UNIT 6

SOUND

Learning Objectives

After the completion of this lesson, students will be able to:

- understand the production of sound.
- explain the propagation of sound in a medium.
- analyse the properties of sound.
- explain the wave nature of sound.
- know about the mechanism of hearing.
- discuss about noise pollution and the ways to control it.

Introduction

We hear variety of sounds in our daily life. Thundering of clouds, chirping of birds, mewing of cats, rustling of leaves, music on the radio and television and noise of vehicles are some of the sounds that all of us are familiar with. Each sound has particular characteristics. Sound enables us to communicate with each other. Animals also communicate with other members of their species with the help of sound. Some sounds like music are pleasing to us and we like to hear them. But some sounds, for example noise in our surrounding is undesired. In this lesson we will study about the production and propagation of sound, human voice system, hearing, noise pollution and the ways to control it.

6.1 Production of Sound

Sound is produced when an object is set to vibrate. Vibration means a kind of rapid to and fro motion of a particle. This to and fro motion of the particle causes the substances around it to vibrate. Thus sound spreads to the surroundings. The substance through which sound is transmitted is called medium. Sound moves through a medium from the point of generation to the listener. We can understand the production of sound with the help of some activities.

Activity 1

Take the tray of an empty match box and stretch a rubber band around it, along its length. Then, pluck the stretched rubber band with your index finger. What do you observe? Do you hear any sound?

On plucking the rubber band, it starts vibrating. You can hear a feeble humming sound as long as the rubber band is vibrating. The humming sound stops as soon as the rubber

band stops vibrating. This confirms that sound is produced by vibrating particles. You can see this kind of vibrations in stringed musical instruments, such as guitar and sitar also.

Activity 2

Take a metal shallow pan. Hang it at a convenient place in such a way that it does not touch anything. Now, strike it with a stick. Touch the pan gently with your index finger. Do you feel the vibrations? Again, strike the pan with the stick and hold it tightly with your hands, immediately after striking. Do you still hear the sound?

This activity shows that vibrating pan produces sound. In this case vibrations can be felt by touching the pan. But in some cases vibrations are visible.

Activity 3

Take a metal dish, pour some water in it. Strike it at its edge with a spoon. Do you hear any sound? Again strike the dish and touch it. Can you feel the dish vibrating? Look at the surface of water. Do you see any movement on the water surface? Now, hold the dish with your hands. What change do you observe on the surface of the water?

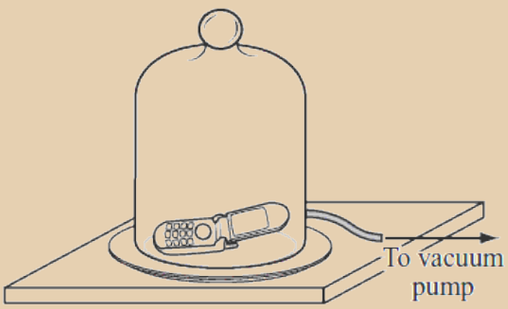
The above activities show that sound is produced when an object is set to vibrate. The sound produced by vibration is propagated from one location to another. When it reaches our ear we hear the sound.

6.2 Propagation of Sound

When you call your friend who is standing at a distance, your friend is able to hear your voice. How your friend is able to hear your voice? He is able to hear because your sound travels from one place to another. As we saw earlier sound is a form of energy and it needs a medium to travel. This can be understood from the activity given below.

Activity 4

Take a bell jar and a mobile phone. Switch on the music in the mobile phone and place it in the jar. Now, pump out the air from the bell jar using a vacuum pump. As more and more air is removed from the jar, the sound from the mobile phone becomes feebler and finally, very faint.



It is clear from this experiment that sound cannot travel in vacuum and it needs a medium like air. Sound travels in water and solids also. The speed of sound is more in solids than in liquids and it is very less in gases.

Thomas Alva Edison, in 1877 invented the phonograph, a device that played the recorded sound.

Activity 5

Take two stones and strike them together and listen to the sound produced by them. Now take the stones underwater and strike them. You will find that the sound produced by the stones underwater is feeble and not very clear.

The speed of sound is the distance travelled by sound in one second. It is denoted by 'v'. It is represented by the expression, $v = n\lambda$, where 'n' is the frequency and 'λ' is the wavelength.

More to know

Wavelength is the distance between two consecutive particles, which are in the same phase of vibration. It is denoted by the Greek letter 'λ'. The unit of wavelength is metre (m).

Frequency is the number of vibrations of a particle in the medium, in one second. It is denoted by 'n'. The unit of frequency is hertz (Hz).

Problem 1

A sound has a frequency of 50 Hz and a wavelength of 10 m. What is the speed of the sound?

Solution

Given, $n = 50$ Hz, $\lambda = 10$m

$v = n\lambda$

$v = 50 \times 10$

$v = 500$ ms^{-1}

Problem 2

A sound has a frequency of 5 Hz and a speed of 25 ms^{-1}. What is the wavelength of the sound?

Solution

Given, $n = 5$ Hz, $v = 25$ ms^{-1}

$v = n\lambda$

$\lambda = v/n = 25/5 = 5$ m

The speed of sound depends on the properties of the medium through which it travels, like temperature, pressure and humidity. In any medium, as the temperature increases the speed of sound also increases. For example, the speed of sound in air is 331 ms^{-1} at 0°C and 344 ms^{-1} at 22°C. The speed of sound at a particular temperature in various medium are listed in Table 6.1.

Table 6.1 Speed of sound in different medium at 25°C

State	Substance	Speed (ms-1)
Solids	Aluminum	6420
	Steel	5960
	Iron	5950
Liquid	Sea Water	1530
	Distilled Water	1498
Gases	Hydrogen	1284
	Oxygen	316

More to know

The amount of water vapour present in the air is known as humidity. It is less during winter and more during summer. The speed of sound increases with increase in humidity. This is because the density of air decreases with increase in humidity.

We saw that sound travels in different medium with different speed. Now let us see how it travels in a medium. When a body vibrates, the particle of the medium in contact with the vibrating body is first displaced from its equilibrium position. It then exerts a force on the adjacent particle. This process continues in the medium till the sound reaches the ear of the person.

In order to understand this let us consider a vibrating tuning fork. When a vibrating tuning fork moves forward, it pushes and

compresses the air in front of it, creating a region of high pressure. This region is called a compression (C), as shown in Figure 6.1. When it moves backward, it creates a region of low pressure called rarefaction (R). These compressions and rarefactions produce the sound wave, which propagates through the medium.

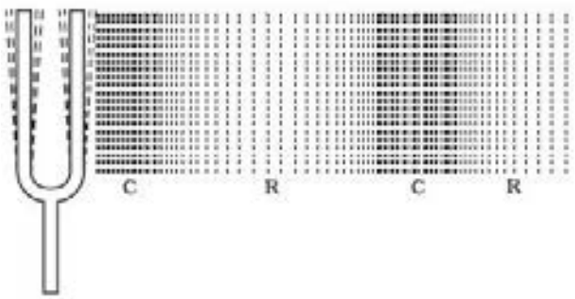


Figure 6.1 Vibrating tuning fork

6.3 Sound Waves

Activity 6

Throw a stone into a pool of still water. It produces waves, which spread rapidly over the surface of water and they travel in all directions. Do water particles move away from the point of disturbance? Check it by placing grains of saw dust over the water. They do not move away. Instead they merely move up and down about their mean position. Similarly, sound travels in the form of a wave.

Sound is a form of energy. It is transferred through the air or any other medium, in the form of mechanical waves. Mechanical wave is a disturbance, which propagates in a medium due to the repeated periodic motion of the particles of the medium, from their mean position. The disturbance which is caused by the vibrations of the particles is passed over to the next particle. It means that the energy is transferred from one particle to another as a wave motion.

6.3.1 Characteristic of wave motion

1. In wave motion, only the energy is transferred not the particles.
2. The velocity of the wave motion is different from the velocity of the vibrating particle.
3. For the propagation of a mechanical wave, the medium must possess the properties of inertia, elasticity, uniform density and minimum friction among the particles.

DO YOU KNOW?

How do astronauts communicate with each other? The astronauts have devices in their helmets which transfer the sound waves from their voices into radio waves and transmit it to the ground (or other astronauts in space). This is exactly the same as how radio at your home works.

6.3.2 Types of mechanical wave

There are two types of mechanical wave. They are

1. Transverse wave
2. Longitudinal wave

Transverse wave

In a transverse wave the particles of the medium vibrate in a direction, which is perpendicular to the direction of propagation of the wave. E.g. Waves in strings, light waves, etc. Transverse waves are produced only in solids and liquids.

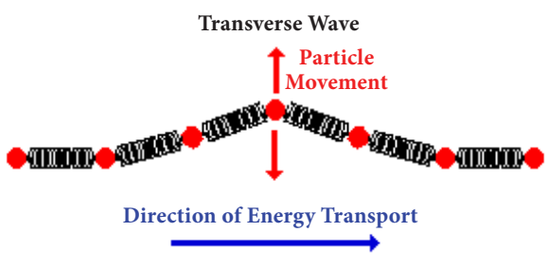


Figure 6.2 Transverse wave

Longitudinal wave

In a longitudinal wave the particles of the medium vibrate in a direction, which is parallel to the direction of propagation of the wave. E.g. Waves in springs, sound waves in a medium. Longitudinal waves are produced in solids, liquids and also in gases.

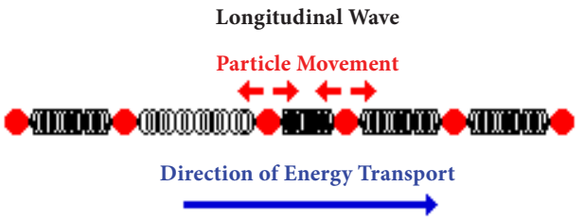


Figure 6.3 Longitudinal wave

DO YOU KNOW?

The seismic wave formed during earthquake is an example for a longitudinal wave. Waves travelling through the layers of the Earth due to explosions, earthquakes and volcanic explosions are called seismic waves. Using a hydrophone and seismometer one can study these waves and record them. Seismology is the branch of science that deals with the study of seismic waves.

6.4 Properties of Sound

All sounds that we hear are not the same. There are some properties that differentiate one kind of sound from another. We will study about these properties now.

6.4.1 Loudness

It is defined as the characteristic of a sound that enables us to distinguish a weak or feeble sound from a loud sound. The loudness of a sound depends on its amplitude. Higher the amplitude louder will be the sound and vice-versa. When a drum is softly beaten, a weak sound is produced. However, when it is beaten strongly, a loud sound is produced. The unit of loudness of sound is decibel (dB).

More to know

Amplitude is the maximum displacement of a vibrating particle from its mean position. It is denoted by 'A'. The unit of amplitude is 'metre' (m).

6.4.2 Pitch

The pitch is the characteristic of sound that enables us to distinguish between a flat sound and a shrill sound. Higher the frequency of sound, higher will be the pitch. High pitch adds shrillness to a sound. The sound produced by a whistle, a bell, a flute and a violin are high pitch sounds.

Normally, the voice of a female has a higher pitch than a male. That is why a female's voice is shriller than a male's voice. Some examples of low pitch sound are the roar of a lion and the beating of a drum.

6.4.3 Quality or Timbre

The quality or timbre is the characteristic of sound that enables us to distinguish between two sounds that have the same pitch and amplitude. For example in an orchestra, the sounds produced by some musical instruments may have the same pitch and loudness. Yet, you can distinctly identify the sound produced by each instrument.

6.4.4 Audibility and Range

According to the frequency we can classify the sounds into three types. They are:

- Audible sound
- Infrasonic sound
- Ultrasonic sound

Audible sound

Sound with frequency, ranging from 20 Hz to 20000 Hz is called sonic sound or audible sound. Sound with this frequency range alone can be heard by the human beings. Human ears

cannot hear sounds with frequencies below 20 Hz or above 20000 Hz. So, the above range is called as audible range of sound.

Infrasonic sound

A sound with a frequency, below 20 Hz is called as subsonic or infrasonic sound. Humans cannot hear the sound of this frequency, but some animals like dog, dolphin, etc., can hear. Uses of infrasonic sound are:

- It is employed in the earth monitoring system.
- It is also used in the study of the mechanism of human heart.

Ultrasonic sound

A sound with a frequency greater than 20000 Hz is called as ultrasonic sound. Animals such as bats, dogs, dolphins, etc., are able to hear certain ultrasonic sounds as well. Some of the uses of ultrasonic sounds are:

- It is extensively used in medical applications like 'sonogram'.
- It is used in the SONAR system to detect the depth of the sea and to detect enemy submarines.
- It is also employed in dish washers.
- Another important application of ultra sound is the Galton's whistle. This whistle is inaudible to the human ear, but it can be heard by the dogs. It is used to train the dogs for investigation.

A bat can hear the sounds of frequencies higher than 20,000 Hz. Bats produce ultrasonic sound during screaming. These ultrasonic waves help them to locate their way and the prey.

6.5 Musical Instruments

Some sounds are pleasing to the ear and make us happy. The sound that provides a pleasing sensation to the ear is called 'music'. Music is produced by the regular patterns of vibrations. Musical instruments are categorized into four types as given below.

- Wind instruments
- Reed instruments
- Stringed instruments
- Percussion instruments

Wind instruments

In a wind instrument the sound is produced by the vibration of air in a hollow tube. The frequency is varied by changing the length of the vibrating air column. Trumpet, Flute, Shehnai and Saxophone are some well-known wind instruments.

Reed instruments

A reed instrument contains a reed. Air, which is blown through the instrument, causes the reed to vibrate, which in turn produces the specific sound. Examples of reed instruments include Harmonium and Mouth Organ.

Stringed instruments

Stringed instruments make use of a string or wire to produce vibrations and hence the specific sound. These instruments also have hollow boxes that amplify the sound that is produced. The frequency of sound is varied by varying the length of the vibrating wire. Violin, Guitar, Sitar are some of the examples of stringed instruments.

A guitar string has a number of frequencies at which it will naturally vibrate. These natural frequencies are known as the **harmonics** of the guitar string. The natural frequency, at which an object vibrates, depends upon the tension of the string, the linear density of the string and the length of the string.

Percussion instruments

Percussion instruments produce a specific sound when they are struck, scrapped or

Figure 6.4 Musical instruments

clashed together. They are the oldest type of musical instruments. There is an amazing variety of percussion instruments all over the world. Percussion instruments like the drum and tabla consist of a leather membrane, which is stretched across a hollow box called the resonator. When a membrane is hit, it starts vibrating and produces the sound.

6.6 Sound produced by Humans

In human being, the sound is produced in the voice box, called the larynx, which is present in the throat. It is located at the upper end of the windpipe. The larynx has two ligaments called 'vocal cords', stretched across it. The vocal cords have a narrow slit through which air is blown in and out. When a person speaks, the air from the lungs is pushed up through the trachea to the larynx. When this air passes through the slit, the vocal cords begin to vibrate and produce a sound. By varying the thickness of the vocal cords, the length of the air column in the slit can be changed. This produces sounds of different pitches. Males generally have thicker and longer vocal cords that produce a deeper, low pitch sound in comparison with females.

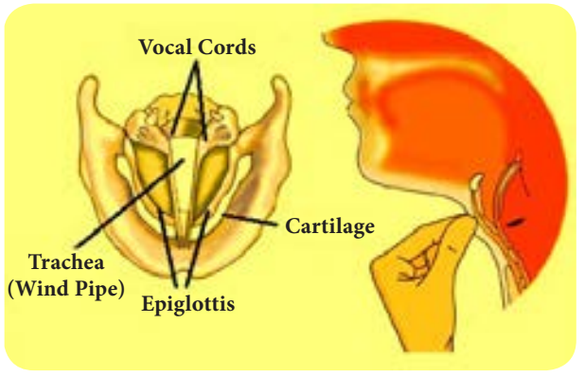


Figure 6.5 Structure of Larynx

6.7 Mechanism of Human Ear

Ear is the important organ for all animals to hear a sound. We are able to hear sound through our ears. Human ear picks up and interprets high frequency vibrations of air. Ears of aquatic animals are designed to pick up high frequency vibrations in water. The outer and visible part of the human ear is called pinna (curved in shape). It is specially designed to gather sound from the environment, which then reaches the ear drum (tympanic membrane) through the ear canal. When the sound wave strikes the drum,

the ossicles move inward and outward to create the vibrations. These vibrations are then picked up by special types of cells in the inner ear. From the inner ear the vibrations are sent to the brain in the form of signals. The brain perceives these signals as sounds.

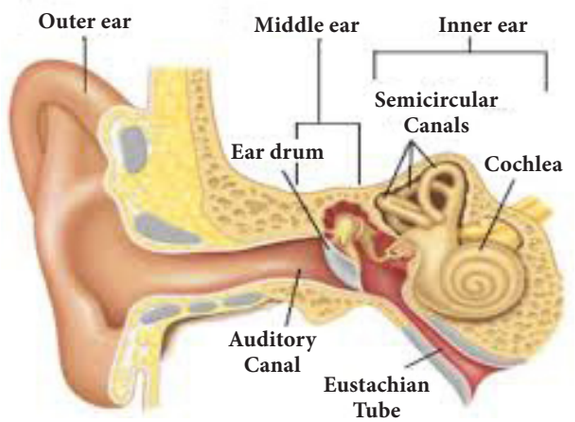


Figure 6.6 Human Ear

6.8 Noise Pollution

Any sound that is unpleasant to the ear is called noise. It is the unwanted, irritating and louder sound. Noise is produced by the irregular and non-periodic vibrations. Noise gives us stress. The disturbance produced in the environment by loud and harsh sounds from various sources is known as noise pollution. Busy roads, airplanes, electrical appliances such as mixer grinder, washing machine and un-tuned radio cause noise pollution. Use of loudspeakers and crackers during the festivals also contributes to the noise pollution. The major source of noise pollution is from the industries. Noise pollution is the bi-product of industrialisation, urbanisation and modern civilisation.

6.8.1 Health hazards due to noise pollution

Noise creates some health hazards. Some of them are listed below.

- Noise may cause irritation, stress, nervousness and headache.

Figure 6.7 Hazards of noise pollution

- Long term exposure to noise may change the sleeping pattern of a person.
- Sustained exposure to noise may affect hearing ability. Sometimes, it leads to loss of hearing.
- Sudden exposure to louder noise may cause heart attack and unconsciousness.
- It causes lack of concentration in one's work. Noise of horns, loud speakers, etc., cause disturbances leading to lack of concentration.
- Noise pollution affects a person's peace of mind. It adds to the existing tensions of modern living. These tensions results in disease like high blood pressure or short-tempered nature.

6.8.2 Controlling noise pollution

We studied about the harmful effects of noise pollution. It becomes necessary for us to reduce it. Noise pollution can be significantly reduced by adopting the following steps.

- Strict guidelines should be set for the use of loudspeakers on social, religious and political occasions.
- All automobiles should have effective silencers.
- People should be encouraged to refrain from excessive honking while driving.
- Industrial machines and home appliances should be properly maintained.

- All communication systems must be operated in low volumes.
- Residential areas should be free from heavy vehicles.
- Green corridor belt should be set up around the industries as per the regulations of the pollution control board.
- People working in noisy factories should wear ear plugs.
- People should be encouraged to plant trees and use absorbing materials like curtains and cushions in their home.

6.8.3 Hearing loss

You may have hearing loss without realising it. The following are the symptoms of hearing loss.

- Ear ache
- A feeling of fullness or fluid in the ear.
- Ringing in your ears

Hearing loss is caused by various reasons. Some of them are listed below.

- Aging
- Ear infections if not treated
- Certain medicines
- Genetic disorders
- A severe blow to the head
- Loud noise

Points to Remember

- Sound is produced by the vibration of the particles of a medium.
- Sound is a form of energy that is transferred as vibrations through the air or any other medium, in the form of waves.
- In a wave motion only the energy is transferred not the particles.
- The distance between two consecutive particles which are in same phase of vibration is called wavelength.
- The time taken by a vibrating particle to complete one vibration is known as time period of the vibration.
- The speed of a wave is the distance travelled by it in one second.
- Higher the frequency of sound, higher will be the pitch.
- The speed of sound increases with increase in humidity.
- Music is produced by the regular patterns of vibrations.
- Sound with the frequency ranging from 20 Hz to 20000 Hz is called sonic sound or audible sound.
- A sound with a frequency below 20 Hz is called as subsonic or infrasonic sound.
- A sound with a frequency greater than 20000 Hz is called as ultrasonic sound.

A-Z GLOSSARY

Amplitude	The measure of a sound wave.
Pitch	How high or low a sound is. It is determined by the frequency of the vibration.
Sonic Boom	A shock wave that consists of compressed sound waves created when something moves faster than the speed of sound.
Sound Wave	Moving pattern of high and low pressure or vibrations.
Speed of Sound	How fast sound moves through an object.
Vibration	Back and forth motion.
Wavelength	The length between the compressions in a sound wave.

TEXTBOOK EXERCISES

I. Choose the best answer.

1. Sound waves travel very fast in
   a) air b) metals
   c) vacuum d) liquids
2. Which of the following are the characteristics of vibrations?
   i. Frequency ii. Time period
   iii. Pitch iv. Loudness
   a) i and ii b) ii and iii
   c) iii and iv d) i and iv
3. The amplitude of the sound wave decides its
   a) speed b) pitch
   c) loudness d) frequency
4. What kind of musical instrument is a sitar?
   a) String instrument
   b) Percussion instrument
   c) Wind instrument
   d) None of these
5. Find the odd one out.
   a) Harmonium b) Flute
   c) Nadaswaram d) Violin
6. Noise is produced by
   a) vibrations with high frequency.
   b) regular vibrations.
   c) regular and periodic vibrations.
   d) irregular and non-periodic vibrations.
7. The range of audible frequency for the human ear is
   a) 2 Hz to 2000 Hz
   b) 20 Hz to 2000 Hz
   c) 20 Hz to 20000 Hz
   d) 200 Hz to 20000 Hz
8. If the amplitude and frequency of a sound wave are increased, which of the following is true?
   a) Loudness increases and pitch is higher.
   b) Loudness increases and pitch is unchanged.
   c) Loudness increases and pitch is lower.
   d) Loudness decreases and pitch is lower.
9. Which of the following may be caused by noise?
   a) Irratition b) Stress
   c) Nervousness d) All the above

II. Fill in the blanks.

1. Sound is produced by _____.
2. The vibrations of a simple pendulum are also known as _____.
3. Sound travels in the form of _____.
4. High frequency sounds that cannot be heard by you are called_____.
5. Pitch of a sound depends on the _____ vibration.
6. If the thickness of a vibrating string is increased, its pitch _____.

III. Match the following.

Ultrasonics	Frequency below 20Hz
Speed of sound in air	Needs material medium
Infrasonics	$330 ms^{-1}$
Sound propagation	Frequency more than 20000 Hz

IV. Consider the statements given below and choose the correct option.

1. **Assertion:** When lightning strikes, the sound is heard a little after the flash is seen.

   Reason: The velocity of light is greater than that of the sound.

2. **Assertion:** Two persons on the surface of moon cannot talk to each other.

   Reason: There is no atmosphere on moon.

A. Both assertion and reason are true and reason is the correct explanation of assertion.

B. Both assertion and reason are true but reason is not the correct explanation of assertion.

C. Assertion is true but reason is false.

D. Assertion is false but reason is true.

E. Both Assertion and reason are false.

V. Answer briefly.

1. What is vibration?
2. Give an example to show that light travels faster than sound?
3. To increase loudness of sound by four times, how much should the amplitude of vibration be changed?
4. What is an ultrasonic sound?
5. Give two differences between music and noise.
6. What are the hazards of noise pollution?
7. Mention few measures to be taken to reduce the effect of noise pollution.
8. Define the following terms.
   a. Amplitude b. Loudness
9. How does planting trees help in reducing noise pollution?

VI. Answer in detail.

1. Describe an experiment to show that sound cannot travel through vaccum.
2. What are the properties of sound?
3. What steps should be taken to reduce the effect of noise pollution?
4. Describe the structure and function of the human ear?

VII. Problems.

1. Ruthvik and Ruha hear a gunshot 2 second after it is fired. How far away from the gun they are standing? (Speed of sound in air is equal to $330ms^{-1}$)
2. A sound wave travels 2000 m in 8 s. What is the velocity of the sound?
3. A wave with a frequency of 500 Hz is traveling at a speed of 200 ms^{-1}. What is the wavelength?

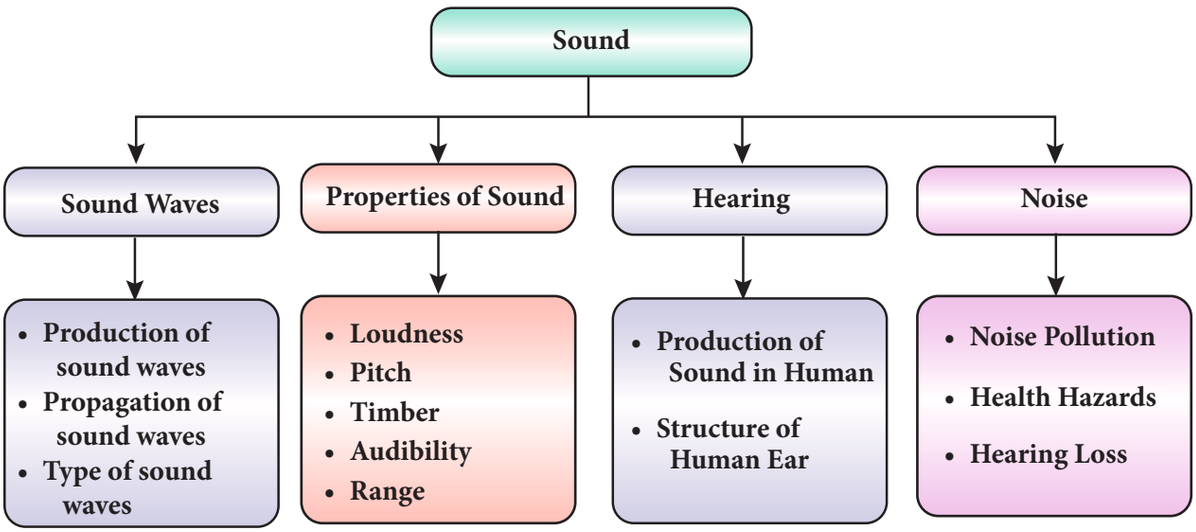
REFERENCE BOOKS

1. The everyday physics of hearing and vision by Bejamin de Mayo
2. Vibration and Waves by Anthony French

INTERNET RESOURCES

1. www.pbslearningmedia.org
2. www.scholastic.com

Concept Map



ICT CORNER

Sound

Make simple science toys from trash and enjoy the sounds so produced.

Step 1 Open the browser and type the URL or scan the QR code given below.

Step 2 Toys from Trash page will open. Simple science toys will appear under the heading 'Simple Sounds'.

Step 3 Click on the Icons to learn the step by step procedure for making simple sounds toys. Enjoy making and playing with various sound producing toys.

Step 1

Step 2

Step 3

Web URL:

http://www.arvindguptatoys.com/simple-sounds.php

*Pictures are indicatives only.

*If browser requires, allow Flash Player or Java Script to load the page

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