UNIT 2

Sound

G9CBRG

Learning Objectives

After completing this lesson, students will be able to

- understand that sound is produced due to vibration of objects.
- know that sound requires a medium to travel.
- understand that sound waves are longitudinal in nature.
- explain the characteristics of sound.
- understand the parameters on which speed of sound depends.
- explain ultrasonic sound and understand the applications of ultrasonic sound.

Introduction

Sound is a form of energy which produces sensation of hearing in our ears. Some sounds are pleasant to hear and some others are not. But, all sounds are produced by vibrations of substances. These vibrations travel as disturbances in a medium and reach our ears as sound. Human ear can hear only a particular range of frequency of sound that too with a certain range of energy. We are not able to hear sound clearly if it is below certain intensity. The quality of sound also differs from one another. What are the reasons for all these? It is because sound has several qualities. In this unit we are going to learn about production and propagation of sound along with its various other characteristics. We will also study about ultrasonic waves and their applications in our daily life.

2.1 Production of sound

In your daily life you hear different sounds from different sources. But have you ever thought how sound is produced? To understand the production of sound, let us do some activities.

Activity 1

Take a tuning fork and strike its prongs on a rubber pad. Bring it near your ear. Do you hear any sound? Now touch the tuning fork with your finger. What do you feel? Do you feel vibrations?

When you strike the tuning fork on the rubber pad, it starts vibrating. That's what you feel with your fingers. These vibrations cause the nearby molecules to vibrate.

Activity 2

Take a steel tumbler and fill it with water. Take a spoon and gently tap the tumbler. What do you observe? Can you hear some sound? Do you see any vibration on the surface of the water?

From the above activities we see that vibrations are produced when some mechanical work is done. Vibration is nothing but to and fro movement of a particle. Thus, mechanical energy vibrates an object and when these vibrations reach our ear we hear the sound. At the end of this chapter, we will study how our ear senses sound.

2.2 Propagation of sound waves

2.2.1 Sound needs a medium for Propagation

In the activities given above we saw that sound needs a material medium like air, water, steel etc., for its propagation. It cannot travel through vacuum. This can be demonstrated by the Bell – Jar experiment.

An electric bell and an airtight glass jar are taken. The electric bell is suspended inside the airtight jar. The jar is connected to a vacuum pump, as shown in Figure 2.1. If the bell is made to ring, we will be able to hear the sound of the bell. Now when the jar is evacuated with the vacuum pump, the air in the jar is pumped out gradually and the sound becomes feebler and feebler. We will not hear any sound, if the air is fully removed (if the jar has vacuum).

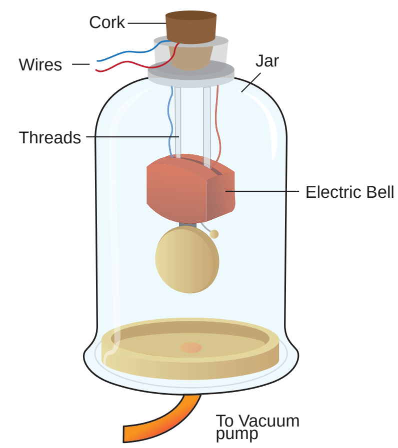


Figure 2.1 Bell-Jar experiment

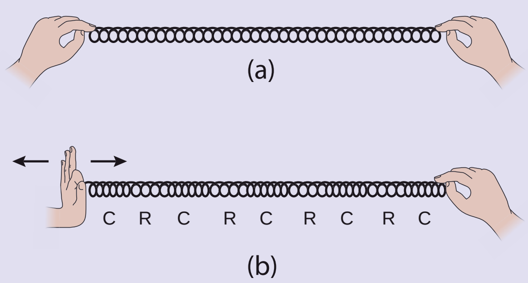
2.2.2 Sound is a wave

Sound moves from the point of generation to the ear of the listener through a medium. When an object vibrates, it sets the particles of the medium around to vibrate. But, the vibrating particles do not travel all the way from the vibrating object to the ear. A particle of the medium in contact with the vibrating object is displaced from its equilibrium position. It then exerts a force on an adjacent particle. As a result of which the adjacent particle gets displaced from its position of rest. After displacing the adjacent particle the first particle comes back to its original position. This process continues in the medium till the sound reaches our ears. It is to be noted that only the disturbance created by a source of sound travels through the medium and not the particles of the medium. All the particles of the medium restrict themselves with only a small to and fro motion called vibration which enables the disturbance to be carried forward. This disturbance which is carried forward in a medium is called wave.

2.2.3 Longitudinal nature of sound waves

Activity 3

Take a coil or spring and move it forward and backward. What do you observe? You can observe that in some parts of the coil the turns will be closer and in some other parts the turns will be far apart. Sound also travels in a medium in the same manner. We will study about this now.



In the above activity you noticed that in some parts of the coil, the turns are closer together. These are regions of compressions. In between these regions of compressions we have regions where the coil turns are far apart called rarefactions. As the coil oscillates, the compressions and rarefactions move along the coil. The wave that propagates with compressions and rarefactions are called longitudinal waves. In longitudinal waves the particles of the medium move to and fro along the direction of propagation of the wave.

Sound is also a longitudinal wave. Sound can travel only when there are particles which can be compressed and rarefied. Compressions are the regions where particles are crowded together. Rarefactions are the regions of low pressure where particles are

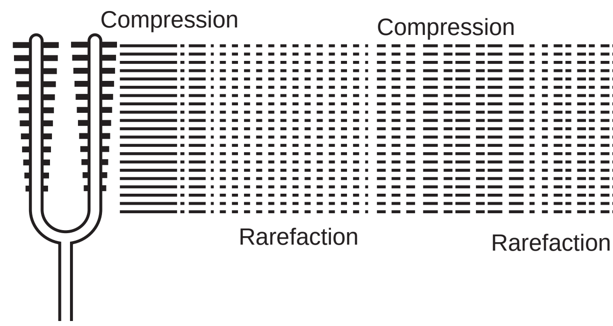


Figure 2.2 Sound is a wave

spread apart. A sound wave is an example of a longitudinal mechanical wave. Figure 2.3 represents the longitudinal nature of sound wave in the medium.

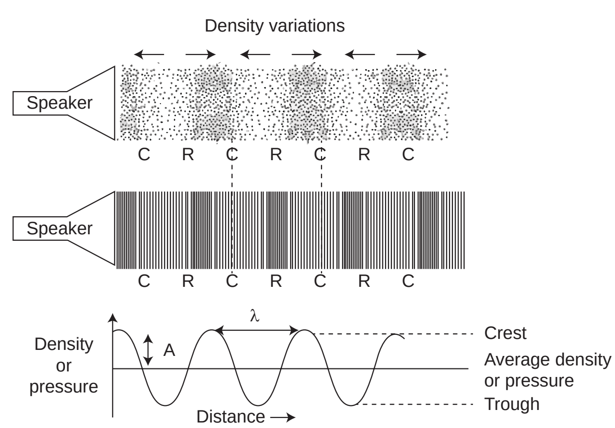


Figure 2.3 Longitudinal nature of sound

2.3 Characteristics of a sound wave

Activity 4

Listen to the audio of any musical instrument like *flute, nathaswaram, tabla, drums, veena* etc., Tabulate the differences between the sounds produced by the various sources.

A sound wave can be described completely by five characteristics namely amplitude, frequency, time period, wavelength and velocity or speed.

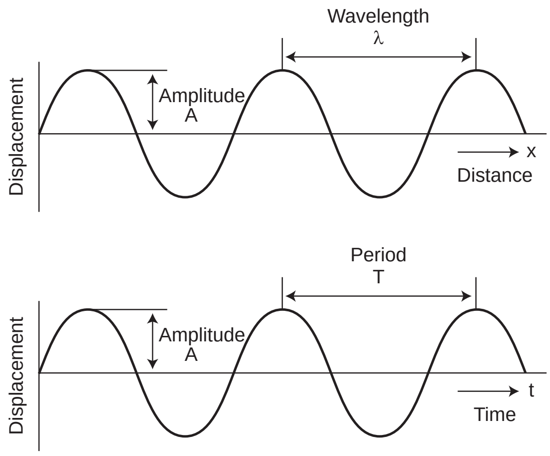


Figure 2.4 Characteristics of sound wave

Amplitude (A)

The maximum displacement of the particles of the medium from their original undisturbed positions, when a wave passes through the medium is called amplitude of the wave. If the vibration of a particle has large amplitude, the sound will be loud and if the vibration has small amplitude, the sound will be soft. Amplitude is denoted as A. Its SI unit is meter (m).

Frequency (n)

The number of vibrations (complete waves or cycles) produced in one second is called frequency of the wave. It is denoted as n. The SI unit of frequency is s^{-1} (or) hertz (Hz). Human ear can hear sound of frequency from 20 Hz to 20,000 Hz. Sound with frequency less than 20 Hz is called infrasonic sound. Sound with frequency greater than 20,000 Hz is called ultrasonic sound. Human beings cannot hear infrasonic and ultrasonic sounds.

Time period (T)

The time required to produce one complete vibration (wave or cycle) is called time period of the wave. It is denoted as T. The SI unit of time period is second (s). Frequency and time period are reciprocal to each other.

DO YOU KNOW?

Heinrich Rudolph Hertz was born on 22 February 1857 in Hamburg, Germany and educated at the University of Berlin. He confirmed J. C. Maxwell's electromagnetic theory by his experiments. He laid the foundation for future development of radio, telephone, telegraph and even television. He also discovered the photoelectric effect which was later explained by Albert Einstein. The SI unit of frequency was named as hertz in his honour.

Wavelength (λ)

The minimum distance in which a sound wave repeats itself is called its wavelength. In a sound wave, the distance between the centers of two consecutive compressions or two consecutive rarefactions is also called wavelength. The wavelength is usually denoted as λ (Greek letter lambda). The SI unit of wavelength is metre (m).

Velocity or speed (v)

The distance travelled by the sound wave in one second is called velocity of the sound. The SI unit of velocity of sound is m s^{-1}.

2.4 Distinguishing different sounds

Sounds can be distinguished from one another in terms of the following three different factors.

1. Loudness
2. Pitch
3. Timbre (or quality)

1. Loudness and Intensity

Loudness is a quantity by virtue of which a sound can be distinguished from another one, both having the same frequency. Loudness or softness of sound depends on the amplitude of the wave. If we strike a table lightly, we hear a soft sound because we produce a sound wave of less amplitude. If we hit the table hard we hear a louder sound. Loud sound can travel a longer distance as loudness is associated with higher energy. A sound wave spreads out from its source. As it move away from the source its amplitude decreases and thus its loudness decreases. Figure 2.5 shows the wave shapes of a soft and loud sound of the same frequency.

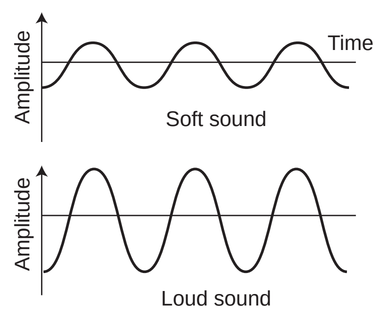


Figure 2.5 Soft and loud sound

The loudness of a sound depends on the intensity of sound wave. Intensity is defined as the amount of energy crossing per unit area per unit time perpendicular to the direction of propagation of the wave.

The intensity of sound heard at a place depends on the following five factors.

i. Amplitude of the source.
ii. Distance of the observer from the source.
iii. Surface area of the source.
iv. Density of the medium.
v. Frequency of the source.

The unit of intensity of sound is decibel (dB). It is named in honour of the Scottish-born scientist Alexander Graham Bell who invented telephone.

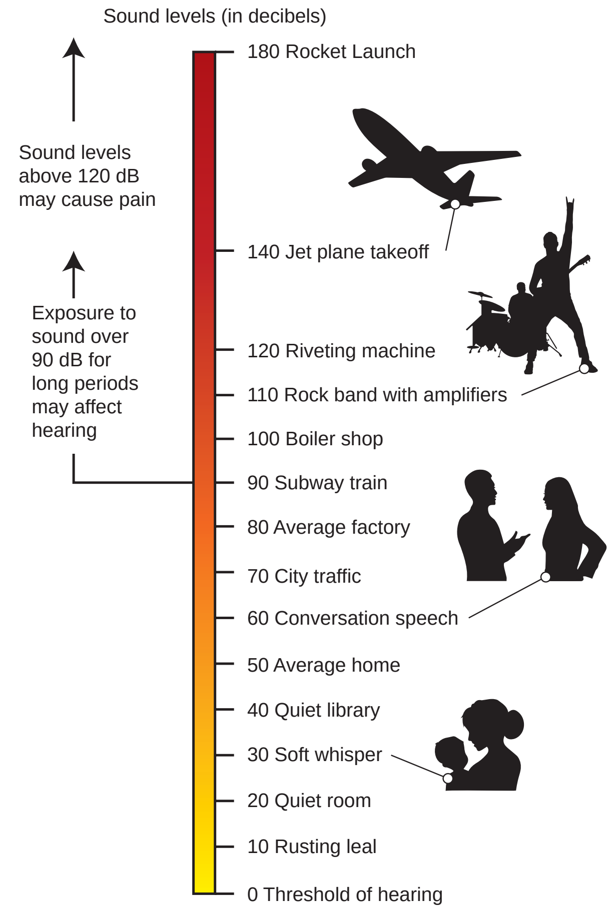


Figure 2.6 Intensity level of sound

2. Pitch

Pitch is the characteristics of sound by which we can distinguish whether a sound is shrill or base. High pitch sound is shrill and low pitch sound is flat. Two music sounds produced by the same instrument with same amplitude, will differ when their vibrations are of different frequencies. Figure 2.7 consists of two waves representing low pitch and high pitch sounds.

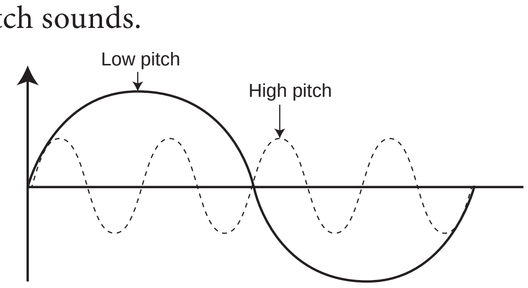


Figure 2.7 Longitudinal nature of sound

3. Timbre or Quality

Timbre is the characteristic which distinguishes two sounds of same loudness and pitch emitted by two different instruments. A sound of single frequency is called a tone and a collection of tones is called a note. Timbre is then a general term for the distinguishable characteristics of a tone.

2.5 Speed of sound

The speed of sound is defined as the distance travelled by a sound wave per unit time as it propagates through an elastic medium.

$$\text{Speed (v)} = \frac{\text{Distance}}{\text{Time}}$$

If the distance traveled by one wave is taken as one wavelength (λ), and the time taken for this propagation is one time period (T), then

$$\text{Speed (v)} = \frac{\text{one wavelength } (\lambda)}{\text{one time period (T)}} \quad \text{(or)} \quad v = \frac{\lambda}{T}$$

As, $T = \frac{1}{n}$ the speed (v) of sound is also written as, $v = n\lambda$

The speed of sound remains almost the same for all frequencies in a given medium under the same physical conditions.

Example 1

A sound wave has a frequency of 2 kHz and wavelength of 15 cm. How much time will it take to travel 1.5 km?

Solution:

Given, Frequency, n = 2 kHz = 2000Hz

Wavelength, λ = 15 cm = 0.15 m

Speed, $v = n\lambda$

$= 0.15 \times 2000 = 300 \text{ m s}^{-1}$

The time taken (t) by the wave to travel a distance (d) of 1.5 km is calculated as,
d = 1.5 km = 1500 m

$$\text{Time (t)} = \frac{\text{Distance (d)}}{\text{Velocity (v)}}$$

$$t = \frac{1500}{300} = 5 \text{ s}$$

The sound will take 5 s to travel a distance of 1.5 km.

Example 2

What is the wavelength of a sound wave in air at 20° C with a frequency of 22 MHz?

Solution:

The speed of sound at 20° C is $v = 344 \text{ m s}^{-1}$.

The frequency of sound n = 22 MHz

$= 22 \times 10^6$ Hz

To find the wavelength λ, we use the wave equation with speed of sound.

$\lambda = v/n$

$\lambda = 344/22 \times 10^6$

$\lambda = 15.64 \times 10^{-6}$ m

Ans. $\lambda = 15.64$ μm.

2.5.1 Speed of sound in different media

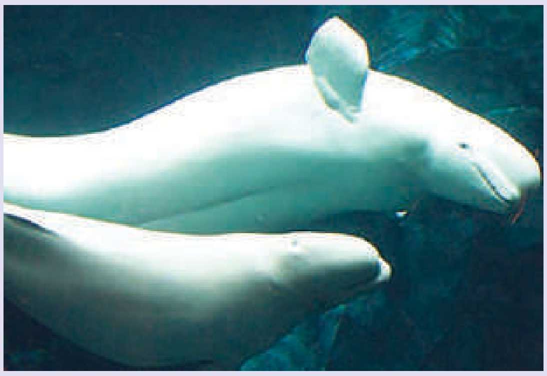
Sound propagates through a medium at a finite speed. The sound of thunder is heard a little later than the flash of light is seen. So we can make out that sound travels with a speed which is much less than the speed of light. The speed of sound depends on the properties of the medium through which it travels.

The speed of sound in a gaseous medium depends on,

- pressure of the medium
- temperature of the medium
- density of the medium
- nature of gas

More to Know

Sound travels about 5 times faster in water than in air. Since the speed of sound in sea water is very large (being about 1530 m s^{-1} which is more than 5500 km h^{-1}), two whales in the sea which are even hundreds of kilometres away from each other can talk to each other very easily through the sea water.



The speed of sound in solid medium depends on,

- elastic property of the medium
- temperature of the medium
- density of the medium

The speed of sound is less in gaseous medium compared to solid medium. In any medium the speed of sound increases if we increase the temperature of the medium. For example the speed of sound in air is 330 m s^{-1} at 0°C and 340 m s^{-1} at 25°C. The speed of sound at a particular temperature in various media is listed in Table 2.1.

More to Know

Sonic boom: When the speed of any object exceeds the speed of sound in air (330 m s^{-1}) it is said to be travelling at supersonic speed. Bullets, jet, aircrafts etc., can travel at supersonic speeds. When an object travels at a speed higher than that of sound in air, it produces shock waves. These shock waves carry a large amount of energy. The air pressure variations associated with this type of shock waves produce a very sharp and loud sound called the 'sonic boom'. The shock waves produced by an aircraft have energy to shatter glass and even damage buildings.

Table 2.1 Speed of sound in different media at 25° C.

State	Medium	Speed in m s^{-1}
Solids	Aluminum	6420
	Nickel	6040
	Steel	5960
	Iron	5950
	Brass	4700
	Glass	3980
Liquids	Water (Sea)	1531
	Water (distilled)	1498
	Ethanol	1207
	Methanol	1103
Gases	Hydrogen	1284
	Helium	965
	Air	340
	Oxygen	316
	Sulphur dioxide	213

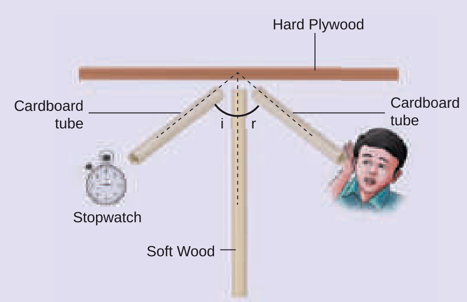
2.6 Reflection of sound

Sound bounces off a surface of solid or a liquid medium like a rubber ball that bounces off from a wall. An obstacle of large size which may be polished or rough is needed for the reflection of sound waves. The laws of reflection are:

- The angle in which the sound is incident is equal to the angle in which sound is reflected.
- Direction of incident sound, direction of the reflected sound and the normal are in the same plane.

Activity 5

Take two identical pipes as shown in below. You can make the pipes using chart paper. The length of the pipes should be sufficiently long as shown in figure. Arrange them on a table near wall. Keep a clock near the open end of one of the pipes and try to hear the sound of the clock through the other pipe. Adjust the position of the pipes so that you can best hear the sound of the clock. Now, measure the angle of incidence and reflection and see the relationship between the angles. Lift the pipes on the right vertically to a small height, and observe what happens.



2.6.1 Uses of multiple reflections of sound

Musical instruments

Megaphones, loud speakers, horns, musical instruments such as nathaswaram, shehnai and trumpets are all designed to send sound in a particular direction without spreading it in all directions. In these instruments, a tube followed by a conical opening reflects sound successively to guide most of the sound waves from the source in the forward direction towards the audience.

Figure 2.8 Megaphone or horn

Stethoscope

Stethoscope is a medical instrument used for listening to sounds produced in the body. In stethoscopes these sounds reach doctor's ears by multiple reflections that happen in the connecting tube.

Figure 2.9 Stethoscope

DO YOU KNOW?

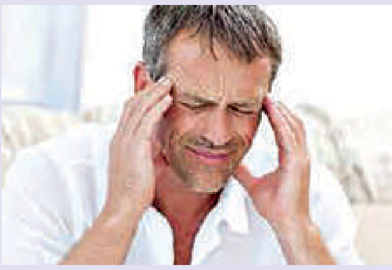
Noise pollution: Noise is an unwanted sound. Sounds with loudness of 120 dB (decibel) and higher can be painful to the ear. Even brief exposures to higher sound levels can rupture eardrum and can cause permanent hearing loss. However, long exposure to relatively lower sound level can also cause hearing problems. Such exposures may lead to psychological damages too. For some jobs, ear protectors must be worn in work places. You may have experienced a temporary hearing loss after being exposed to a loud band for long time or a loud bang for a short time. Ear protectors are commercially available at medical stores and hardware stores.

2.7 Echo

When we shout or clap near a suitable reflecting surface such as a tall building or a mountain, we will hear the same sound again a little later. This sound which we hear is called an echo. The sensation of sound persists in our brain for about 0.1s.

More to Know

Use of ear phones for long hours can cause infection in the inner parts of the ears, apart from damage to the ear drum. Your safety is in danger if you wear ear phones while crossing signals, walking on the roads and travelling. Using earphones while sleeping is all the more dangerous as current is passing in the wires. It may even lead to mental irritation. Hence, you are advised to deter from using earphones as far as possible.



Hence, to hear a distinct echo the time interval between the original sound and the reflected sound must be at least 0.1s. Let us consider the speed of sound to be 340 m s^{-1} at 25° C. The sound must go to the obstacle and return to the ear of the listener on reflection after 0.1 s. Thus, the total distance covered by the sound from the point of generation to the reflecting surface and back should be at least 340 m s^{-1} × 0.1 s = 34 m.

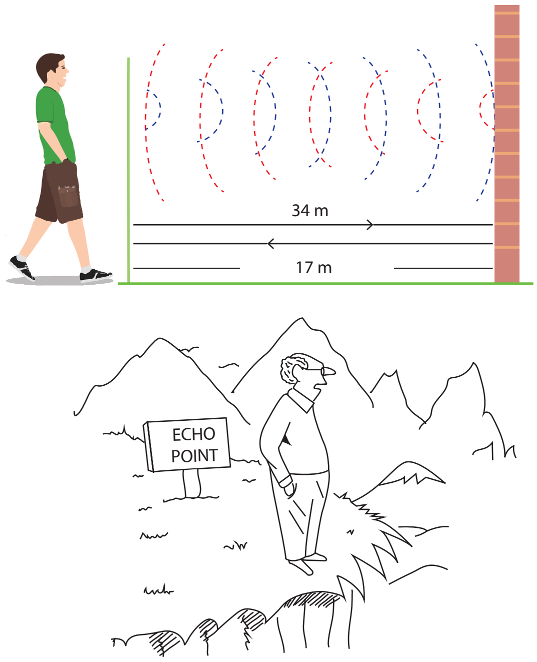


Figure 2.10 Echo

Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance i.e. 17 m. This distance will change with the temperature of air. Echoes may be heard more than once due to successive or multiple reflections. The roaring of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as the clouds at different heights and the land.

Example 3

A person claps his hands near a cliff and hears the echo after 5 s. What is the distance of the cliff from the person if the speed of the sound is taken as 330 m s^{-1}?

Solution:

Speed of sound, v = 330 m s^{-1}

Time taken to hear the echo, t = 5 s

Distance travelled by the sound, d = v × t

= 330 × 5

= 1650 m (or) 1.65 km

In 5s sound travels twice the distance between the cliff and person. Hence the distance between the cliff and the person $= \frac{1650}{2}$ = 825 m.

Example 4

A man fires a gun and hears its echo after 5 s. The man then moves 310 m towards the hill and fires his gun again. If he hears the echo after 3 s, calculate the speed of sound.

Solution:

Distance (d) = velocity (v) × time (t)

Distance travelled by sound when gun fires first time, 2d = $v \times 5$ (1)

Distance travelled by sound when gun fires second time, $2d - 620 = v \times 3$ (2)

Rewriting equation (2) as,

$2d = (v \times 3) + 620$ (3)

Equating (1) and (3), $5v = 3v + 620$

$2v = 620$

Velocity of sound, $v = 310\ \text{m s}^{-1}$

2.8 Reverberation

A sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value where it is no longer audible. The repeated reflection that results in this persistence of sound is called reverberation. In an auditorium or big hall excessive reverberation is highly undesirable. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound absorbing materials like compressed fiberboard, flannel cloths, rough plaster and draperies. The seat materials are also selected on the basis of their sound absorbing properties.

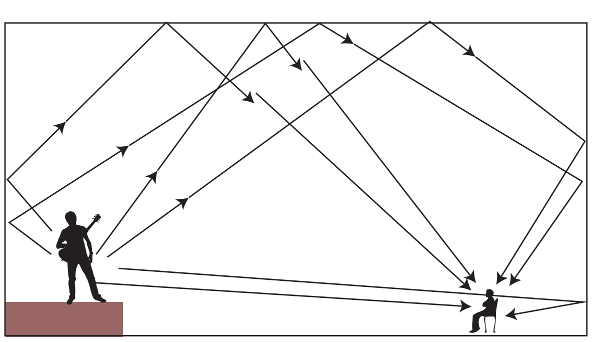


Figure 2.11 Reverberation of sound in a auditorium

There is a separate branch in physics called acoustics which takes these aspects of sound in to account while designing auditoria, opera halls, theaters etc. (You will study about acoustics in class X).

2.9 Ultrasonic sound or Ultrasound

Ultrasonic sound is the term used for sound waves with frequencies greater than 20,000 Hz. These waves cannot be heard by the human ear, but the audible frequency range for other animals includes ultrasound frequencies. For example dogs can hear ultrasonic sound. Ultrasonic whistles are used on cars to alert deer to oncoming traffic so that they will not leap across the road in front of cars.

An important use of ultrasound is in examining inner parts of the body. Thus ultrasound is an alternative to X-rays. The ultrasonic waves allow different tissues such as organs and bones to be 'seen' or distinguished by bouncing of ultrasonic waves by the objects examined. The waves are detected, analysed and stored in a computer. An echogram is an image obtained by the use of reflected ultrasonic waves. It is used as a medical diagnostic tool. Ultrasonic sound is having application in marine surveying also.

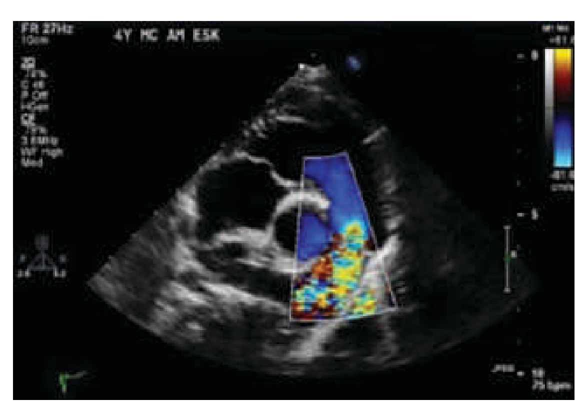
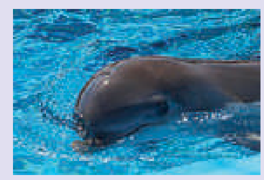
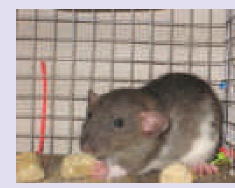


Figure 2.12 Echogram using ultra sound

More to Know

Animals, such as bats, dolphins, rats, whales and oil birds, use ultrasound to navigate or communicate. Bats, dolphins and some toothed whales use echolation, an ultrasound technique that uses echoes to identify and locate objects. Echolation allows bats to navigate through dark caves and find insects for food. Dolphins and whales emit a rapid series of underwater clicks in ultrasonic frequencies to locate their prey and navigate through water. Many nocturnal insects including moths, grasshoppers, praying mantis, beetles and lacewings, have sharp ultrasonic hearing, which helps them escape predators. While oil birds use ultrasound to fly safely and hunt at night, they use lower echolation frequencies compared to bats and other nocturnal insects.





2.9.1 Applications of ultrasonic waves

- ❖ Ultra sound can be used in cleaning technology. Minute foreign particles can be removed from objects placed in a liquid bath through which ultrasound is passed.
- ❖ Ultrasounds can also be used to detect cracks and flaws in metal blocks.
- ❖ Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called 'echo cardiography'.
- ❖ Ultrasound may be employed to break small 'stones' formed in the kidney into fine grains. These grains later get flushed out with urine.

2.10 SONAR

SONAR stands for Sound Navigation And Ranging. Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects. Sonar consists of a transmitter and a detector and is installed at the bottom of boats and ships.

The transmitter produces and transmits ultrasonic waves. These waves travel through water and after striking the object on the seabed, get reflected back and are sensed by the detector. The detector converts the ultrasonic waves into electrical signals which are appropriately interpreted. The distance of the object that reflected the sound wave can be calculated by knowing the speed of sound in water and the time interval between transmission and reception of the ultrasound.

Let the time interval between transmission and reception of ultrasound signal be 't' and

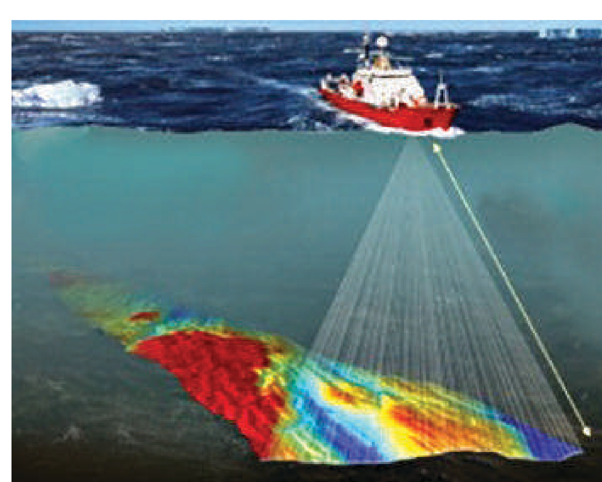


Figure 2.13 Sonar

the speed of sound through sea water be $2d = v \times t$. This method is called echo-ranging. Sonar technique is used to determine the depth of the sea and to locate underwater hills, valleys, submarine, icebergs etc.

Example 5

A ship sends out ultrasound that returns from the seabed and is detected after 3.42 s. If the speed of ultrasound through sea water is 1531 m s^{-1}, what is the distance of the seabed from the ship?

Solution

Time between transmission and detection, t = 3.42 s.

Speed of ultrasound in sea water, v = 1531 m s^{-1}

Distance travelled by the ultrasound = 2 × depth of the sea

We know, distance = speed × time

2d = speed of ultrasound × time

$$2d = 1531 \times 3.42$$

$$\therefore d = \frac{5236}{2}\, m$$

$$d = 2618 \text{ m}$$

Thus, the distance of the seabed from the ship is 2618 m or 2.618 km.

2.11 Electrocardiogram (ECG)

The electrocardiogram (ECG) is one of the simplest and oldest cardiac investigations available. It can provide a wealth of useful information and remains an essential part of the assessment of cardiac patients. In ECG the sound variation produced by heart is converted into electric signals. Thus, an ECG is simply a representation of the electrical activity of the heart muscle as it changes with time. Usually it is printed on paper for easy analysis. The sum of this electrical activity, when amplified and recorded for just a few seconds is known as an ECG (Fig. 2.14).

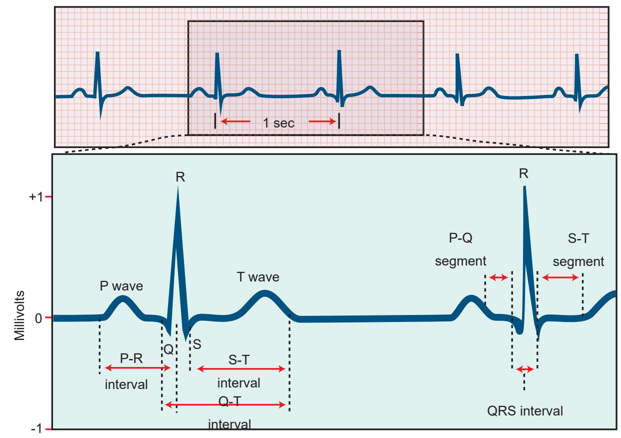


Figure 2.14 ECG diagram

2.12 Structure of human ear

How do we hear? We are able to hear with the help of an extremely sensitive device called the ear. It allows us to convert pressure variations in air with audible frequencies into electric signals that travel to the brain via the auditory nerve. The auditory aspect of human ear is discussed below.

The outer ear is called 'pinna'. It collects the sound from the surroundings. The collected sound passes through the auditory canal. At the end of the ear is eardrum or tympanic membrane. When a compression of the medium reaches the eardrum the pressure on the outside of the membrane increases and forces the eardrum inward. Similarly the eardrum moves outward when a rarefaction reaches it. In this way the eardrum vibrates. The vibrations are amplified several times by three bones (the hammer, anvil and stirrup) in the middle ear. The middle ear transmits the amplified pressure variations received from the sound wave to the inner ear. In the inner ear, the pressure variations are turned into electrical signals by the cochlea. These electrical signals are sent to the brain via the auditory nerve and the brain interrupts them as sound.

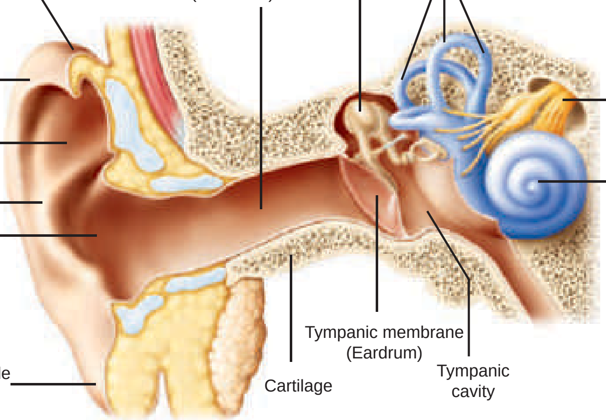


Figure 2.14 Human ear

More to Know

Hearing Aid

People with hearing loss may need a hearing aid. A hearing aid is an electronic, battery operated device. The hearing aid receives sound through a microphone. The microphone converts the sound waves into electrical signals. These electrical signals are amplified by an amplifier. The amplified electrical signals are given to a speaker of the hearing aid. The speaker converts the amplified electrical signals to sound and sends to the ear for clear hearing.

Points to Remember

- Sound is produced due to vibration.
- Sound travels as a longitudinal wave through a material medium.
- Sound travels as successive compressions and rarefactions in the medium.
- In sound propagation, it is the energy of the sound that travels and not the particles of the medium.
- Sound cannot travel through vacuum.
- The distance between two consecutive compressions or two consecutive rarefactions is called the wavelength.
- The time taken by the wave to complete one oscillation.
- The number of oscillations per unit time is called the frequency. $n = 1 / T$
- The speed v, frequency n, and wavelength λ, of sound are related by the equation. $v = n \lambda$
- The speed of sound depends primarily on the nature and the temperature of the transmitting medium.
- The law of reflection of sound: (i) The angle of incidence ray, the angle of reflection and normal drawn at the point of incidence all lie in the same plane (ii) The angle of incidence i and the angle of reflection r are always equal.
- For hearing distinct echo sound, the time interval between the original sound and the reflected sound must be at least 0.1 s.
- The persistence of hearing sound in an auditorium is the result of repeated reflections of sound and is called reverberation.
- The amount of sound energy passing each second through unit area is called the intensity of sound.
- The audible range of hearing for average human being is in the frequency range of 20 Hz to 20000 Hz

- Sound waves with frequencies below audible range are termed as 'Infrasonics' and those above audible range are termed as 'Ultrasonics'.
- The SONAR technique is used to determine the depth of the sea and to locate under water hills, valleys, submarines, icebergs, etc.

A-Z GLOSSARY

Amplitude	The maximum displacement of a particle.
Compressions	The region of increased pressure.
ECG	Electrocardiogram.
Echo	The repetition of sound caused by the reflection of sound.
Frequency	Number of waves produced in one second.
Longitudinal wave	The wave that propagates with compressions and rarefactions are called longitudinal waves.
Loudness	Loudness or softness of sound depends on the amplitude of the wave.
Pitch	Characteristics of sound based on frequency.
Rarefactions	The region of decreased pressure.
Reverberation	The repeated reflection that results in persistence of sound is called reverberation.
SONAR	Sound Navigation And Ranging.
Speed of sound	Distance travelled by a sound wave per unit time.
Timbre (or quality)	Characteristic which distinguishes the two sounds of same loudness and pitch emitted by two different instruments.
Time period	Time taken to produce one wave.
Ultrasonic sound	Sound waves with frequencies greater than 20,000 Hz.
Velocity (or) Speed	Distance travelled by the wave in one second.
Wave	The propagating disturbance that travels in a medium is called a wave.
Wavelength	The minimum distance in which a sound wave repeats itself.

TEXTBOOK EVALUATION

G9L7T4

I. Choose the correct answer:

1. Which of the following vibrates when a musical note is produced by the cymbals in a orchestra?
   a) stretched strings
   b) stretched membranes
   c) air columns
   d) metal plates

2. Sound travels in air:
   a) if there is no moisture in the atmosphere.
   b) if particles of medium travel from one place to another.
   c) if both particles as well as disturbance move from one place to another.
   d) if disturbance moves.

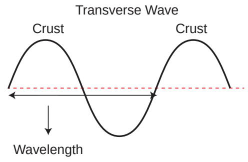
3. A musical instrument is producing continuous note. This note cannot be heard by a person having a normal hearing range. This note must then be passing through
   a) wax　　b) vacuum
   c) water　　d) empty vessel

4. If the speed of a wave is 340 $m s^{-1}$ and its frequency is 1700 Hz, then wavelength λ for this wave in cm will be
   a) 34　　b) 20　　c) 15　　d) 0.2

5. Which of the following statement best describes frequency?
   a) the number of complete vibrations per second.
   b) the distance travelled by a wave per second.
   c) the distance between one crest of wave and the next one.
   d) the maximum disturbance caused by a wave.

6. The maximum speed of vibrations which produces audible sound will be in
   a) seawater　　b) ground glass
   b) dry air　　d) Human blood

7. In the sound wave produced by a vibrating turning fork as shown in the diagram, half the wave length is represented by:



   a) BD　　b) AB　　c) AE　　d) DE

8. The sound waves travel faster
   a) in liquids　　b) in gases
   c) in solids　　d) in vacuum

9. When the pitch of note by a harmonium is lowered, then the wave length of the note
   a) first decreases and then increases
   b) decreases
   c) remains the same
   d) increases

10. The speeds of sound in four different media are given below. Which of the following is the most likely speed in $m s^{-1}$ with which the two under water whales in a sea can talk to each other when separated by a large distance?
   a) 5170　　b) 1280
   c) 340　　d) 1530

11. Which of the following can produce longitudinal waves as well as transverse waves under different conditions?
   a) TV transmitter　　b) tuning fork
   c) water　　d) slinky

12. The velocities of sound waves in four media P, O, Q, R and S are 18,00 km/h, 900 km/h, 0 km/h, and 1200 km/h respectively. Which could be a liquid medium?
   a) R　　b) Q　　c) P　　d) S

II. Fill in the blanks.

1. Vibration of object produces __________ .
2. Sound is a ____________ wave and needs a material medium to travel.
3. Number of vibrations produced in one second is ____________ .
4. The velocity of sound in solid is ____________ than the velocity of sound in air.
5. Loudness is proportional to the square of the ____________ .
6. A sound wave has a frequency of 4 k hz and wavelength 2 m. Then the velocity of sound is ____________ .
7. ____________ is a medical instrument used for listening to sounds produced in the body.
8. The repeated reflection that results in persistence of sound is called ____________ .
9. Ultrasounds can also be used to detect cracks and flows in __________ .
10. In the inner ear, the pressure variations are turned into electrical signals by the _______ .

III. Match the following.

Tuning fork	The point where density of air is maximum
Sound	Maximum displacement from the equilibrium position
Compressions	The sound whose frequency is greater than 20,000 Hz
Amplitude	Longitudinal wave
Ultasonics	Production of sound

IV. Matrix matching.

Loudness	Number of vibrations produced in unit time	decibel
Time period	The amount of sound produced / received	Metre
Amplitude	Distance travelled by sound in unit time	Hertz
Velocity of sound	The time required to produce one complete wave	Metre per second
Frequency	The maximum displacement from the mean position	second

V. Answer in brief.

1. Name the device which is used to produce sound in laboratory experiments.
2. Through which medium sound travels faster, iron or water? Give reason.
3. What should an object do to produce sound?
4. Can sound travel through vacuum?
5. Name the physical quantity whose SI unit is 'hertz'. Define.
6. What is meant by supersonic speed?
7. How does the sound produced by a vibrating object in a medium reach your ears?
8. You and your friend are on the moon. Will you be able to hear any sound produced by your friend?

VI. Answer in detail.

1. Describe with diagram, how compressions and rarefactions are produced.
2. Verify experimentally the laws reflection of sound.
3. List the applications of sound.
4. Explain how does SONAR work?
5. Explain the working of human ear with diagram.

VII. Numerical problems.

1. The frequency of a source of sound is 600 Hz. How many times does it vibrate in a minute?
2. A stone is dropped from the top of a tower 750 m high into a pond of water at the base of the tower. When is the splash heard at the top? (Given g = 10 m s^{-2} and speed of sound = 340 m s^{-1})

REFERENCE BOOKS

1. An Introduction to Physical Science- James T-Shipman, Jerry D. Wilson and Aaron W. Todd.—Houghton Miffin Company, Boston, Newyark.
2. Applied Physics – Rajasekaran S and others – Vikas Publishing House Pvt Ltd.
3. Fundamentals of Physics – Halliday, Resnick and Walker- Sixth Edition – Wiley India Pvt Ltd. NewDelhi.

INTERNET RESOURCES

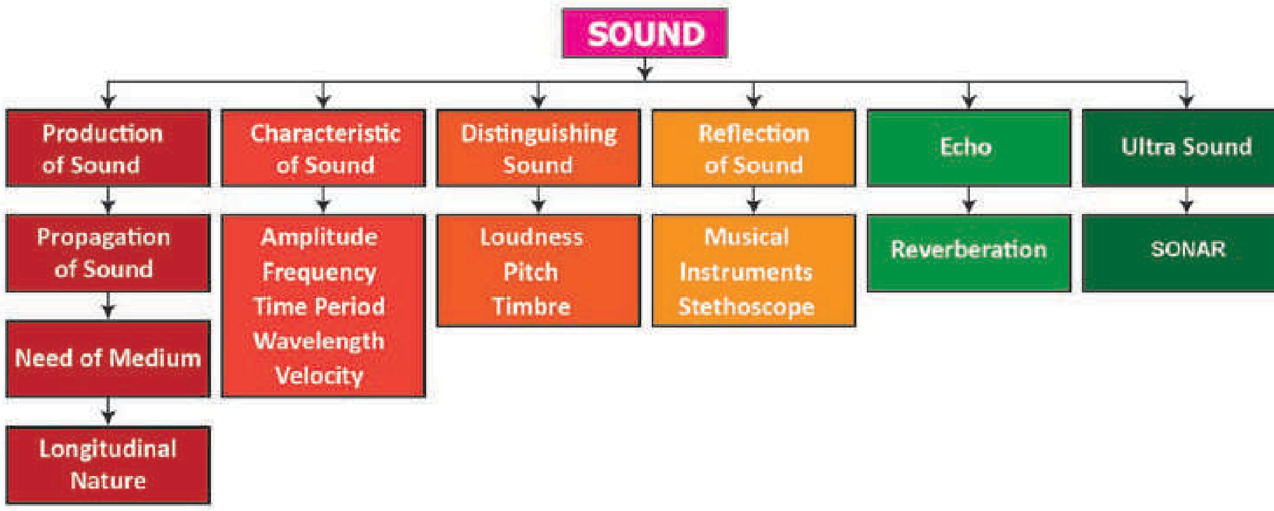
www.britannica.com/science/ultrasonics

www.reference.com/pets-animals/animals-use-ultrasound

https://www.searchencrypt.com

https://www.soundwaves.com/

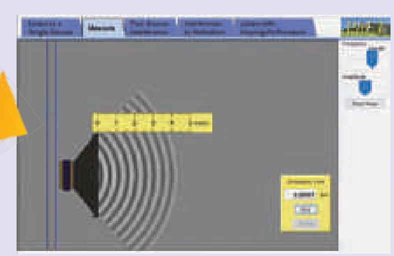
Concept Map



ICT CORNER

Sound

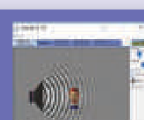
Experiment with *sound waves* using virtual simulator.



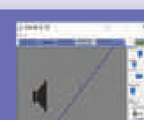
Steps

- Type the given URL to reach "pHET Simulation" page and download the "java" file of Sound.
- Open the "java" file and plug in your headphone. Click "Audio enabled" box from right side to hear the sound waves.
- Switch the tabs from the top to simulate various properties of sound waves. Watch the longitudinal sound waves from different interfaces by altering "Frequency" and "Amplitude".
- Alter "Air Density" and observe its effect on the sound waves. Use "Reset" to repeat the experiment.

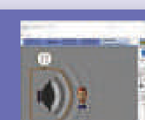
Step1



Step2



Step3



Step4

Sound Simulator

URL: https://phet.colorado.edu/en/simulation/legacy/sound or Scan the QR Code.

*Pictures are indicative only

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