CLASS IX: SCIENCE
Chapter 11: Sound

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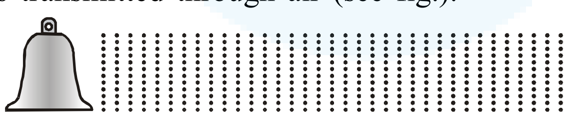
Q1. How does the sound produced by a vibrating object in a medium reach your ear ?

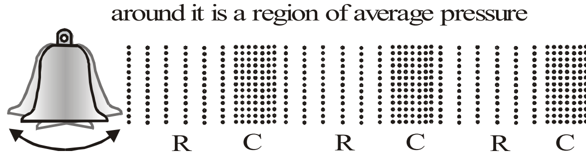
Ans. Air is the most common material through which sound propagates. When a vibrating object like prongs of tuning fork move forward, they push the molecules of the air in front of them. This in turn compresses the air, thus creating a region of high pressure and high density called compression. This compression in the air travels forward. When the prongs of the tuning fork move backward, they create a region of low pressure and low density in the air, commonly called rarefraction. As the tuning fork continues to vibrates, it produces a series of successive compressions and rarefractions in the air, thus, propagating sound through the air which finally reaches our ears.

Q2. Explain how sound is produced by your school bell.

Ans. When we hit a school bell by a hard gong, it moves back and forth about its equilibrium position. Thus, the edge of the bell strikes the particles in the air. When the edge moves forward, air particles are driven forward. This forward motion of the bell produces a region where the air pressure is slightly higher than average. This region is called compression. When the edge moves backward, air particles near it have more space and thus, they spread farther apart. This backward motion produces a region where the air pressure is slightly below average pressure. This region is called rarefraction. Collisions among the air particles cause the pressure variations to move away from the bell in all directions. If you were to focus at one spot, you would see the value of the air pressure rise and fall. In this way, the pressure variations i.e., the sound is produced by the bell which is transmitted through air (see fig.).



(a) Before the bell is struck, the air around it is a region of average pressure



(b) Once the bell is struck, the vibrating edge creates regions of high and low pressure.

Q3. Why are sound waves called mechanical waves ?

Ans. The waves which require a medium for their propagation are called mechanical waves. Sound waves also propagate through a medium because of the interaction of the particles present in that medium. Sound waves force the medium particles to vibrate. Hence, these waves are known as mechanical waves.

Q4. Suppose you and your friend are on the moon. Will you be able to hear any sound produced by your friend?

Ans. No, I will not be able to hear sound, because Moon has no atmosphere. Therefore, no sound waves can travel to my ears and therefore, no sound is heard.

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Q1. Which wave property determines
(a) loudness (b) pitch ?

Ans. (a) The amplitude of the wave determines the loudness; more the amplitude of a wave, more is the loudness produced.
(b) The pitch is determined by the frequency of the wave. Higher the frequency of a wave, more is its pitch and shriller is the sound.

Q2. Guess which sound has a higher pitch: guitar or car horn ?

Ans. The frequency of vibration of a sound produced by a guitar is greater than that produced by a car horn. Since the pitch of a sound is proportional to its frequency, the guitar has a higher pitch than a car horn.

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Q1. What are wavelength, frequency, time period and amplitude of a sound wave ?

Ans. **Wavelength :** It is the distance between two consecutive compressions or two consecutive rarefactions.

Frequency : The number of compressions or rarefactions taken together passing through a point in one second is called frequency.

Time Period : It is the time taken by two consecutive compressions or rarefactions to cross a point.

Amplitude : It is the magnitude of maximum displacement of a vibrating particle about its mean position.

Q2. How are the wavelength and frequency of a sound wave related to its speed ?

Ans. Speed of sound = frequency × wavelength

Q3. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 ms^{-1} in a given medium.

Ans. Given, frequency, ν = 220 Hz ;

speed of sound, v = 440 ms^{-1}

Speed, $v = \nu \lambda$ or $\lambda = \frac{v}{\nu} = \frac{440}{220} = \mathbf{2\ m}$

Q4. A person is listening to a tone of 500 Hz sitting at a distance of 450 m from the source of the sound. What is the time interval between successive compressions from the source ?

Ans. The time interval between two successive compressions is equal to the time period of the wave. It has nothing to do with the distance (450 m) of the person from the source.

Time interval $= \frac{1}{\text{Frequency}} = \frac{1}{500} = \mathbf{2 \times 10^{-3}\ s}$

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Q1. Distinguish between loudness and intensity of sound.

Ans. Intensity is an objective property of the sound wave. In fact, it is related to the square of the wave amplitude, and does not depend on the particular characteristics of a person's ears. The amount of sound energy passing each second through unit area is called the intensity of sound. Loudness, on the other hand, is a subjective property of the sound that depends on the human ear, the sensitivity of the ear to the frequency of the sound, and the distance from the source of the sound. In other words, loudness can be considered as the intensity of an audible sound.

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Q1. In which of the three media, air, water or iron, does sound travel the fastest at a particular temperature?

Ans. Sound travels the fastest in solids. Its speed decreases in liquids and it is the slowest in gases. Therefore, for a given temperature, sound travels fastest in iron.

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Q1. An echo is returned in 3 s. What is the distance of the reflecting surface from the source, given that the speed of sound is 342 ms^{-1} ?

Ans. Given, speed of sound, $v = 342\ m\ s^{-1}$;

time taken for hearing the echo, $t = 3$ s ;

distance of the reflecting surface, $s = ?$

Now, $s = \frac{v \times t}{2} = \frac{342 \times 3}{2}$ = **513 m**

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Q1. Why is the ceiling of concert halls curved ?

Ans. The ceiling of concert halls is curved so that sound after reflection from it reaches all the corners of the hall and is audible to every person in the hall.

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Q1. What is the audible range of the average human ear ?

Ans. An average human ear can hear sound waves of frequencies between 20 Hz to 20,000 Hz.

Q2. What is the range of frequencies associated with
(a) Infrasound ? (b) Ultrasound ?

Ans. (a) **Infrasound :** Sound waves of frequencies between 1 to 20 Hz.
(b) **Ultrasound :** Sound waves of frequencies above 20,000 Hz.

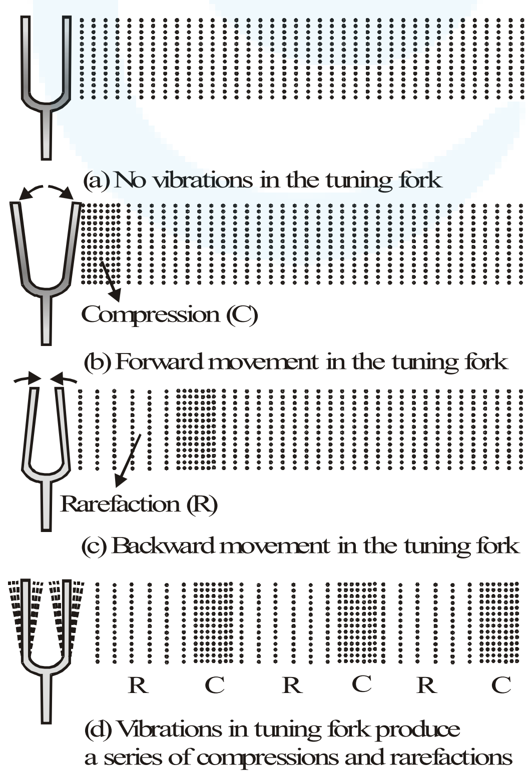
EXERCISES

Q1. What is the sound and how it is produced?

Ans. Sound is a form of energy which produces sensation of hearing. When an object is set into vibrations, sound is produced.

Q2. Describe with the help of a diagram, how compressions and rarefactions are produced in air near a source of sound.

Ans. When a vibrating body like a tuning fork moves forward, it creates a region of high pressure in its vicinity. This region of high pressure is known as compression. When it moves backward, it creates a region of low pressure in its vicinity. This region is known as a rarefaction. As the body continues to move forward and backward, it produces a series of compressions and rarefactions (see fig.).



Q3. Why is sound wave called a longitudinal wave ?

Ans. Sound wave is called longitudinal wave because the particles of the medium vibrate in the direction of the propagation of wave.

Q4. Which characteristic of the sound helps you to identify your friend by his voice while sitting with others in a dark room ?

Ans. The characteristic of sound that helps you to identify your friend's voice is 'quality' or 'timbre'.

Q5. Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen. Why ?

Ans. The speed of light is 3×10^8 ms^{-1} and the speed of sound is 344 ms^{-1} in air. That is, the speed of light is very large as compared to the speed of sound. Thus, flash of lightning is seen at first, but sound takes a little bit more time to reach our ears.

Q6. A person has a hearing range from 20 Hz to 20 kHz. What are the typical wavelengths of sound waves in air corresponding to these two frequencies? Take the speed of sound in air as 344 ms^{-1}.

Ans. Given, speed of sound, $v = 344\ ms^{-1}$
For frequency $\nu_1 = 20$ Hz, wavelength, $\lambda_1 = ?$
Wavelength of sound of frequency 20 Hz

$$\lambda_1 = \frac{v}{\nu_1} = \frac{344}{20} = \mathbf{17.2\ m}$$

For frequency $\nu_2 = 20$ kHz = 20000 Hz,
wavelength, $\lambda_2 = ?$

$$\lambda_2 = \frac{v}{\nu_2} = \frac{344}{20000} = \mathbf{1.72 \times 10^{-2}\ m}$$

Q7. Two children are at opposite ends of an aluminium rod. One strikes the end of the rod with a stone. Find the ratio of times taken by the sound wave in air and in aluminium to reach the second child.

Ans. Here, the distance travelled by sound waves through air and aluminium is same which is equal to the length (s) of the rod.

For air, let the speed be v_1 and time be t_1.

For Al, let the speed be v_2 and time be t_2.

Now, $v_1 = \frac{s}{t_1}$ or $s = v_1 t_1$ ----- (1)

Also, $v_2 = \frac{s}{t_2}$ or $s = v_2 t_2$ ----- (2)

From (1) & (2), we get, $v_1 t_1 = v_2 t_2$

$$\frac{t_1}{t_2} = \frac{v_2}{v_1} = \frac{6420}{346} = \mathbf{18.55}$$

Q8. The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute ?

Ans. No. of vibrations produced in 1 s = 100

$\therefore$ No. of vibrations produced in 1 minute i.e.,

60 seconds = 100 × 60 = 6000.

Thus, the source of sound vibrates 6000 times in a minute.

Q9. Does sound follow the same laws of reflection as light does ? Explain.

Ans. Yes, sound and light follow the same laws of reflection given below :

(a) Angle of incidence = Angle of reflection.

(b) The incident sound wave, the normal and the reflected sound wave lie in the same plane.

Q10. When a sound is reflected from a distant object, an echo is produced. Let the distance between the reflecting surface and the source of sound production remain the same. Do you hear echo sound on a hotter day ?

Ans. If the temperature rises, the speed of sound will increase. Thus, the time taken by the sound to reach initial point decreases. That is, it will be certainly less than 0.1 s (the sensation of sound persists in our brain for about 0.1 s). Thus, no echo is heard.

Q11. Give two practical applications of reflection of sound waves.

Ans. (i) Megaphones which are designed to send sound waves in particular direction are based on the reflection of sound.

(ii) In stethoscope the sound of patient's heartbeat reaches the doctor's ears by multiple reflection in the tubes.

Q12. A stone is dropped from the top of a tower 500 m high into a pond of water at the base of the tower. When is the splash heard at the top ? Given, g = 10 ms^{-2} ; speed of sound = 340 m/s.

Ans. For the downward journey of stone,

Initial velocity, u = 0

Distance travelled, s = height of tower = 500 m

Time of fall, t_1 = ?

Acceleration due to gravity, g = 10 ms^{-2}

$$s = ut + \frac{1}{2}gt^2$$

or $500 = 0 \times t_1 + \frac{1}{2} \times 10 \times t_1^2$

or $500 = 5t_1^2$ or $t_1^2 = 100$

$\therefore t_1 = 10$ s

For the sound travelling upward,

Time taken, t_2 = ?

There is no effect of gravity on the propagation of sound i.e, always the formula of uniform motion is used for sound or any other wave.

Speed of sound, $v = \frac{s}{t_2}$

or $t_2 = \frac{s}{v} = \frac{500}{340} = 1.47$ s

Total time = $t_1 + t_2 = 10 + 1.47 =$ **11.47 s**

Q13. A sound wave travels at a speed of 339 ms^{-1}. If its wavelength is 1.5 cm, what is the frequency of the wave? Will it be audible ?

Ans. Speed of sound wave, v = 339 ms^{-1} ;

Wavelength, λ = 1.5 cm = 0.015 m ;

Frequency, ν = ?

Frequency, $\nu = \frac{v}{\lambda} = \frac{339}{0.015}$ = **22600 Hz**

The sound will not be audible, because human beings can hear only up to 20,000 Hz.

Q14. What is reverberation ? How can it be reduced ?

Ans. Reverberation is the repeated/multiple reflections of sound in any big enclosed space. It can be reduced by covering the ceiling and walls of the enclosed space with some sound-absorbing materials like fibre board, loose woolens etc.

Q15. What is loudness of sound ? What factors does it depend on ?

Ans. The loudness of the sounds humans perceive relates to the intensity of the audible sound. Loudness is a subjective property of the sound that depends on the human ear, the sensitivity of the ear to the frequency of the sound, and the distance from the source of the sound.

Loudness of the sound depends inversely on the square of the distance of the observer from the source of sound, and is directly proportional to the square of the amplitude of the sound wave.

Q16. How is ultrasound used for cleaning ?

Ans. The object to be cleaned is put in a tank fitted with ultrasonic vibrator. The tank is filled with water containing detergent. As the ultrasonic vibrator is switched on, the detergent rubs against the object at a very high speed and hence cleans it.

Q17. Explain how defects in a metal block can be detected using ultrasound.

Ans. Ultrasounds are used to detect cracks and flaws in metal blocks that are generally used in construction of big structures like buildings, bridges, machines and also scientific equipment. The cracks or holes inside the metal blocks, which are invisible from outside, reduce the strength of the structure. Ultrasonic waves are allowed to pass through the metal block and detectors are used to detect the transmitted waves. If there is even a small defect, the ultrasound gets reflected back indicating the presence of the flaw or defect (see fig.41). Ordinary sound of longer wavelengths cannot be used for such purpose as it will bend around the corners of the defective location and enter the detector.