Sound

Production of Sound

If somebody calls you from behind, you will quickly turn around. **What makes you do so?**

We turn back in response to a call because of the sound heard by us. We are able to talk to each other because of the sound produced by us. We are able to predict the distance of a train only by listening to the sound it produces. Similarly, we can distinguish between different musical instruments because of the sounds they produce.

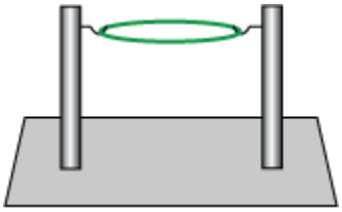
How do you realize that an alarm bell is ringing?

So, what is sound?

Sound is a form energy that produces the sensation of hearing in our ears and vibrating bodies produce sound.

Do you know how a sound is produced? To find out, let us perform the following activities.

Take a frying pan and suspend it in air with the help of support. Hit the pan with a metal spoon. Now, touch the pan. **Can you feel the vibrations?** When you beat an object, you can feel its vibrations with the help of your sense of touch. Touch the pan when it is not producing any sound. **Can you feel the vibrations now?**



Take a rubber band and stretch it between two poles (as shown in the given figure). Now, pluck the rubber band in the middle. **Can you hear any sound? Does the rubber band vibrate when it produces a sound?** On plucking a stretched rubber band or a stretched string, it vibrates rapidly and produces a sound.

Take a cooking utensil and pour some water in it. Now, beat the utensil with a rod. You will hear a sound. Carefully, observe the surface of water in the utensil**. Do you see concentric circles moving on the water surface?** These are vibrations in water, produced by vibrations of the utensil body, on beating.

Therefore, it can be concluded that a vibrating body produces sound.

The back and forth movement of an object produces sound. An object moving back and forth is said to be in vibration. Hence, sound is produced by vibrating objects.

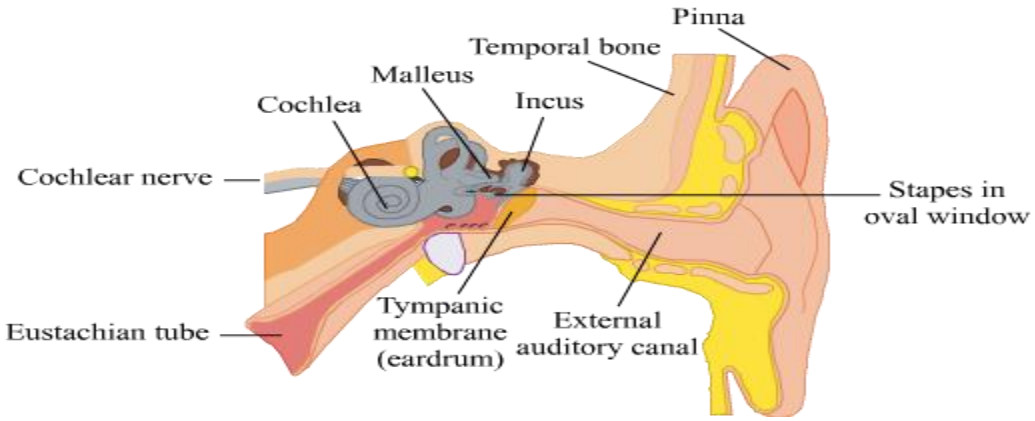
The Human Ear

The Human Ear

We have two ears to hear the different sounds that are around us—the soft purring of a cat, the loud barking of a dog, the tinkling of a bell, the blaring of a horn, etc. Our ears detect all types of sounds lying in the hearing range and send sound signals to the brain. In this lesson, we will learn about the working of the human ear.

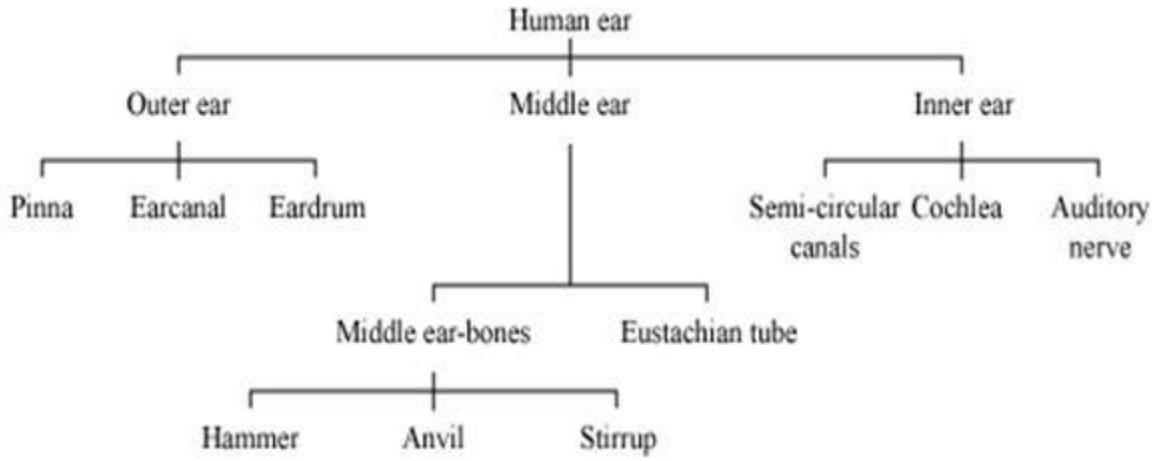
Structure of the Human Ear

The ear is one of the five sensory organs of the human body. It can sense sound waves from various sources. Take a look at this figure to know the various parts of the human ear.



The Human Ear

The human ear consists of three main parts—the outer ear, the middle ear and the inner ear. The following chart shows these three parts and their sub-parts.



- The eardrum is the intersection of the outer ear and the middle ear.
- The oval window is the intersection of the middle ear and the inner ear.

The stirrup bone of the middle ear is the smallest bone in the human body.

Parts of the Human Ear with Their Functions

The following table lists the functions of the different parts of the human ear.

Ear parts	**Sub-parts**	**Functions**
Outer ear	Pinna	Collects and sends sound to the ear canal
	Ear canal	Provides passage for sound to reach the eardrum
	Eardrum or tympanic membrane	Vibrates in response to sound; very sensitive membrane
Middle ear	Middle ear bones	Transfer sound energy to the cochlea
	Eustachian tube	Connects the middle ear to the throat
	Semi-circular canals	Send messages to the brain for balancing

Inner ear	Cochlea	Sends sound messages in the form of electrical impulses to the brain
	Auditory nerve	Conducts electrical messages to the brain where sound is then heard

Working of the Human Ear

Know More

The cochlea is a circular or snail-shaped, fluid-filled bone containing hair cells. Sound vibrations in the cochlea cause the hair cells to bend. As a result, electrical impulses get generated. These are then are carried to the brain by the auditory nerve. Consequently, sound is heard.

The Eustachian tube allows the middle ear fluids to drain and enables air to enter it from the throat.

Hearing Loss

Sounds above 85 dB can damage the eardrum. This may lead to hearing loss. Decibel (dB) is the unit of the intensity of sound. The following table lists the intensity of sound corresponding to various sounds and sources of sound.

Sources of sound	**Intensity levels (dB)**
Blowing leaves	10
Whisper	20
Mosquito buzz	40
Normal conversation	60
Busy city traffic	80
Large orchestra	100
Leaf blower	110
Jackhammer	120
Jet plane	140

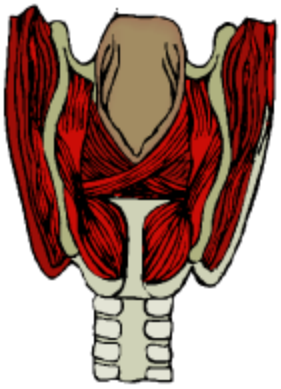
The diaphragm of the eardrum may break or perforate at the sound intensity level equal to or greater than 160 dB.

Disclaimer: The sources of sound produce different noise level at different distances.

Sound Produced By Humans

While watching a group of children playing hide and seek, Himesh observed how a blind-folded boy was able to catch the other children by hearing the sounds produced by them. **This made him wonder how sounds are produced by humans.**

While singing a song, put your hand on your throat. You will find a part of your throat moving up and down. This part of your throat is known as the **voice box** or **larynx**. The larynx is responsible for producing sounds in humans. It moves when we swallow something.

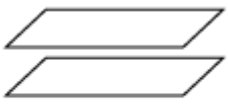


Voice box

We know that a vibrating object produces sound. **Then, which part of our body vibrates to produce sounds?**

The voice box consists of two vocal chords. These chords are arranged in such a manner that there is a small gap between them. This small gap allows air to pass through. When we speak, air is forced into this small gap by the lungs. This prompts our vocal chords to vibrate and hence, produce sounds.

Let us understand better by performing a small activity. Take a piece of paper and cut two small rectangles out of it. Now, put these two pieces of paper one above the other such that there is a small gap between them.



A rectangular slit

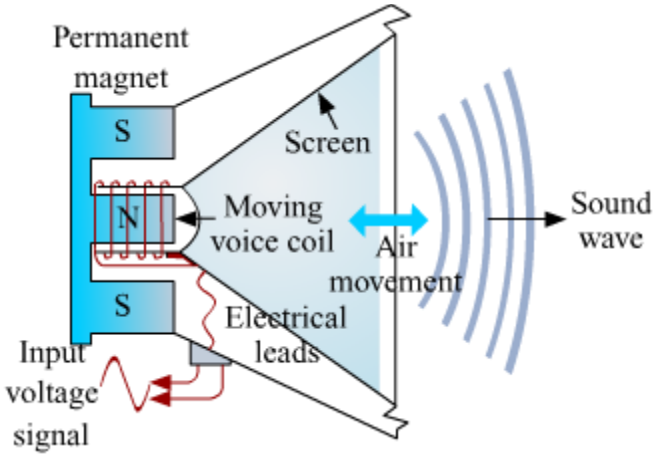
Now, blow air through this small gap. **Can you hear a sound?** Your voice box functions in the same way.

We can hold these pieces of paper tightly as well as loosely. In the same way, our vocal chords can be held tightly or loosely with the help of the muscles attached to them. Different people have different vocal chords. Due to this reason, we all have a different voice quality.

We have seen other devices too which produce sound. One of the examples is loudspeaker. Have you ever wondered how does it produce sound?

A loudspeaker consists of following parts:

- An electric coil wound on a permanent magnet.
- A conical shaped screen of the speaker connected to the coil.



Now, when variable current flows through the coil, magnetic field is produced around it due to electromagnetism and it behaves like an electromagnet. Because of this, the coil is repelled and attracted by the permanent magnet alternately. The screen attached to the coil moves back and forth due to the attraction and repulsion of the coil and produces sound. The frequency and amplitude of movement of the coil and thus the screen depends on the variation of current through the coil.

Sound Requires Medium for Propagation

We are able to hear the bursting of crackers even when we are standing at a distance. **How is it possible? How does the sound produced by a cracker reach us?**

The sound of a bursting cracker reaches us through air. It shows that sound can travel through air.

A material medium is necessary for the propagation of sound. Vacuum is devoid of any material. Hence, sound cannot travel through vacuum.

Outer space is devoid of any material medium. Hence, no sound can be heard in outer spaces. To communicate in such areas, astronauts use walkie-talkies. A walkie-talkie is an instrument, which uses radio waves for the transportation of messages.

Can sound travel through liquids?

To find out whether sound can travel through liquids, let us perform the following activity.

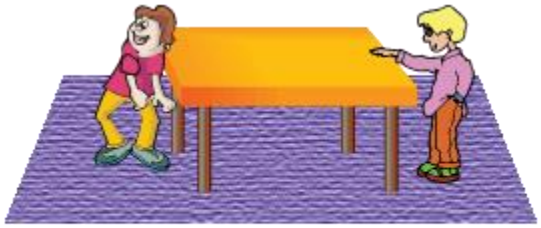
Take a metal plate and spoon. Place them inside a bucket filled with water. Hit the plate with the spoon in such a way that it does not touch the body of the bucket.

Now, carefully place your ear near the surface of water. **Are you able to hear the sound produced?**

You can hear the produced sound. Sound reaches your ear after travelling through water. Hence, we can say that sound travels through liquids.

Dolphins communicate with each other by sending high pitched squalls. It shows that sound can travel through water.	

Can sound travel through solids?



Place your ear on one end of a long table. Ask your friend to tap the table from the other end. **Do you hear any sound?**

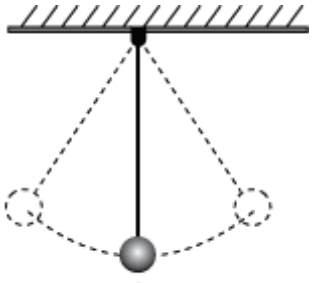
You can hear the produced sound. Sound reaches your ear after travelling through the table. This indicates that sound can travel through solids.

Stethoscope is an example of sound travelling through solids. Doctors use stethoscopes to listen to your heartbeat.	

Sound can travel in solids, liquids, and gases. However, sound cannot travel in vacuum.

Characteristics of Sound

Consider a pendulum moving continuously from left to right such that it passes through point **C** each time. This type of to and fro motion of an object is known as **vibration** or **oscillation**.



An oscillating pendulum

Frequency

The number of oscillations of a vibrating body per second is known as the **frequency of oscillation**. It is measured in **hertz (Hz)**. If in one second, the pendulum passes through point **C** 10 times then, its frequency of oscillation is 5 Hz. This is because in one complete oscillation the pendulum passes through any point twice. **What would be its frequency if it passes through point C 30 times in one second?**

Time period

The time required to complete one oscillation is known as the **time period of an oscillation**. It is given by the inverse of the frequency of oscillation. It is expressed in seconds (s).

Hence,

$$\text{Time period} = \frac{1}{\text{frequency}}$$

Example: An object oscillates at the rate of 2 oscillations per second. What is its time period?

$$\text{Time period} = \frac{1}{\text{frequency}}$$

$$= \frac{1}{2} = 0.5\,\text{s}$$

Hence, the time period of the given object is 0.5 second.

Amplitude

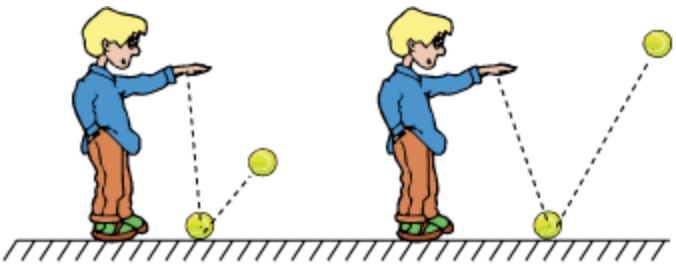
Amplitude of an oscillation is the distance covered on either side of the mean position. In the above example of a pendulum, distance covered by the bob on either side of point **C** gives its amplitude.

Loudness

You can easily distinguish between the difference in sounds produced by a *tabla* and guitar. Similarly, there are many sounds that you can identify without looking at the objects producing them. This shows that there are some characteristics that make these sounds different.

Let us perform an activity to understand better.

Take a plastic ball and throw it on the ground. When it hits the floor, it produces a sound. Again, throw the ball with greater force. In this case, the sound produced will be louder and the height to which it bounces will also be higher. The height to which the ball bounces gives the measure of its amplitude of vibrations. Hence, we can say that loudness increases with an increase in amplitude.



When a ball is thrown with greater force, it bounces higher and makes a louder sound

Loudness of sound is proportional to the square of the amplitude of the vibration produced. Loudness of sound is expressed in **decibels (dB)**. As the amplitude of vibrations increase, the loudness of a sound also increases.

Loudspeakers increase the amplitude of the produced sound. Due to this, the sound produced becomes very loud.

Loudspeaker

When we burst crackers, a loud sound is produced. Hence, they have large amplitude.

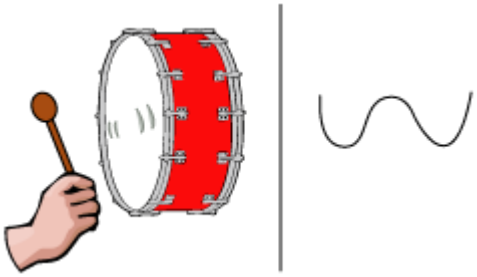
Bursting of crackers

Whispering has small amplitude, whereas shouting has large amplitude. Hence, shouting is louder than whispering.

Pitch

We can easily distinguish between the sound of a drum and the whistle of a train. **Why is it so?** The sound produced by two different objects can be equally loud. Even then we can distinguish between them. **How?**

The frequency of an oscillation determines the shrillness or pitch of a sound. If the frequency of vibration is higher and the sound produced is shrill, it will have a high pitch. Similarly, if the frequency of oscillations is small then, the sound produced will have a low pitch.



Sound produced by a drum is an example of low pitched sound. However, it has large amplitude.

Sound produced by the buzzing of a bee is shriller than the roar of a lion. This suggests that buzzing of a bee has higher frequency of oscillations than the roar of a lion. Likewise, the voice of a child is always shriller than the voice of a man.

Male voice is less **shrill** than female voice. This is because of the **pitch** of sound. Female voice has a higher pitch in comparison to the male voice.

When your teacher writes on the blackboard with a piece of chalk, sometimes the chalk makes a displeasing sound. **Is this an example of a high pitched sound?**

Can you name some objects that make high and low pitched sounds? Two examples are already given in the table. Fill in the rest.

Object	Type of sound
1. Whistle	High pitched
2. Drum	low pitched
3.	
4.	
5.	

Audible and Inaudible Sounds

The sounds that can be heard by humans are called **audible sounds**. The range of **audible sounds** is **20 Hz** to **20000 Hz.** We cannot hear the sounds having a frequency of vibration less than 20 Hz or greater than 20000 Hz. These are called **inaudible sounds**.

The following table lists the audible range of some animals.

Animal	Audible range in Hz
Dog	67 -45000
Elephant	16 -12,000
Cat	45 - 64,000
Cow	23 -35000
Rat	200 -76000

The police use high frequency sound whistles (above 20000 Hz), which dogs can hear but humans cannot. In medical science, ultrasound devices are used for analysing and observing internal organs. Ultrasound devices produce sounds of frequency greater than 20000 Hz.

Some sounds produced by musical instruments such as *Shehnais*, *manzira* etc. are pleasant. Whereas traffic sound, factory sound, sound produced in a class room etc. are not pleasant. **Do you know why?** This is because all sounds are not musical. Noise is unpleasant to the ear.

Noise and Music

Have you ever visited a carpenter's shop? The various sounds produced in the shop are loud and unpleasant. This is because the sounds produced in a carpenter's shop are examples of noise. Similarly, in a busy traffic, sounds produced by horns are noise. **Noise is always unpleasant and painful**.

Prepare a list of sources producing noise.

Musical instruments such as *tanpura and flute* produce sounds, which are pleasant to the ears. However, the melody of a sound is lost if it becomes too loud. Then, it becomes noise. Therefore, **music is pleasant and melodious.**

Noise Pollution

Pollution occurs when there is an excess of some unwanted entity. Noise pollution occurs when there is an excess of unwanted sound in the environment. It is one of the biggest problems of modern era. Noise pollution like air pollution is largely created by humans. It is mainly caused by factories, vehicles, construction instruments such as jackhammer, bulldozer, leaf blower, air conditioner, desert cooler etc.

Jackhammer

Leaf blower

Bulldozer

Loudspeakers and crackers produce noise pollution. Televisions and transistors running on high volumes can also contribute to noise pollution. However, the worst offenders of noise pollution are transportation vehicles.

Loudspeaker

Bursting of crackers

Busy traffic

Prepare a list of some sound sources that produce noise pollution.

Effects of noise pollution:

Noise pollution can lead to many health related problems like:

- Insomnia
- Loss of hearing
- Hypertension
- Severe headache
- Stress related diseases
- Aggressiveness in behavior

How can noise pollution be controlled?

To control noise pollution, we must control its source. Hence, silencers must be installed in vehicles such as motorcycles, cars, trucks, buses, and other noise producing machines. We should watch television and listen to music at a low volume. Also, use of loudspeakers as well as horns of buses and trucks should be minimized.

Regular maintenance of automobiles should be done so that noise produced by them can be kept under check. All industrial work should be done away from residential areas. More trees should be planted in residential areas as they help in reducing noise.