3 SOUND

THEORY

3.1 INTRODUCTION

We hear a variety of sounds in our surroundings. The sound of an alarm clock, barking of dogs, voices of friends and teachers, sounds made by tabla and harmonium, humming of insects and mosquitoes and the ticking of a clock are some of the common sounds we hear everyday.

It is a form of energy that gives us sensation of hearing.

Sound helps us to communicate with one another. Can you recognize your friends by just listening to them without looking at them? Yes You can, because the sound (the voice) produced by each one of them has a different character.

Like humans, even animals produce and hear sounds. How is sound produced? How does sound travel from one place to another? Why do we all sound different? We shall study about all these in this chapter.

We hear many types of sound around us everyday. We hear the sound of our friends and parents talking, the sound of buses and other automobiles running on the street, the chirping of birds, the barking of dogs, the cries of street vendors, the screeching of brakes, the zooming of aeroplane overhead, the clatter of pans in the kitchen and so on. In the night, when most sound cease, we can still hear the buzzing of mosquito. Each type of sound is a characteristics of the object producing it.

3.2 SOUND IS PRODUCED BY VIBRATING BODIES

- A vibration is a rapid back and forth movement of a body about a central position.
- A sound is produced because of a vibration. Thus, sound is a vibration that is capable of being heard. We can also call every sound-producing object a vibrating body.

Perform the following activities :

ACTIVITY - 1

To prove that vibrating bodies produces sound.

Take a rubber band & scissor. Cut a rubber band. Hold one end of it in your mouth and the other end in your hand and stretch it. Now, pull it downward with the other hand and release it (fig.). What happens to the rubber band ? You will notice that it moves to and fro or vibrate and it also produces sound.

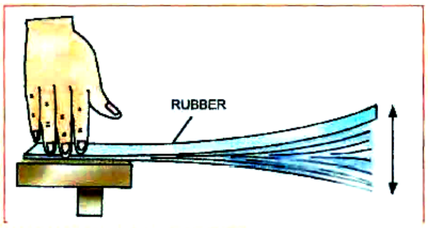
Vibrations in a stretched rubber band produces sound

ACTIVITY - 2

To show that a vibrating meter produce sound.

Take a scale and hold its one end firmly on the table with your left hand. Flick the free end of the scale with your right hand; let it go (fig.). What do you observe ?

The ruler is seen vibrating and a humming sound is heard. The humming sound is produced by the to and fro motion of the ruler.

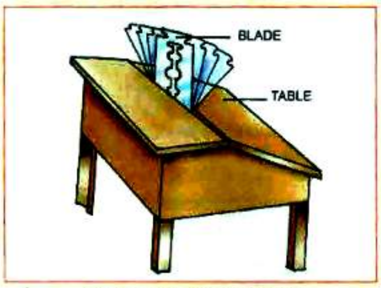


A vibrating ruler

ACTIVITY - 3

To show that a vibrating blade produces sound.

Take a used shaving blade and fix it on a table, or desk as shown in Fig 13.3. Bend the upper end of the blade and leave it. The blade begins vibrate. You can actually see it vibrating. Touch the blade carefully with your finger. It stops vibrating. Does it produce any sound now ?

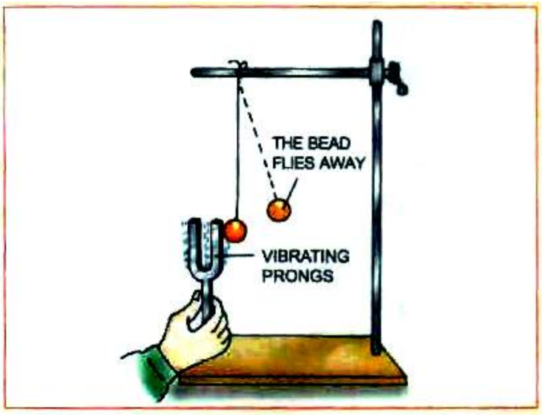


A vibrating shaving blade

ACTIVITY - 4

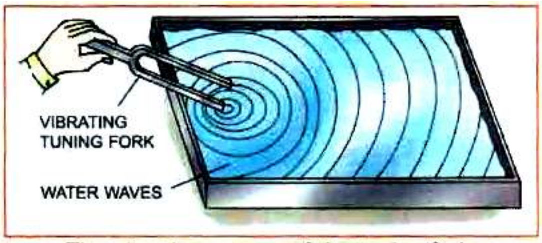
To show that a vibrating blade produces sound.

- Take Tuning fork, Rubber pad, Bead, Thread. First, strike the tuning fork against the rubber pad and touch its one prong with a small bead suspended with a thread (fig.).
The bead will be set into vibrations indicating about their mean position.



Vibrating prongs of the tuning fork

If the tuning fork is held upside down in a basin of water, you will see waves in the water, because of the vibration of the tuning fork (fig.)
Now, bring this vibrating tuning fork near your ear. Do you hear any sound when the prongs stop vibrating?



The vibrating prongs of the tuning fork produce circular waves in water

All these examples show that sound is only produced when a body vibrates. As soon as the vibrations stop, the sound also stops. From this, we conclude that the sound is produced by the vibrating bodies. The above activity suggests that vibration is produced by the back and forth movement of a body about it mean position. Sound, in fact, is a vibration that can be heard.
Sound travels in the form of waves and a wave is characterised by three basic quantities - amplitude, frequency and time period. Two characteristics of sound loudness and pitch are determined by amplitude and frequency of the sound wave respectively.
We therefore will first know about the characteristics of wave with the help of a simple pendulum.

3.3 WAVE MOTION

Introduction : When a pebble is thrown in a pond of still water, circular ripples called waves or pulses move outward on the surface of water as shown in the figure . These waves are in the form of disturbance that travels outward and no portion of the medium (water in this case) is transported from one part to another part of the medium. The particles of the medium simply vibrate about their mean positions.

Definition : A wave motion is a means of transfering energy from one point to another without any actual transportation of matter between these points.
In a wave motion, disturbance travels through some medium, but the medium does not travel along with the disturbance.

3.4 CLASSIFICATION OF WAVES

(A) DEPENDING ON MEDIUM REQUIREMENT WAVES CAN BE CLASSIFIED AS :

(1) Mechanical waves (2) Non Mechanical or Electromagnetic waves

(1) Mechanical wave : Those waves which need a material medium (like solid, liquid or gas) for their propagation, are called mechanical waves or elastic waves.
A mechanical wave cannot travel through vacuum.

Examples of mechanical waves:

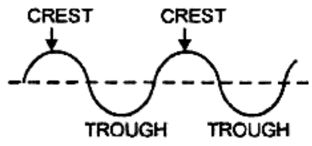
(i) Sound waves in air. (ii) Water waves
(iii) Waves produced in a stretched string. (iv) Waves produced in spring.

(2) Electromagnetic waves : Those waves which do not need a material medium for their propagation and can travel even through a vacuum, are called electromagnetic waves because they do not require a material medium (like solid, liquid or gas) for their propagation, they can travel even through vacuum. Examples of electromagnetic waves are (i) Radio waves (ii) Infrared waves (iii) Visible (light) waves.

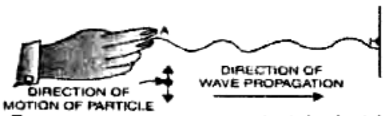
(B) DEPENDING UPON THE DIRECTION OF VIBRATION OF MEDIUM PARTICLES WAVES ARE CLASSIFIED AS :

(1) Transverse waves (2) Longitudinal waves

(1) Transverse wave : A wave motion in which an individual particle of the medium vibrates in a direction at right angles to the direction of propagation of wave is called transverse wave motion.



(a) Water waves show crests and troughs



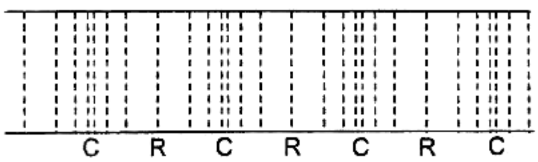
(b) Transverse waves on a stretched string

In the case of waves formed over the surface of water, the individual particles of water oscillate in a direction at right angles to the direction of propagation of wave figure (a). Similarly, if a heavy rope with one of its ends tied to a hook H in the wall is stretched along the length of the room and is given an upward and downward jerk at the free end A, a wave is seen to travel along the length of the room as shown in figure (b). Every part of rope vibrates up and down while wave train travels along the rope.

(2) Longitudinal Wave : A wave motion in which the particles of the medium vibrate about their mean position along the direction of propagation of the wave is called longitudinal wave motion. For example, sound wave in air (340 m/s) .

When a longitudinal wave travels in a medium then the particles of the medium vibrate back and forth in the same direction in which the wave travels.

At any instant there are points in space where pressure or density is maximum, called as compression and there are points where pressure or density is minimum called as rarefaction. These compressions and rarefactions occur one after the other. From a compression to a rarefaction the pressure or density continually varies from a maximum to a minimum. Figure below shows the propagation of a longitudinal wave in say air.



3.5 PROPAGATION OF SOUND

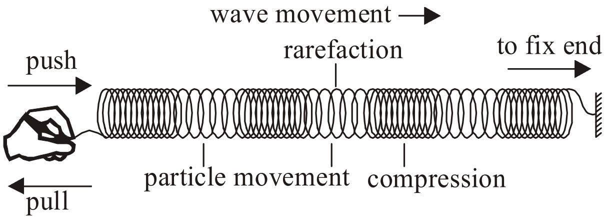
Have you ever thrown pebbles in a pool of water? The impact of pebbles in water creates ripples of waves that spread in the pool.

In a similar fashion, vibrations cause waves in the air. We hear the sound when these waves reach our ears. To understand how this happens, let us take the example of a loudspeaker.

When a loudspeaker is switched on, a membrane in the loudspeaker moves backward and forwards i.e. it vibrates. This causes the air molecules surrounding the loudspeaker to vibrate. If we imagine the air molecules to be like small balls, as a sound wave travels through air it alternatively makes these balls pushed close together and then pulled away from each other.

The area where they lie together are called compressions.

The area where they lie away from each other are called rarefactions.
As the sound wave propagates, the molecules themselves do not move from one point to another, they only vibrate about a mean position. It is the effect that propagates and reaches our ears.



Propagation of sound waves in air

ACTIVITY - 5

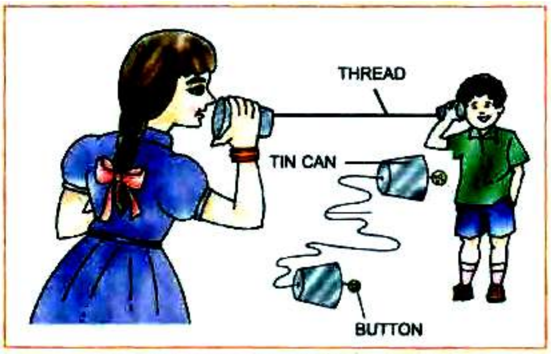
To show that Sound Travels through Solids

(1) Take a wooden stick and table, press your ear at one end of it. Ask a friend to gently knock at the other end (Fig.). You will be able to hear the sound very clearly.
This shows that **sound can travel through solids**.

Sound can travel through solids

ACTIVITY - 6

Make a toy telephone by using two shirt buttons, two empty tin cans and a long thread. Make a hole at the bottom of each tin can, pass the thread through the hole and tie its end to a button as shown in Fig.. Use this telephone to talk to your friends. This activity also proves that sound can travel through cotton thread (solid).



A toy telephone depicting that sound can travel through solids

ACTIVITY - 7

To show that Sound Travels through Liquids

Place a squeaking toy in a polythene bag and hold it in a bucket of water (Fig.). Can you hear its squeak, when you squeeze it? Place your ear against the side of the bucket and squeeze the toy again. Do you hear its squeak? In which case did you hear the sound better?

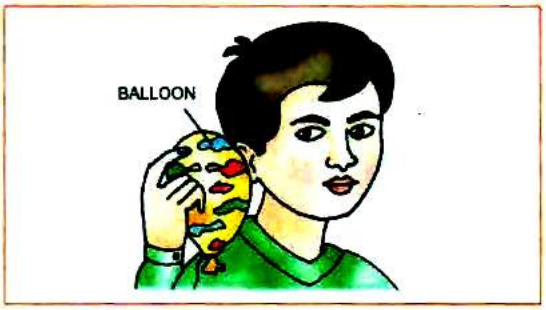
This activity shows that **sound can travel through liquids as well**.

Sound can travel through liquids

ACTIVITY - 8

To show that Sound Travels through Gases

Fill a balloon with air and press it to your ear. Scratch the other end of it with your fingers (Fig.). You will note that the sound reaches your ear. This activity shows that **sound can also travel through gases**.

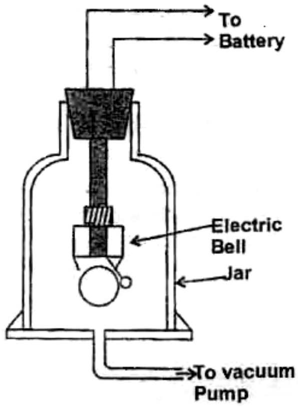


Sound can travel through air (gas)

We, therefore, conclude that sound can travel through gases, liquids and solids. It travels better through solids than liquids and gases.

3.6 SOUND NEEDS A MEDIUM TO TRAVEL

An electrical bell is enclosed inside an inverted bell jar by hanging from the rubber cork. The jar is closed at the bottom by an airtight plate with a hole in the centre A pipe through the hole leads out to a vacuum pump (pump which draws the air out of a vessel).



The bell is connected to a battery through a key.

The bell is started by closing the key. Initially when the jar has normal air inside, sound waves produced by the ringing bell heard outside the jar.

The vacuum pump is started and the air form inside the jar is gradually run out. With decrease air inside the jar, sound heard becomes weaker and weaker. After sometime no sound is heard, but the bell hammer is seen in vibration.

➤ **CONCLUSION :** In the absence of medium (air) around the source, sound is not being propagated.

A natural fact : Moon has no atmosphere. The space above the atmosphere is also vacuum. If some explosion takes place on moon, sound of the explosion will not be propagated to the earth. So the sound waves never reach the earth.

As you know sound waves travel by the compression and rarefaction of air molecules. It requires a material like a solid, liquid or gas to travel through.

Sound waves can travel through solids, liquids and gases, but sound waves cannot travel through vacuum. Why do you think this is so?

This is because sounds travel by producing an oscillation in the molecules of the medium surrounding it.

In vacuum, there are virtually no molecules; hence sound cannot travel in vacuum.

The presence of a medium is absolutely essential for the propagation of sound waves.

3.7 CHARACTERISTICS OF A WAVE

Sound waves can be described by its

(i) Wavelength	(ii) Frequency	(iii) Time period
(iv) Amplitude	(v) Speed	

(i) **Wavelength :** The distance between the two consecutive compression (C) or two consecutive rarefactions (R) or two consecutive crests or troughs, is called the wavelength. Wavelength is the minimum distance in which a sound wave repeat itself.

In other words, it is the combined length of a compression and an adjacent rarefaction. It is represented by a Greek letter **lambda** λ. Its SI unit is meter (m).

(ii) **Frequency :** It tells us how frequently an event occurs. The number of complete waves (or oscillations) produced in one second is called **frequency of the wave**. It is the number of vibrations that occur per second.

The frequency of a wave is fixed and does not change even when it passes through different substances. It denoted by ν (Greek letter. nu). Its SI unit is **hertz** (**symbol, Hz**) named in honour of **Heinrich Rudolf Hertz** who discovered photoelectric effect.

$$\boxed{\begin{array}{c}\text{1 hertz is equal to 1 vibration per second}\\ 1\,\text{kHz} = 1000\,\text{Hz}\end{array}}$$

(iii) **Time period :** The time taken by two consecutive compressions or **rarefactions** to cross a fixed point is called the time period of the wave. In other words, the time required to produce one complete wave (or oscillations) is called time period of the wave. It is denoted by symbol T. Its SI unit is second (s).
The time period of a wave is the reciprocal of its frequency, i.e.,

$$\boxed{T = \frac{1}{\nu}}$$

or $\text{Time period} = \dfrac{1}{\text{Frequency}}$ or $\text{Frequency} = \dfrac{1}{\text{Time period}}$

(iv) **Amplitude :** The maximum displacement of the particles of the medium from their original mean positions on passing a wave through the medium, is called **amplitude of the wave**. It is used to describe the size of the wave. It is usually denoted by the letter A. Its SI unit is **metre (m)**.
The amplitude of a wave is the same as the amplitude of the Vibrating body producing the wave.

(v) **Speed :** The distance travelled by a wave in one second is called **speed of the wave or velocity of the wave**. Under the same physical conditions, the speed of sound remains same for all frequencies. It is represented by letter v. Its SI unit is metre per second (**m/s** or **ms^{-1}**).

➢ RELATIONSHIP BETWEEN SPEED, FREQUENCY AND WAVELENGTH OF A WAVE

$$\boxed{\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}}$$

Suppose distance travelled by a wave is λ (wavelength), in time T, taken the speed is given by

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

We know that, $f = \nu = \dfrac{1}{T}$

Therefore, $v = \lambda \cdot \nu$ or $\boxed{v = \nu\lambda}$

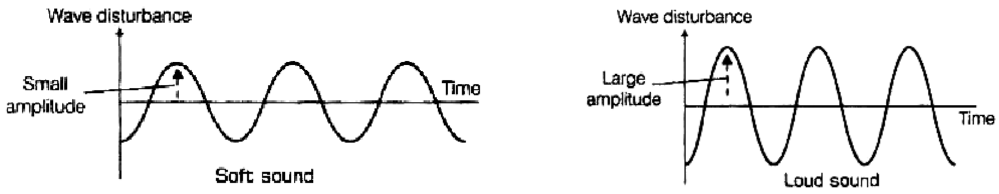
or $\boxed{\text{Speed (velocity)} = \text{Frequency} \times \text{Wavelength}}$

3.8 CHARACTERISTICS OF SOUND

A sound has four characteristics such as loudness, pitch, quality (or timbre) and intensity.

(i) Loudness : It is the measure of the sound energy reaching the ear per second. Greater the sound energy reaching our ears per second, louder the sound will appear to be.

If the sound waves have a small amplitude, then sound will be faint or soft but if waves have a large amplitude, then the sound will be loud. Figure shown below shows the wave shapes of a loud and a soft sound of the same frequency.



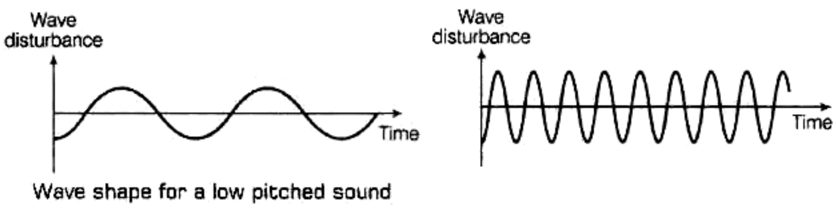
Soft sound has small amplitude and louder sound has large amplitude

Since, the **amplitude** of a sound wave is equal to the amplitude of vibrations of the source producing the sound waves, hence, the loudness of sound depends in the amplitude of vibrations of the source producing the sound waves. Loud sound can travel a larger distance as it is associated with higher energy, sound wave spreads out from its source, as it move away from the source, its amplitude as well as its loudness decreases. The loudness of sound is measured in **decibel** (dB). It depends on the sensitivity or the response of our ears.

(ii) Pitch or Shrillness : It is that characteristic of sound by which we can distinguish between different sounds of the same loudness. Due to this characteristic, we can distinguish, between a man's voice and woman's voice of the same loudness without seeing them.

Pitch of a sound depends on the frequency of vibration. Greater the frequency of a sound, the higher will be its pitch.

In other words, the faster the vibration of the source, the higher is the frequency and hence, higher is the pitch, as shown in figure. Thus, a high pitch sound corresponds to more number of compressions and rarefactions passing a fixed point per unit time.



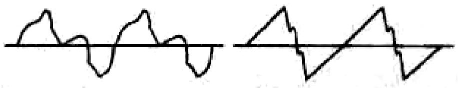
Low pitch sound has low frequency and high pitch of sound has high frequency.

Objects of different sizes and conditions vibrate at different frequencies to produce sounds of different pitches.

(iii) Quality (or Timbre) : The **quality** or **timbre** of sound is that characteristic of sound which enables us to distinguish one sound from another having the same **pitch** and **loudness**. The pleasant sound is said to be of a rich quality.

A sound of single frequency is called a **tone**. The sound produced due to a mixture of several frequencies is called a note and is pleasant in listening too. Noise is unpleasant to ear, music is pleasant to ear and is of rich quality.

The sound produced by different musical instruments like flute, violin, sitar, tanpura, etc. and similarly sound produced by different singer , like Kumar Sanu, Mohammad Rafi, Udit Narayan, etc. an be distinguished from one another on the basis of their quality or timbre.



(a) Shape of sound waves produced by a note played on flute (b) Shape of sound waves when the same note is played on violin

The quality of musical instrument depends on

(a) the shape of the sound wave produced

(b) mixture of frequencies present.

(iv) **Intensity :** The amount of sound energy passing each second through unit area is known as the **intensity of sound**. Loudness and intensity are not the same terms. Loudness is a measure of the response of the ear to the sound. Even when two sounds are of equal intensity, we may hear one as louder than the other, simply because our ear detects it in better way. The S.I. unit of intensity is **watt per square metre (W /m^2).**

3.9 SPEED OF SOUND

Sound waves travel at different speeds in different substances gives the speed of sound in various substances. The speed of sound varies with various factors such as temperature, nature of the material, physical state of the substances, etc. For example, the speed of sound in air is about 330 m/s at 0°C and 346 m/s at room temperature. Notice also from table that sound waves travel fastest in solids and slowest in gases.

Table: Approximate values of speed of sound in different media

Substance	Speed (m/s)
Air	346
Water	1498
Mercury	1452
Glass	5000
Aluminium	5000
Iron	5000
Diamond	12000

3.10 SOUND PRODUCED BY MUSICAL INSTRUMENT

What is music? We find certain sounds pleasant and we associate these sounds with music. Sound that are harsh to the ear are called noise.

In a musical sound, there are a number of frequencies present in a definite ratio or in relation to each other.

Broadly musical instruments are classified into three categories. These are

(i) Stringed instruments (ii) Wind instruments (iii) Percussion instruments

➢ **Sound produced by musical instruments**

There are basically three families of musical instruments.

1. **Stringed Instruments : [Tantu Vadya] :** Stringed instruments have taut strings mounted over specially designed wooden frenal which are partially hollow from inside where air trapped in, forms an air column. The air column increases the intensity of musical sound due to the resonance. When the strings are plucked or struck or played with bow, they vibrate to produce a musical sound of some particular frequency. The pitch of the sound of a musical instrument can be changed by altering its length.

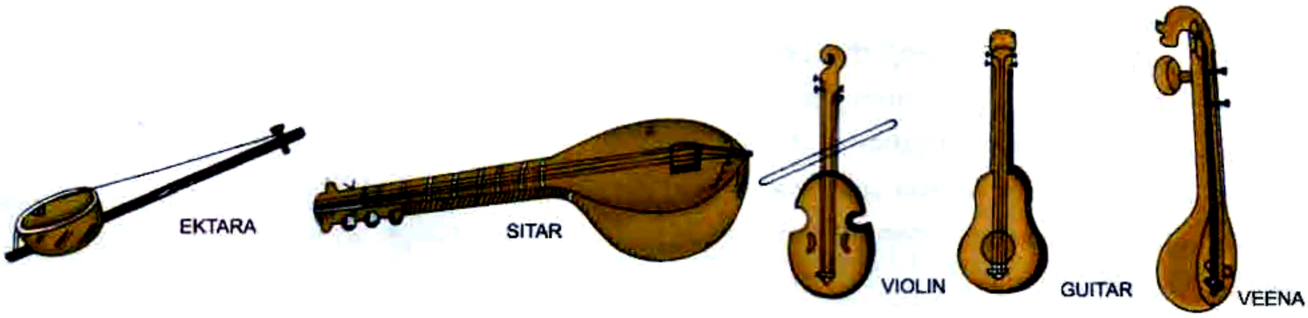


Fig.: Stringed instruments

2. **Wind or Reed Instruments: [Sushir Vad] :** Wind instruments make use of vibrating air columns. In these instruments the air is blown in either directly or through the reeds. Flute, shehnai, bagpipes, bugles are some of the examples of wind instruments.

Fig.: Wind instruments

3. **Percussion or Membrane Instruments: [Avanaddhu Vadya]** All percussion instruments have a taut skin over a hollow metal or wooden frame. When the skin is struck it produces musical sound. Dholak, tabla, mridangam and drums, etc. are some of the examples of percussion instruments.

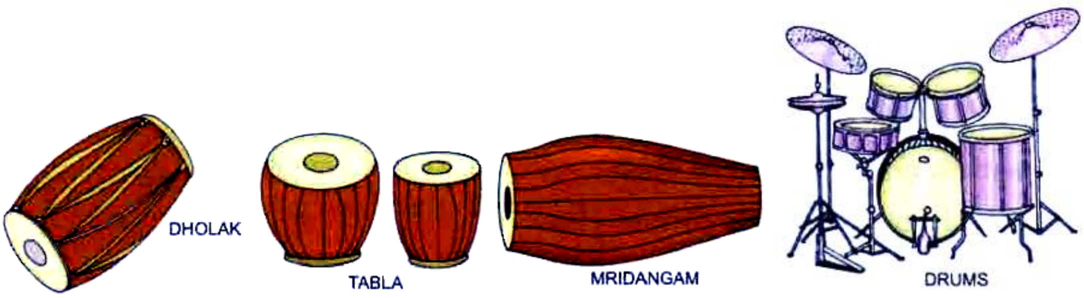


Fig. :Percussion or membrane instruments

There are some other musical instruments which are exclusively used in our country but do not belong to any of the above three kinds of the musical instruments. They can be placed in fourth class of musical instruments.

4. **Ghana Vadya :** These instruments are simply beaten or struck in a rhythm to produce musical sound. Manjira (cynlbals), the ghatam (mud pots), jal tarang are some of the Ghana Vadya. In Jaltarang, the frequency in each cup is adjusted using appropriate amount of water.

Fig.: Ghana vadya

3.11 AUDIBLE AND INAUDIBLE SOUNDS

Infrasound < 20 Hz - 20000 Hz < Ultrasound
Audible range

(a) **Audible Wave :** The human ear is sensitive to sound waves of frequency between 20Hz to 20 kHz. This range is known as audible range and these waves are known as audible waves.
Eg. Waves produced by vibrating sitar, guitar, organ pipes, flutes, shehnai etc.

(b) **Ultrasonic Wave :** A longitudinal wave whose frequency is above the upper limit of audible range i.e. 20 kHz, is called ultrasonic wave. It is generated by very small sources.

(c) **Infrasonic Wave :** A longitudinal elastic wave whose frequency is below the audible range i.e. 20Hz, is called an infrasonic wave. It is generally generated by a large source.
Eg. : Earthquake

3.12 ULTRASOUND

Sound of very high frequency (greater than 20 kHz) is called ultrasound.

(a) **Production :** These are produced by electronic oscillator using high frequency vibrations of quartz crystal.

(b) **Properties :** Sound wave of all frequencies carry energy with them, with increase in frequency. Vibration becomes faster and also energy contents and force increase. When ultrasound travels in solid, liquid and gas it subjects the particles of matter to face large force and energy.

3.13 REFLECTION OF SOUND

When sound waves strike a surface, they return back into the same medium. This phenomenon is called reflection.

The reflection of sound waves is similar to that of light rays. The only difference is that sound waves being larger in length, require bigger surfaces for reflection.

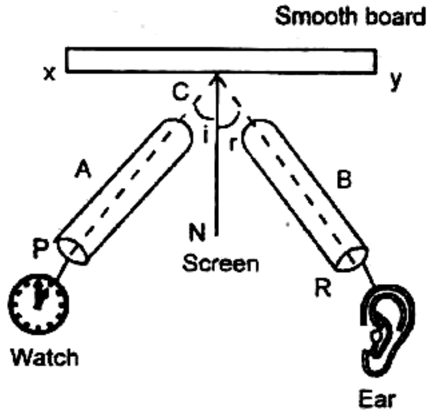
(a) Laws of Reflection :

(i) Angle of incidence is equal to the angle of reflection.

(ii) The incident wave, the reflected wave and the normal, all lie in the same plane.

(b) Verification of Laws of Reflection :

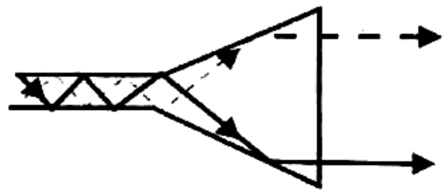
Take a smooth polished large wooden board and mount it vertically on the table. At right angle to the board, fix a wooden screen. On each side of the screen, place a long, narrow and highly polished tube (inside). Place a clock at the end of the tube A. Move the tube B slightly from left to right, till a distinct tick of clock is heard. Measure the ∠PCN and ∠RCN between tubes and wooden screen. It is found ∠PCN = ∠RCN. This experiment illustrates the laws of reflection.



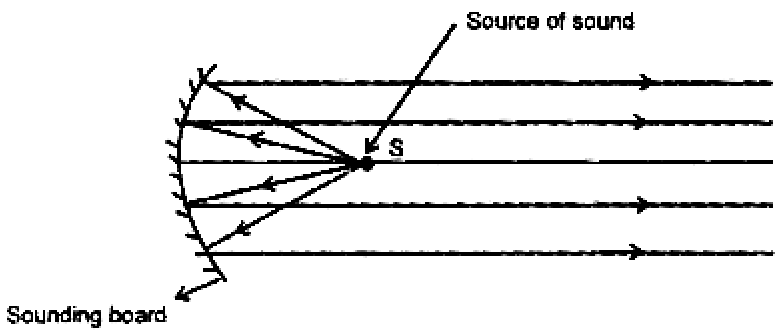
(c) Applications of Reflection of Sound :

(i) Mega phone or speaking tube : When we have to call someone at a far off distance (say 100m), we cup our hands and call the person with maximum sound we can produce. The hands prevent the sound energy from spreading in all directions. In the same way, the people use horn shaped metal tubes, commonly called megaphones.

The loud speakers have horn shaped openings. In all these devices, the sound energy is prevented from spreading out by successive reflections from the horn shaped tubes.



(ii) Sound board : The sound waves obey the laws of reflection on the plane as well as curved reflecting surfaces. In order to spread sound evenly in big halls or auditoriums, the speaker (**S**) is fixed at the principal focus of the concave reflector. This concave reflector is commonly called sounding board. The sound waves striking the sound board get reflected parallel to the principal axis.



3.14 ECHO

Echo is based on the reflection of sound. An echo is defined as repetition of sound due to reflection. There are a number of tourist places where echo points are marked. If you speak something from there loudly you will hear back your sound after sometime. This is called an echo. At some places, you might listen a number of echos one after the other. This is called as multiple echo. It is not that you will hear an echo at any place. There are certain conditions required for an echo to be heard. Before discussing these conditions we will firstly talk about the term persistence of sound. The impact of any sound heard by us does not vanish immediately. It is due to this that a person can't hear two sounds if the time delay between them is less than the minimum required. It is found by scientists that of the time delay between the sounds is less than 1/10 sec, they are heard as single sound. Thus to hear two sounds as different sounds the time delay must be at least 1/10 sec. This forms the basis of an important condition needed to hear an echo.

3.15 RELATION BETWEEN SPEED OF SOUND, TIME OF HEARING ECHO AND DISTANCE OF REFLECTING BODY

If t is the time at which an echo is heard, d is the distance between the source of sound and the reflecting body and v is the speed of sound. The total distance travelled by the sound is 2d.

Speed of sound, $v = \frac{2d}{t}$

or $d = \frac{vt}{2}$

(a) Calculation of Minimum Distance of Hearing Echo :

d is minimum distance required for hearing an echo when persistence of hearing is $\frac{1}{10}$ second.

The velocity of sound (at room temperature) is 340 m/s.

So, $d = \frac{vt}{2} = \frac{340}{2} \times \frac{1}{10} = \frac{34}{2}$

d = 17 metre (approx).

17 metre is the minimum distance of hearing echo.

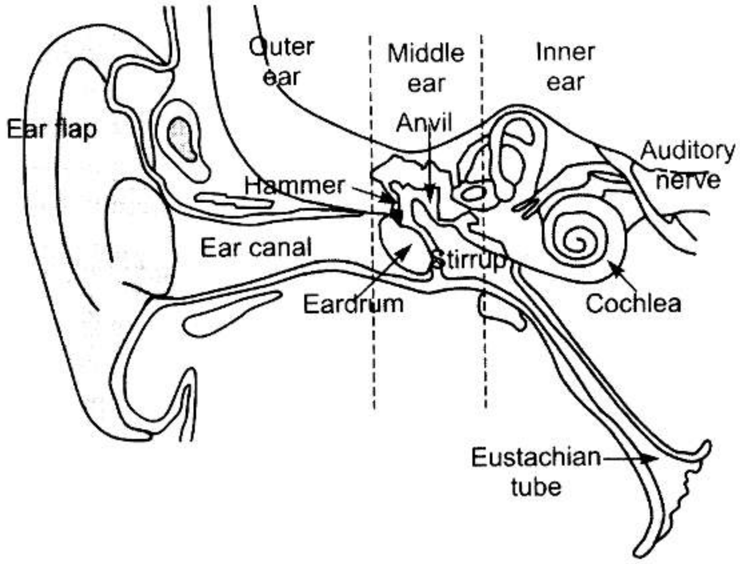
(b) Conditions for Formation of an Echo :

(i) The minimum distance between the source of sound and the reflecting body should be 17 metres.

(ii) The wavelength of the sound should be less than the height of the reflecting body.

(iii) The intensity of sound should be sufficient so that it can be heard after reflection.

3.16 HUMAN EAR



Sound waves from outside reach the eardrum through the auditory canal. Sound waves on striking the eardrum make it vibrate, these vibrations are passed to the oval window. They magnify the force of vibration.
These vibrations affect the auditory nerves which send messages to the brain.
The ear is the organ of the body that detects sound waves. It is divided into three parts - the outer ear, middle ear and inner ear.

- **THE OUTER EAR**
  When sound waves reach the outer ear some directly down the middle of the tube called the auditory canal. At the end of the auditory canal is a thin membrane which stretches across it. This is called the eardrum. When sound waves reach the eardrum they push and pull on it and make it vibrate.

- **THE MIDDLE EAR**
  In the cavity of the middle ear are three bones. They are called the hammer, anvil and stirrup, after their shapes.
  The middle ear also has a tube, the Eustachine tube, which connects to the throat.

- **THE INNER EAR**
  The Inner ear is filled with a fluid. The vibrations of the stirrup set up waves in the fluid. There is a membrane with delicate fibres in the cochlea. Each fibre only vibrates in response to a sound wave with a particular pitch. When a fibre vibrates it stimulates a nerve ending and a nerve impulse or message is sent to the brain where we become aware of the sound.

3.17 MUSIC AND NOISE

Unwanted sound from any source that causes discomfort of any kind is called noise pollution. Noise pollution is undesirable and can cause irritability, loss of concentration, stress, sleep disturbance, and can even damage hearing.
We hear different types of sounds from different sources around us. Some of sounds are pleasant to ear and some are not. A sound which has pleasant sensation on ear is called music. A sound which does not have a pleasant sensation on the ear is called noise. For example, the sound produced by various machines, the sound of too many persons talking simultaneous, the bark of dog, the sound of supersonic aircraft etc. are not pleasant to ears.

3.17.1 Noise Pollution

the disturbance produced in the environment by undesirable, loud and harsh sound from various sources is called noise pollution.

Noise pollution is recent phenomenon of twentieth century. Increasing dependence of man on various kinds of machines at home or workplace of factories etc. has contributed a lot of noise pollution.

Noise pollution at a particular place is determined by the following factors :

1. Loudness of the sound.
2. Duration of noise at a particular place.

3.17.2 Harmful Effects of Noise Pollution

The harmful effects of noise pollution are as follows :

1. Noise in the surroundings interfere with speech and talk with another person.
2. A long exposure to noise pollution may result in the loss of hearing of deafness.
3. Noise pollution reduces concentration and results in the loss of work efficiency.
4. Noise causes anger, tension and interferes with the sleep pattern of individuals.
5. Noise produces headaches, irritability and nervous tension.
6. Noise can cause loss of night vision as well as colour blindness.

3.17.3 Prevention and Control of Noise

In the modern society, we cannot eliminate noise, but can lower down its level to bearable limits by taking following measures :

1. Machines should be designed in such a way that they produce minimum noise.
2. All automobiles, electric generators, etc. should be provided with improved and modified silencers.
3. Heavy vehicles should not be allowed in residential areas.
4. Use of loudspeakers for various social or religious functions should be banned.
5. Factories should be relocated far away from the residential areas.
6. At homes, the television, the radio , the power music system should be played at lower volume.

3.17.4 Measures to reduce noise pollution

Minimizing noise pollution requires a certain degree of discipline on the part of all of us. The following are some of the measures one should adopt to keep noise pollution under control.

(i) The use of loudspeakers at functions, etc. should be stopped.

(ii) People living in flats (and houses close to each other) should not talk too loudly or play the TV/ music too loudly so don't get disturbed the neighbours.

Figure: Noise Pollution

(iii) People working in factories etc. where they are subjected to constant loud noise of machinery should take special precautions to protect their ears.

(iv) Traffic noise could be reduced to a great extent by instilling traffic discipline among bus and automobile drivers.

(v) Cars and other vehicles should not play loud music while driving. This can disturb the concentration of other drivers and also disturb the residents of the neighbourhood.

Illustration 2

State the factor that determines (i) pitch, (ii) loudness, (iii) timbre or quality

Solution

(i) Frequency of sound wave determines the pitch of sound.

(ii) Amplitude of the vibrating body determines the loudness of the sound.

(iii) The wave form produced by a vibrating body determines the timbre or quality of sound.

Illustration 3

A loud sound can be heard at a large distance but a feeble or soft sound cannot be heard at a large distance. Explain, why?

Solution

Sound is a form of energy which is transferred from one place to another place. As sound energy is directly proportional to the square of the amplitude of a vibrating body, so loud sound has large energy, whereas soft sound has small energy. As the sound travels through a medium, sound with small energy is absorbed after travelling a small distance in the medium. Therefore, loud sound can be heard at a large distance but feeble sound cannot be heard at a large distance.

Illustration 4

A bat can hear sound of frequency 100 kHz. Find the wavelength of the sound wave in air corresponding to this frequency. Given, speed of sound in air = 344 ms^{-1}.

Solution

Here, $\nu = 100\text{ kHz} = 100 \times 10^3\text{ Hz} = 10^5\text{ Hz}$

$V = 344\text{ ms}^{-1}$

Using, $V = \nu\lambda$,

we get $\lambda = \dfrac{V}{\nu} = \dfrac{344\text{ms}^{-1}}{10^5\text{Hz}(\text{s}^{-1})} = 344 \times 10^{-5}\text{ m} = 344 \times 10^{-3}\text{ m} = 3.44 \times 10^{-3}\text{ m}$

Illustration 5

A boy heard a sound of frequency 100 Hz at a distance of 500 m from the source of sound. What is the time period of oscillating particles of the medium?

Solution

Here, $\nu = 100\text{ Hz}$

Using, $T = \dfrac{1}{\nu} = \dfrac{1}{100} = 0.01\text{s}$

Thus, time period = 0.01 s

Illustration 6

The water waves are produced at a frequency of 40 Hz. If the wavelength of these waves is 2.5 cm, calculate the speed of the waves.

Solution

Here, Frequency, $\nu = 40$ Hz (or s^{-1})
Wavelength, $\lambda = 2.5$ cm $= 0.025$ m
Using, $V = \nu\lambda$, we get
$V = 40\ s^{-1} \times 0.025\ m = 1\ ms^{-1}$

LET US RECAPITULATE

- Sound is produced by rapid 'to and fro' movements, called vibrations. tuning fork is an instrument used to do experiment with sound vibrations.
- Sound requires a medium to travel through. Sound cannot travel through vacuum.
- Sound is propagated as waves.
- Sound travels in all directions.
- The distance to which an oscillating object moves from its central position is called amplitude.
- The time taken by an object for one complete oscillation or vibration is called the time period of that object.
- Sound is characterised by pitch and loudness.
- The pitch of the sound depends upon the frequency of the vibrating body.
- Shrillness of the sound is known as its pitch.
- Higher frequency sounds are called ultrasounds.
- Low frequency sound which we cannot hear are called infrasounds.
- We can hear sound frequencies between 20 and 20,000 vibrations per second.
- Unwanted and unpleasant sound is called noise. Excess noise in our environment is called noise pollution.