CHAPTER 11

WAVES AND SOUNDS

SOLUTIONS

EXERCISES

Q1. Define sound and explain how is it produced?

Ans: Sound is a form of energy which can produce a sensation of hearing in our ears. It is produced by the vibrational motion of a body.

Q2. Explain the formation of compressions and rarefactions in air near a source of sound.

Ans: Sound propagates in air in the form of longitudinal wave.

When a vibrating object moves forward, it pushes and compresses the air adjacent to it creating a region of high pressure i.e. compressed region. This compression moves forward from the vibrating object. When the vibrating prong moves backward in course of its motion, it creates a region of low pressure called rarefaction(R). As the prong vibrate back and forth repeatedly, a series of compression and rarefaction is formed in the air along the direction of propagation which causes the air drums to vibrate with their frequency producing the sensation of hearing.

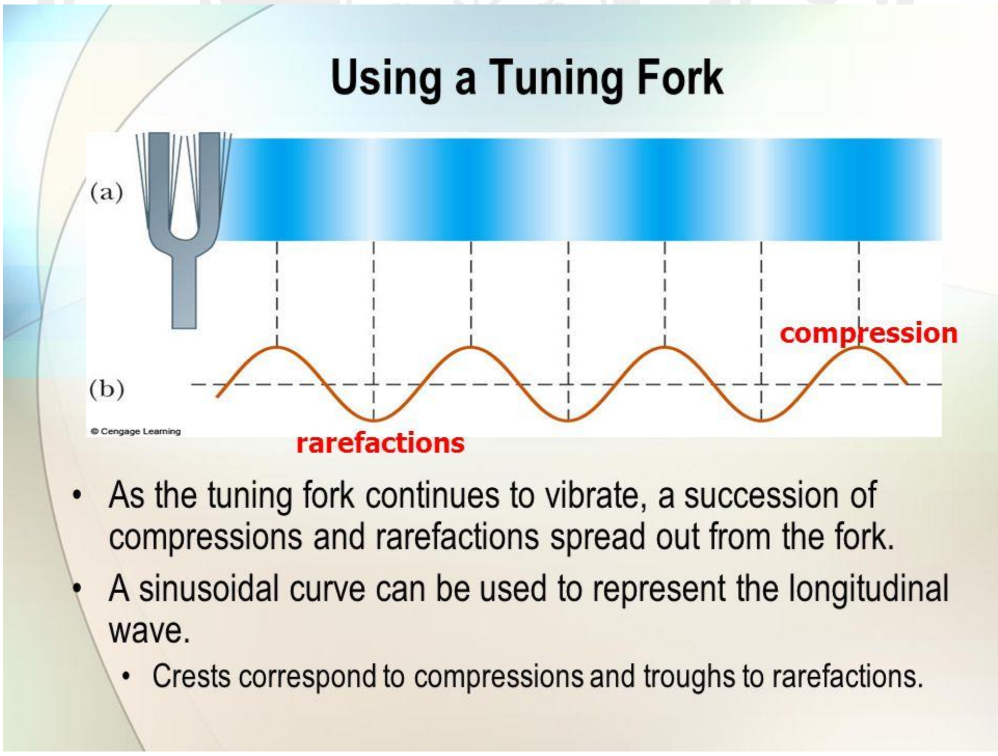

Fig: A vibrating tuning fork creating compression and rarefaction in succession

Q3. **Define wavelength, periodic time and frequency of a wave.**

Ans: Wavelength – the distance between two adjacent compression or rarefaction is called wavelength of the wave.

Periodic time- the time taken for one complete oscillation is called the time period or periodic time of the wave.

Frequency of the wave - the number of complete oscillations per unit time is called the frequency of the wave.

Q4. **Define the relation between wavelength, frequency and time period of a periodic wave.**

Ans: The relationship between wavelength, frequency and time period of a periodic wave as:

$$\textbf{Speed} = \frac{\textit{distance travelled}}{\textit{time taken}}$$

A sound wave takes time equal to its time period (T) to travel a distance equal to its wave length (λ)

$$\text{Therefore, } \textbf{Speed of sound} = \frac{\textit{wavelength of the sound}}{\textit{time period}}$$

$$\mathbf{v} = \frac{\lambda}{T}$$

$$\text{or,} \quad \mathbf{v} = \lambda\nu$$

$$\text{or,} \quad \textbf{speed} = \textbf{wavelength} \times \textbf{frequency}$$

Q5. **When you call your friend by name, do you produce a wave pulse of sound or a periodic wave?**

Ans: A periodic wave.

Q6. **Show graphically how density of air varies with distance when a periodic sound wave travel in it,. Show the graphs for two instants of time differing by half of periodic time.**

Ans:

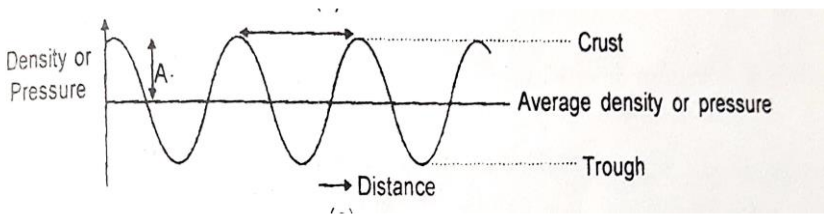

Fig: Diagram represents graphically the density and pressure variation

Q7. Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen, why?

Ans: Light travels much faster than sound as well the velocity of light is much more than the velocity of sound. So, the flash is seen earlier and the thunder is heard later.

Q8. Does sound follow the same laws of reflection as light does? Explain.

Ans: Yes, sound follows the same laws of reflection like light because

(i) Angle of incidence of sound is always equal to that of angle of reflection of sound waves.

(ii) The direction in which sound is incident, the direction in which it is reflected and normal all the three lie in the same plane.

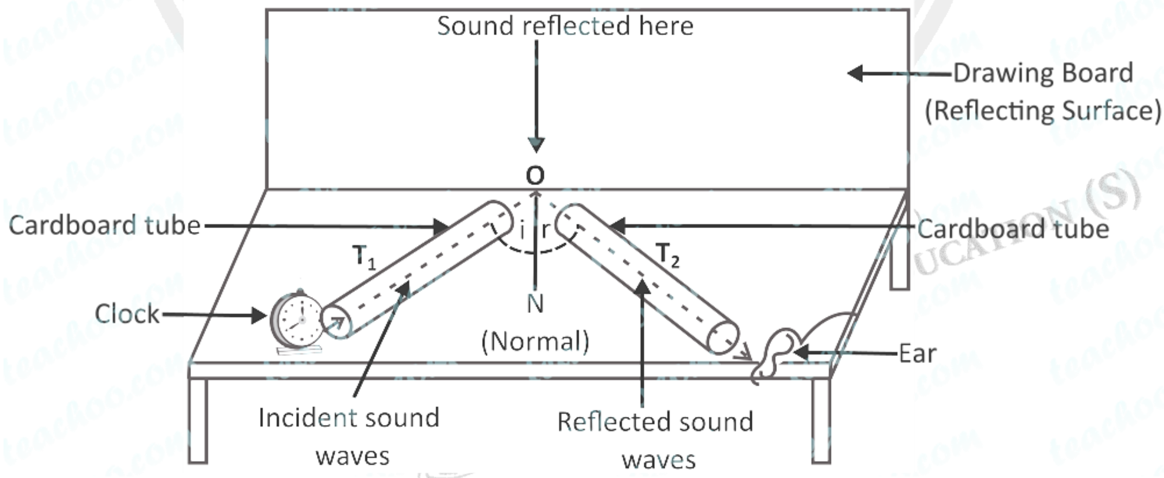

Fig : Reflection of sound

Q9. Describe an experiment to show that sound needs a medium to propagate.

Ans: An electric bell is fitted inside a glass jar. The mouth of the jar is closed with an air tight cork. The glass jar is connected to a vacuum pump to remove the air. Initially, the jar is filled with air. When the switch is pressed, the bell starts ringing and the sound is heard clearly. Now, air is removed from the jar with the help of a vacuum pump. As more and more air is removed from the jar the sound of the bell becomes fainter and fainter. When all the air inside the jar is removed, the sound is not heard at all. This shows that sound waves require a medium like air for its propagation.

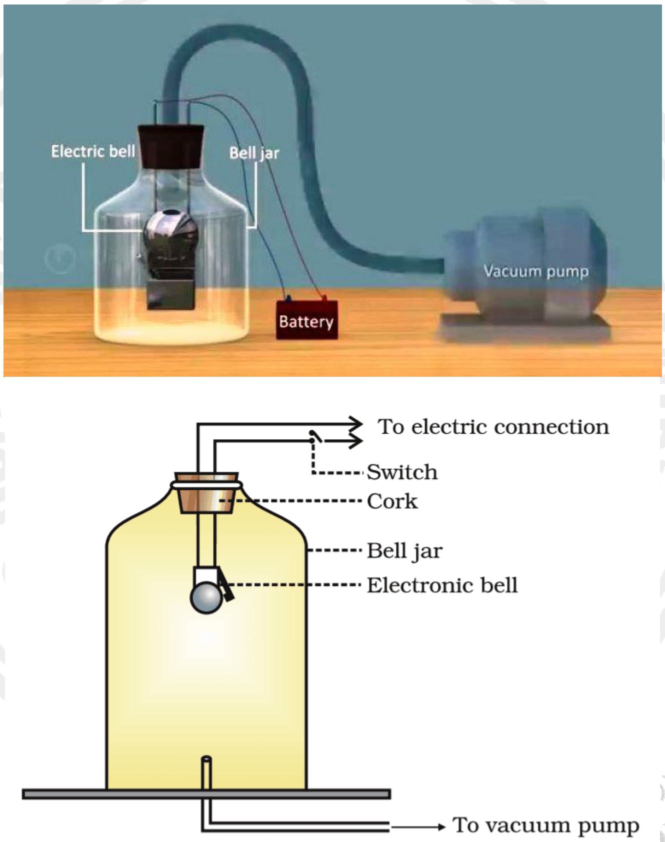

Fig: Bell jar experiment to show that sound cannot propagate in vacuum

Q10. Give two practical applications of reflection of sound waves.

Ans:

1) Stethoscope – instrument used by doctors for listening to the sounds produced in the heart or lungs of human body. The sound of heartbeat reaches the doctors ear by multiple reflections.

2) Megaphones. Here the sound will travel in a particular direction without spreading in all directions.

Q11. What is loudness of sound? On which factors does it depend?

Ans: Loudness is the amount of sensation produced in the ear.

It depends on amplitude, intensity of sound and sensitiveness of ear.

Q12. Explain the working and application of SONAR.

Ans: SONAR consists of a transmitter and a detector for ultrasonic waves. Both are installed in a boat or a ship.

Working and application:

The transmitter of the SONAR produces and transmits ultrasound waves of very high frequency. The waves are reflected from the sea bed and are received by the receiver of the SONAR. The receiver converts the ultrasound waves into electrical signals which are appropriately interpreted. The time interval between the transmitted and received signals is noted.

Let d be the depth of the sea and v be the speed of ultrasound in sea water. The speed of ultrasound in water is same as that of ordinary sound in water.

Let t be the time interval between the transmitted and received signals of the ultrasound waves.

Then, time taken by the ultrasound to reach the bottom of sea

$= \frac{1}{2} \times$time interval between the transmitted and received signals of ultrasound waves

$= \frac{t}{2}$

Therefore, depth of the sea, $d = v \times \frac{t}{2}$

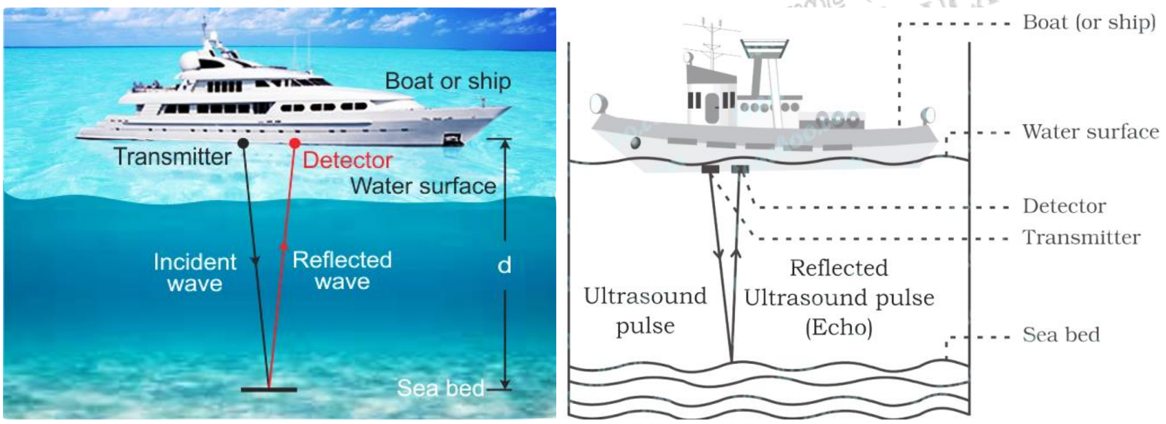

Fig. working and application of SONAR

Q13. A sound waves travels in a medium at a speed of 340m/s. If its wavelength is 1.7cm, what is the frequency? Will it be an audible sound?

Ans: Here,

Speed of sound wave = 340m/s

Wavelength = 1.7cm

$= \frac{17}{1000}$m

= 0.017m

Now, $v = \nu \lambda$

$340 = 0.017 \times \nu$

$\Rightarrow \nu = \frac{340 \times 1000}{17}$

= 20,000Hz

= 20 khz

It will be audible.

Q14. Explain the working of human ear.

Ans: Human perceives sound with the help of our ear. The auditory nerve of our ear converts the pressure variation in air with audible frequencies into electric like signals that travel to the brain through the auditory nerve.

The human are has three main parts:

1. **Outer ear:** The outer ear is called pinna. It collects the sound from the surrounding. The collected sound passes through the auditory canal. At the end of the auditory canal there is a thin membrane called the ear drum or tympanic membrane. When compression of the medium produced due to vibration of the object reaches the eardrum, the pressure on the outside of the membrane increases and forces the eardrum inward. The eardrum moves outward when a rarefaction reaches. In this way the eardrum vibrates.
2. **Middle ear:** The vibrations are amplified several times by three bones- (the hammer, anvil, stirrup) in the middle ear. The middle ear transmits the amplified pressure variations received from the sound to the inner ear.

3. **Inner ear:** In the inner ear, the pressure variation is turned into electrical signals by the cochlea. These electrical signals are sent to the brain through the auditory nerves, and the brain interprets them as sound.

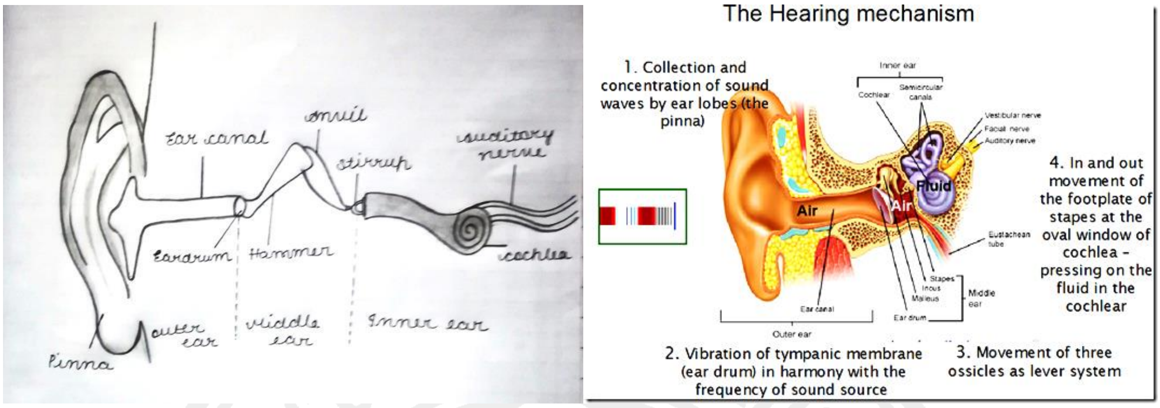

Fig: Auditory parts of human ear

Q15. A source of sound produces 20 crests and 20 troughs in 0.2s. Find the frequency of the wave.

Ans: No. of waves produced in 0.2s= 20 waves

Therefore, frequency of the wave, i.e. No. of waves produced in

$$1s = \frac{20}{0.2}$$

$$= \frac{200}{2}$$

$$= 100Hz.$$

Q16. The time period of a periodic wave is 0.02s. At a particular position there is a crest at t=0. A trough will appear at this position at t equal to

A) 0.005s B) 0.01s C) 0.015s D) 0.02s

Ans: B) 0.01s

Explanation: since time period is the time taken to produce two consecutive compression or rarefaction. The trough will appear at half its time.

TEXTUAL QUESTION & ANSWERS

1. How sound is produced by bell at your school? Observe and explain.

Ans. When the school bell rings it vibrates. These vibrations are passed to adjacent particles. And the neighbouring particles start moving giving rise to a sound wave. As the bell moves forward, the air in front of it is also pushed thereby creating a region of high pressure called compression. When the bell moves backward, the rarefaction which is a region of low pressure occurs. Thus a series of compression and rarefaction is produced on the movement of bell back and forth. This causes the sound of the bell to reach our ears.

2. The sound wave are called mechanical wave. Why?

Ans. When sound wave propagates through a medium, it causes the neighbouring particles to vibrate. Sound waves propagate due to interaction of particles in the medium. Hence, these waves are called mechanical wave.

3. What are wavelength, frequency, amplitude and periodic time of a sound wave? Which of the above quantities does not change when sound passes through different media?

Ans. The distance between two consecutive crests or troughs is known as the wavelength.

The number of complete oscillations per unit time is called frequency of a sound wave.

The magnitude of the maximum disturbance in the medium on either side of the mean value of density or pressure of the medium is called the amplitude.

The time taken by the wave to produce two consecutive compressions and two consecutive rarefactions crossing a fixed point in the medium through which sound is propagating is called time period of the sound wave.

The frequency does not change when sound passes through different medium.

4. What is the relation between frequency, wavelength of a sound wave and its speed in a medium?

Ans. Frequency, wavelength and speed in a medium of a sound wave are related by the following equation-

Speed = wavelength x frequency

5. Distinguish between intensity and loudness of sound.

Ans. Intensity of a sound wave is defines as the amount of sound energy passing through a unit area per second.

Loudness measures the amount of sensation produced in the ear and hence depends upon the listener. Thus sounds of different intensities may produce different loudness when perceived by our ears.

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