time is 0.58 s, then the speed is 200 / 0.58 ≈ 345 m s^{-1}, close to the typical value of 346 m s^{-1} at 25 °C. Differences arise from errors in starting and stopping the stopwatch and in measuring the distance.

c (vi) Why time between seeing and hearing?

Light travels much faster than sound, so you see the burst almost at the instant it happens. Starting the watch on seeing it marks the moment the sound starts. The time until you hear the pop is then the time taken by the sound to travel the distance.

Therefore, speed of sound = distance / (time between seeing and hearing), which should come out close to 346 m s^{-1} at 25 °C.

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QUESTION 5 *The Journey Beyond · p. 207*

Explore the internet resources to explore the effect of humidity and temperature on the speed of sound. Some such resources are: (i) https://phet.colorado.edu/en/simulations/sound-waves/ (ii) https://musiclab.chromeexperiments.com/Experiments (iii) https://phyphox.org/experiments

ANSWER

This is an exploration task using the websites listed. The result to expect from the chapter is given below.

a Expected finding

- As the temperature of air increases, the speed of sound increases.
- As the humidity increases, the speed of sound also increases.
- Example from the chapter: the speed of sound in dry air is about 331 m s^{-1} at 0 °C and nearly 344 m s^{-1} at 22 °C; it is about 346 m s^{-1} at 25 °C.

Therefore, a rise in temperature or humidity increases the speed of sound in air.

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