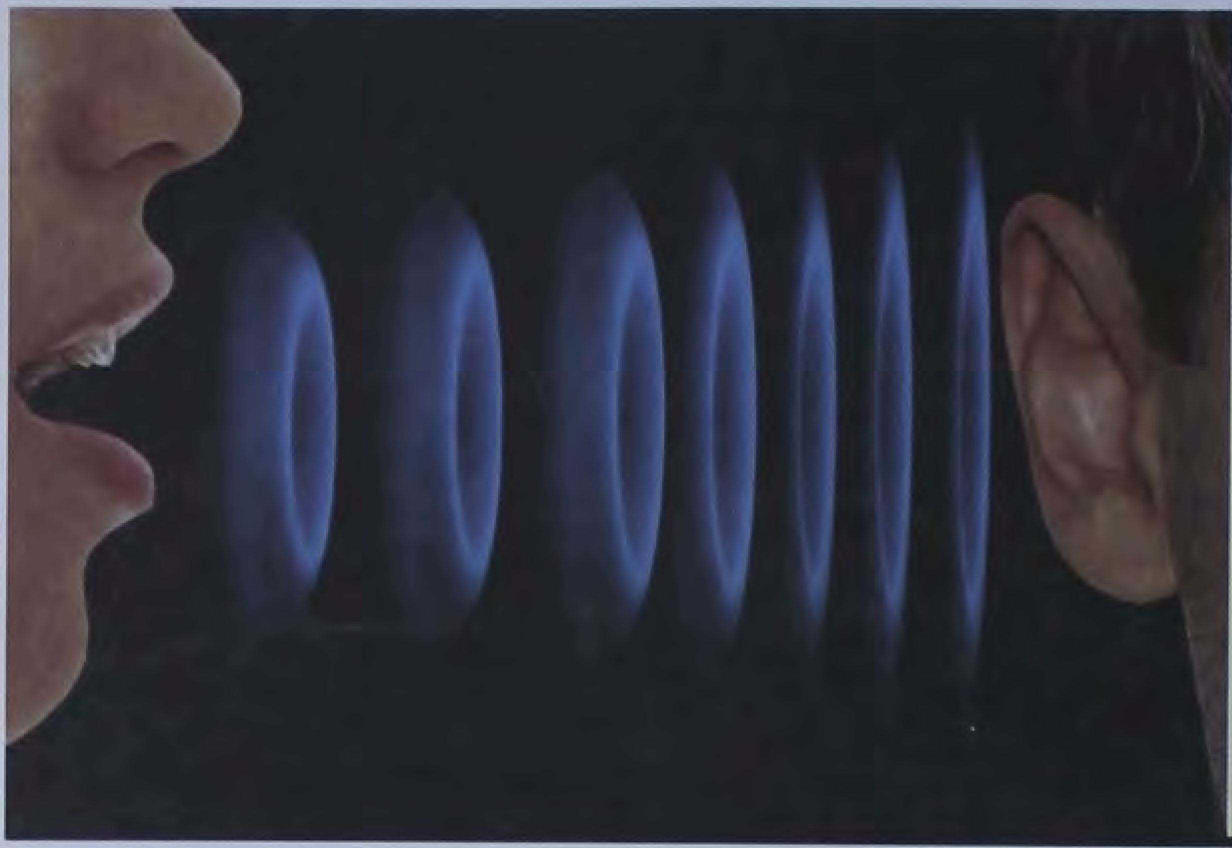


3 Sound

SYLLABUS

1. Sound is caused by vibrations — sources of sound : the human voice, names of common musical instruments – identifying which part vibrated to produce sound.
2. (a) Distinguishing between loud/soft sound; high/low pitch; musical sounds/noise.
   (b) Differentiating between loudness and pitch.
   (c) Defining amplitude, frequency.
3. Every sound has the following three properties;
   (a) Loudness — dependent on the amplitude of the vibrations.
   (b) Pitch — dependent on the frequency of the vibrations.
   (c) Quality — dependent on which part of an instrument is vibrating.
4. Sound needs a medium for propagation — travels faster through solids than through liquids/gases – applications : sonar apparatus, echoes – speed of sound in air.
5. Decibel — some samples of decibel levels – noise pollution – causes and steps to reduce it – sound insulation is useful in some spaces (e.g. recording studios).
   • Making improvised musical instruments and finding how to vary the pitch, loudness and quality of the notes (E).

WHAT IS SOUND ?

In our daily life, we hear different types of sounds like the ringing of a school bell, the sound from a clock, the honking of vehicles, the sound of playing a guitar or tabla, etc. Different people have different types of voice. Similarly, animals also produce different types of sound.

Sound is a form of energy that produces the sensation of hearing in our ears.

SOUND DEPENDS ON VIBRATIONS

Sound is a form of energy carried by waves of vibrating particles. These waves can travel through solids, liquids and gases but they cannot travel through vacuum because there are no particles present to vibrate. Thus, **vibration of a particle is the necessary condition to produce sound.**

A rapid back and forth motion of a particle about its mean position is known as vibration. When we speak, our vocal cord is under vibration. When a bell is struck, the bell is under vibration. Similarly, when a guitar is played, its strings are disturbed and they produce vibrations in the instrument.

How is sound produced

ACTIVITY 1

Take a hack-saw blade and fix its one end on a table or desk as shown in the figure. Bend the other end of the blade and release it. What do you observe? Does the blade vibrate ? Do you hear any sound ?

You will see that the blade is vibrating. You will also hear a sound, provided the blade vibrates very fast.

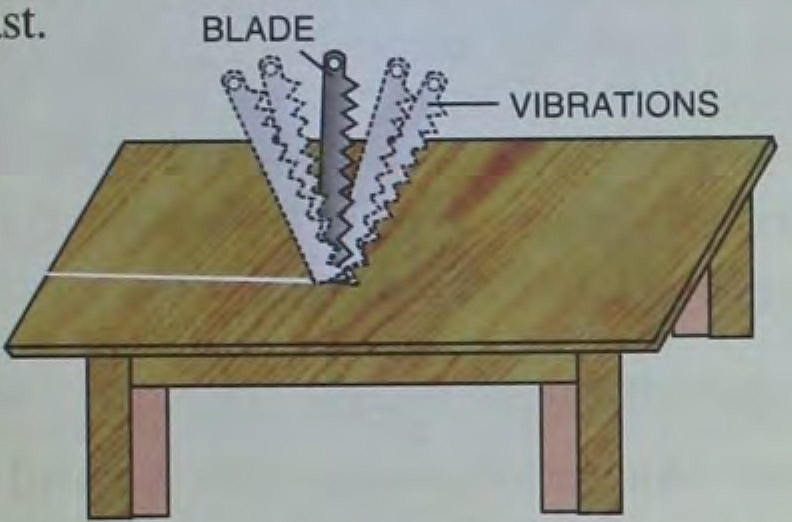


Fig. 3.1 Vibrations produced by a blade

ACTIVITY 2

Take a rubber string. Hold its one end between your teeth and the other end in your hand and stretch it. Pull the rubber string with the other hand and release it. What happens to the rubber string ?

You will see that the rubber string vibrates and as long as it vibrates, a sound is produced.

Fig. 3.2 Vibrations in a stretched rubber string produces sound

ACTIVITY 3

Take a tuning fork. It is a U-shaped metallic piece with a stem in the middle. Its arms are known as prongs. They are set into vibrations when any one of the prong is struck. Hit the tuning fork hard against a rubber pad. Bring it close to your ear. You will hear a sound. When these vibrations stop, the sound stops as well. Normally vibrations of the prongs are not visible because the vibrations are very fast. But if you touch it with the surface of water, you will notice ripples.

Now suspend a table tennis ball with the help of a thread and tie the other end to a stand. Strike the tuning fork with a rubber pad and bring it just in contact with the suspended ball. You will observe that on touching the prong the ball starts moving. The ball will start moving to and fro (oscillating). It shows that the prongs of the tuning fork are vibrating which set the ball in motion.

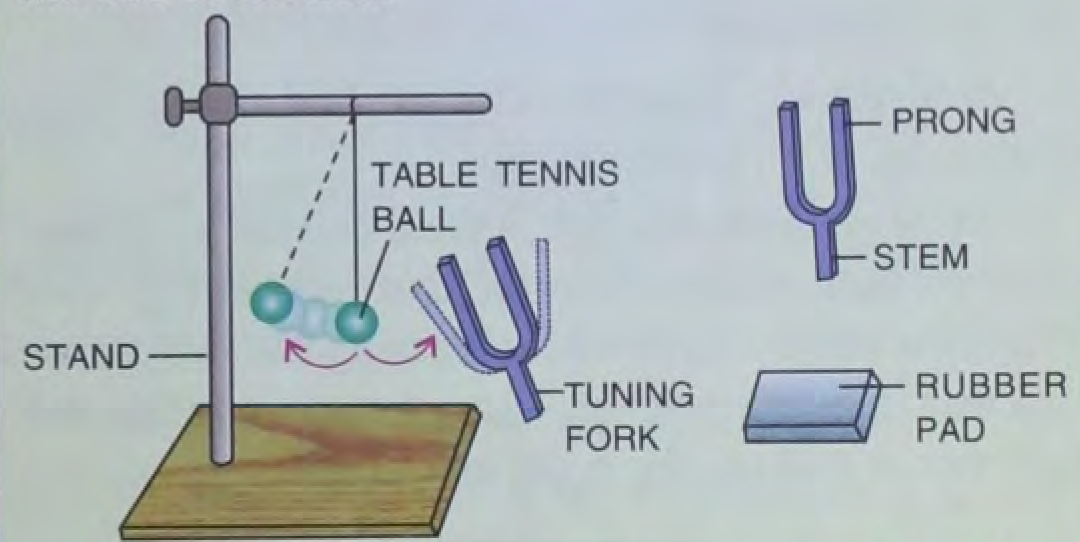


Fig. 3.3 Tuning fork produces sound due to vibrations produced by it

From the above observations, it is concluded that the source of sound essentially produces vibrations.

SOUND REQUIRES A MEDIUM TO PROPAGATE

Some forms of energies require a medium to travel. Sound is one of them. When you provide energy, such as mechanical energy, heat energy, or electrical energy, to any kind of matter, the molecules start vibrating about their mean positions transferring the energy from neighbour to neighbour. This constitutes a wave. A wave is a disturbance that carries energy without carrying the material with it. *For example*, when you beat a drum or a tabla, their membranes start vibrating and constitute sound waves. These sound waves carry sound energy and travel in the air just like ripples in the water.

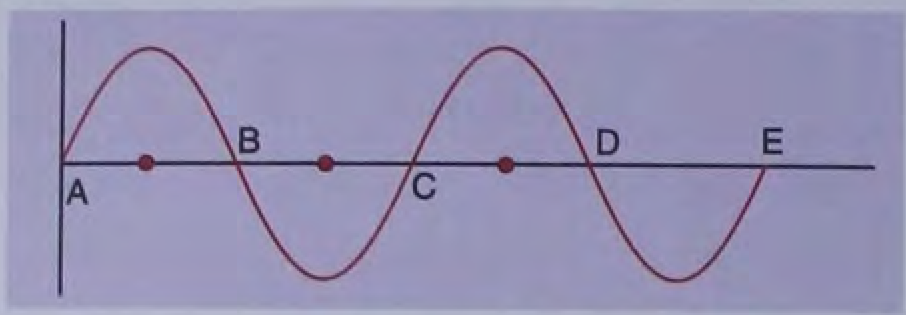


Fig. 3.4 A wave

ACTIVITY 4

To show that sound requires a medium to propagate.

Materials required : An electric bell, a big glass jar, vacuum pump.

Procedure : Hang an electric bell inside a jar connected to a vacuum pump.

Arrange an electric bell, a glass bell jar, a vacuum pump, a battery and a switch as shown in Fig. 3.5. When the circuit is closed by pressing the switch, we can hear the bell ringing. Also, we can see that the hammer is striking the gong of the bell.

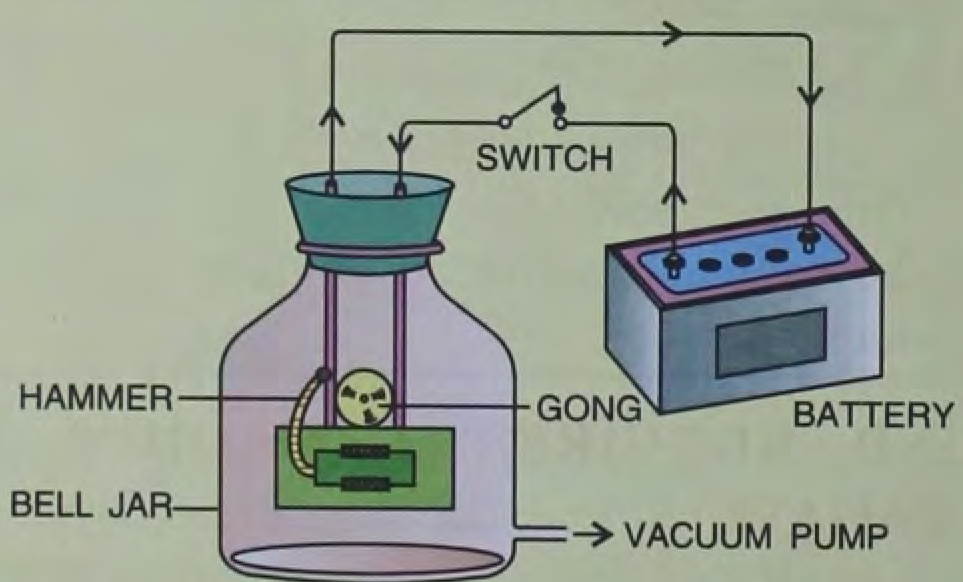


Fig. 3.5 Sound requires a medium to travel

Now remove the air present inside the jar with the help of a vacuum pump. We observe that as the air is taken out, the loudness of the sound gradually decreases and a stage comes when no sound is heard although we can see the hammer striking the gong of the bell. This will happen when the air is completely removed from the jar.

Can sound travel through vacuum ? **No.**

Conclusion : This experiment proves that sound cannot travel through vacuum because a medium is necessary for sound to travel.

Do You Know ?

The reactions carried out inside the sun due to which we get heat and light energy also produce a very large amount of sound. It fails to reach the surface of the earth as there is vacuum in-between the sun and the earth, up to a certain distance. This prevents the sound from reaching the earth as sound cannot travel through vacuum. Life would have been impossible if sound inside the sun had reached the surface of the earth.

SOUND CAN PROPAGATE THROUGH SOLIDS, LIQUIDS AND GASES

Propagation of sound through solids.

You can easily hear the sound of an approaching train by putting your ear on the track well before you could hear its sound in the air. Why ? This is because sound travels much faster through steel or iron (a solid) than through the air (a gas).

ACTIVITY 5

Place a clock on one end of a table and bring your ear close to that end (or near the clock), Fig. 3.6(a).

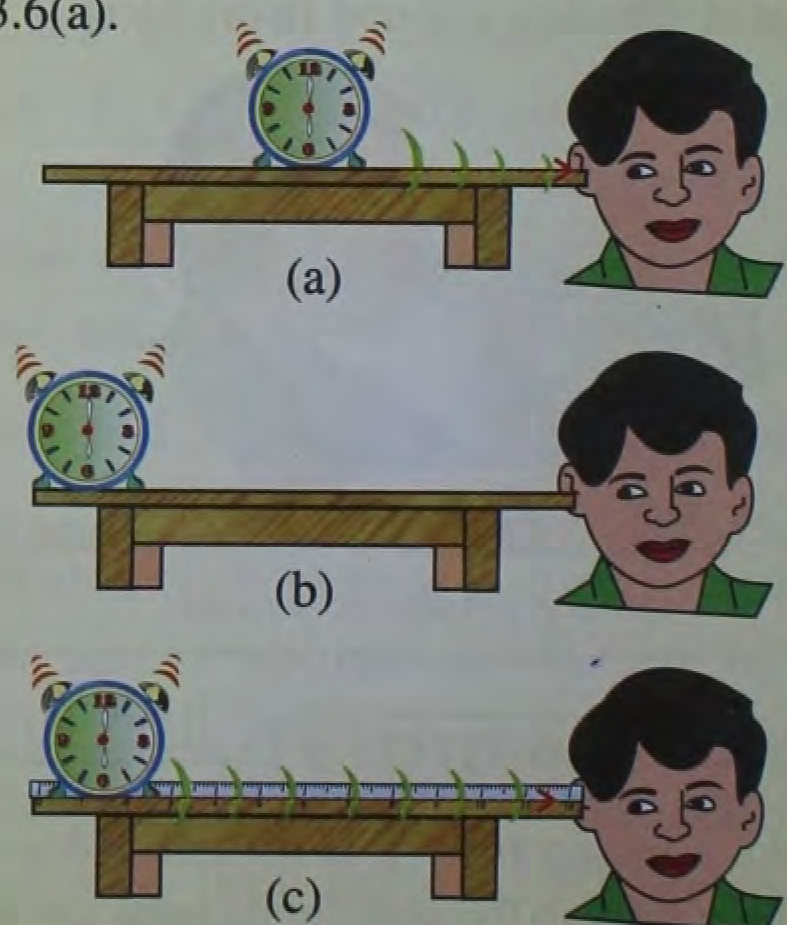


Fig. 3.6 Sound can travel through solids

Slowly move the clock away from yourself, till you stop hearing the sound of the clock Fig. 3.6(b). Now place one end of a ruler or a metal rod below the clock and the other end very close to your ear, as shown in Fig. 3.6(c). You will again be able to hear the sound of the clock.

Propagation of sound through liquids

ACTIVITY 6

To show that sound can travel through liquids.

Meterials required : A balloon and a watch.

Procedure : Fill a balloon with water as shown in Fig. 3.7. Hold it near your ear. Now keep the watch gently to the other side of the balloon. Do you hear the sound ? Yes!

Conclusion : Sound can travel through liquid.

Fig. 3.7 Sound can travel through liquids

Propagation of sound through air

Let us take the case of a vibrating tuning fork. The particles of the surrounding medium *i.e.* air, are pushed against the particles next to them and come back again. Hence, pushing is carried on from particle to particle till it reaches the observer's ear. Fig. 3.8(a) shows the steady or mean position of the metal strip and normal condition of air layers near the strip. When the prong of the vibrating tuning fork moves to the right as shown in Fig. 3.8(b), it compresses the air particles resulting in the formation of **compression,** shown as C. Similarly, when the prong of the tuning fork moves towards left as shown in Fig. 3.8(c), the air particles are separated again forming **rarefaction** shown as R in

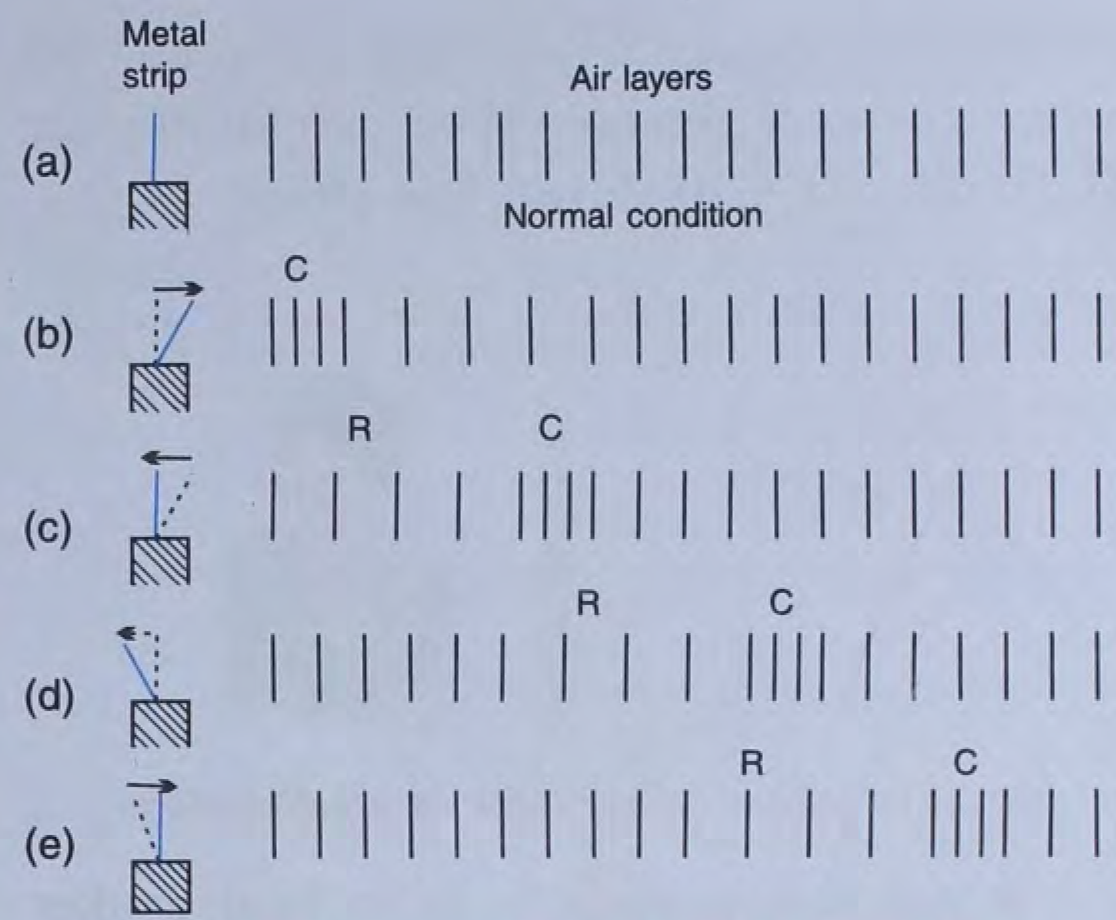


Fig. 3.8 Propagation of sound through air

Fig. 3.8(d). Therefore, sound propagates in air or gases through alternate compressions and rarefactions. Now when the strip returns to its mean position, the rarefaction R moves forward and the air layers near the strip come back to their normal position Fig. 3.8(e).

ACTIVITY 7

Take two metal rods and strike them against each other. Then immerse the rods into a vessel containing water as shown in the figure. Strike the rods against each other inside the water. Which sound is louder ? What do you conclude from this experiment ?

We hear the sound louder through liquids than the sound through air.

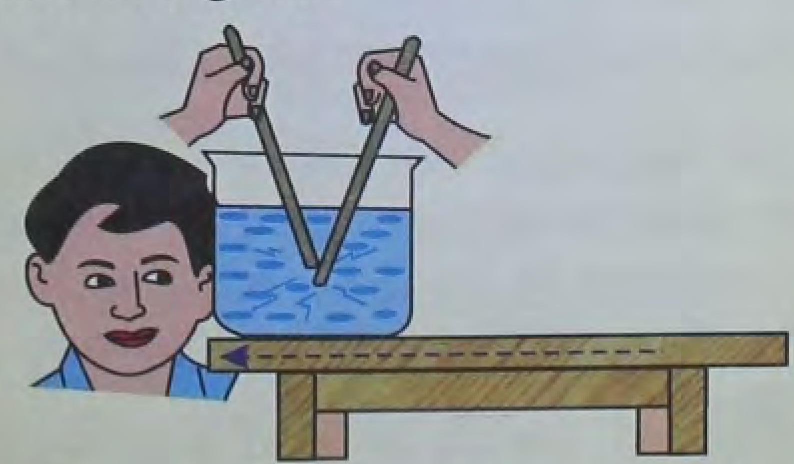


Fig. 3.9 Sound travels better in liquids than in air

Sound Propagates in all Directions

Sound is a kind of energy which propagates in all directions. *For example*, when your school bell rings, you hear the sound no matter wherever you are in the campus of your school. Figure 3.10 shows this effect.

Fig. 3.10 Sound propagates in all directions

When the diaphragm of a loudspeaker vibrates due to music or speech, the vibrations move the molecules of air surrounding it. These air molecules vibrate about their mean positions. Because air particles are all around us, the waves of sound travel outward in all directions.

Hence, we say that sound propagates in all possible directions through a medium.

SPEED OF SOUND

Sound travels faster if the medium through which it is travelling becomes denser. Sound travels fastest through solids, little slower through liquids and comparatively much slower through gases or air.

ACTIVITY 8

Take a long metal rod. Keep it on a flat surface such as a table. Bring your ear close to one end of the rod as shown in Fig. 3.11. Ask your friend to strike the other end of the rod by a hammer.

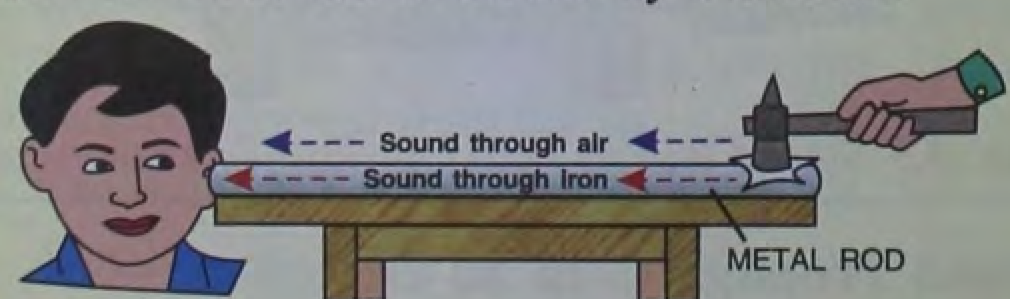


Fig. 3.11 Sound travels faster through a solid medium than through air

What do you observe from this activity ?

We hear the sound two times. First, through metal rod and second time, through the air.

We conclude that sound travels faster through the solid.

Sound travels through the air at a speed of 332 m/s, through water, it travels at a speed of 1440 m/s and through iron, it travels at a speed of 5000 m/s.

$$\text{Speed of sound} = \frac{\text{Distance travelled by the sound}}{\text{Time taken}}$$

Example : A gun is fired in the air at a distance of 660 m from a person. He hears the sound of the gun after 2 seconds. What is the speed of sound ?

Solution :

Distance travelled by sound = 660 m

Time taken by the sound = 2 seconds

Speed of sound in air = ?

$$\text{So, speed of sound} = \frac{\text{Distance travelled by the sound}}{\text{Time taken by the sound}}$$

$$\text{Speed of sound} = \frac{660\text{ m}}{2\text{ s}} = 330\text{ m/s}$$

Thus, the speed of sound in air is 330 m/s.

TYPES OF SOUND

Sound is classified into two groups – music and noise.

Musical sound : Musical sound is produced by periodic vibrations. It has a regular wave pattern. Musical sound is pleasant to hear and is produced by instruments like the sitar, violin, drum, guitar, piano, *etc*. Human voice is also considered as a musical sound.

Noise : It is produced by non-periodic vibrations. It has irregular wave patterns. Noise is unpleasant to hear and is generally produced in a factory or by moving vehicles like a bus, train, *etc*.

Table 3.1 Differences between noise and music

Noise	Music
1. Noise is produced by irregular vibrations.	Music is produced by regular and periodic vibrations.
2. Noise is very irritating to the ears.	Music is pleasant to the ears.
3. Same type of noise cannot be reproduced.	Same type of music can be reproduced.
4. Noise has intensity level more than 120 decibel.	Music has intensity level less than 60 decibel.

A musical sound differs from noise in the following ways

Parameter	Noise	Musical sound
1. Waveform	Irregular	Regular
2. Nature of vibration	Irregular and non-periodic	Regular and periodic
3. Effect in ear and mind of a person.	Displeasing and discordant	Pleasant and comfortable

ACTIVITY 9

Take a tuning fork and bang one of its prong against a hard rubber block. What do you observe ? The prong is vibrating. Do you hear any sound ?

Yes, the tuning fork produces sound.

Touch the vibrating prong with the surface of water taken in a China dish.

What do you see ?

Waves are produced on the surface of water.

SOURCES OF SOUND

1. Tuning Fork

Tuning fork is a U-shaped metallic piece with a stem in the middle. Its arms are known as prongs. They are set into vibrations when any one of the prongs is struck. Generally, tuning forks are made of frequencies which correspond to musical notes. Different tuning forks may have different frequencies. When struck with a rubber pad, a tuning fork vibrates with its own (natural) frequency. The value of frequency produced by the tuning fork is marked on the body of the tuning fork.

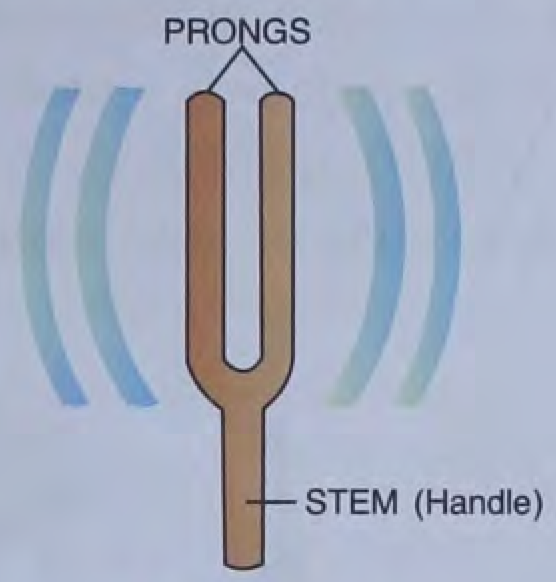


Fig. 3.12 Tuning fork

2. Musical Instruments

There are several types of musical instruments which produce sound. *For example*, stringed instruments, percussion instruments, wind instruments, *etc*. All types of instruments produce sound, but in a different manner.

Stringed Instruments

Some of the stringed instruments are violin, sitar, sarangi, guitar, *etc*. These instruments have two parts, the string which when disturbed vibrates and produce sound and the other part is the body of the instrument with a hollow box which enhances this sound.

There are many ways to vibrate the string of the instrument to produce sound. Sitar and guitar strings are plucked, piano strings are struck while a bow is drawn back and forth across violin string. The strings are attached to some kind of hollow boxes made of different materials. Air inside the hollow boxes is set into vibrations and this helps in enhancing the sound.

In stringed instruments, the pitch (frequency) of the sound can be changed either by changing the length or thickness or tightness of the string.

A shorter length of the vibrating string produces higher pitch (a higher frequency). A tightened string produces vibrations of higher pitch (or high frequencies). A thick string produces vibrations of low frequency.

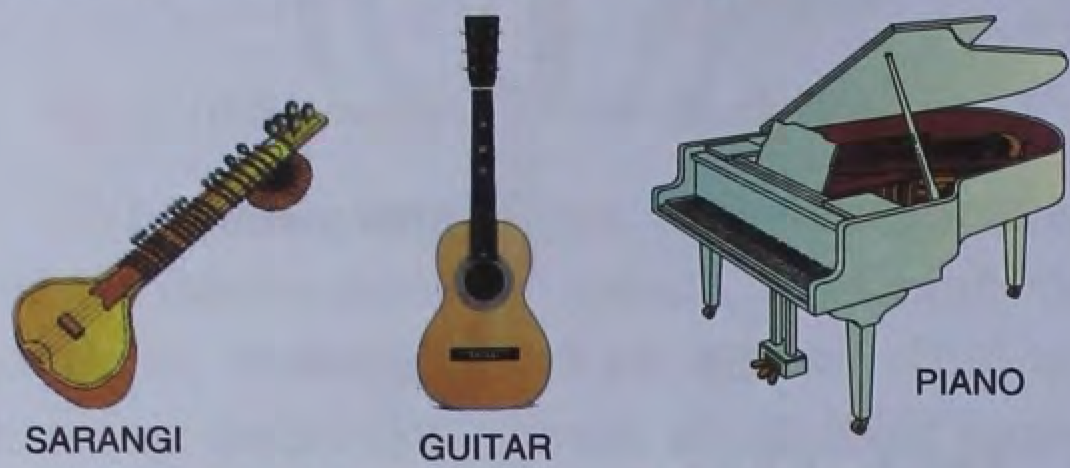


Fig. 3.13 Some stringed instruments

These are also called rhythm instruments or membrane musical instruments.

Percussion Instruments

The drum and the tabla are percussion instruments. Each of these instruments consists of a tightly stretched membrane which is made to vibrate by striking it. The more tight and small is the membrane, higher is the pitch of the note it produces.

Fig. 3.14 Some percussion instruments

Wind Instruments

Wind instruments are generally instruments having a pipelike structure. Some of the wind instruments are flute, trombone, bugle, trumpet, clarinet, shehnai, etc (Fig. 3.15). When you blow

Fig. 3.15

through one end, air inside the instrument vibrates and thus produces a note.

Reed Instruments

The harmonium and the mouth-organ are called reed instruments (Fig. 3.16). These instruments have metal reeds. When air is blown through these instruments the reed inside them vibrates and sound is produced.

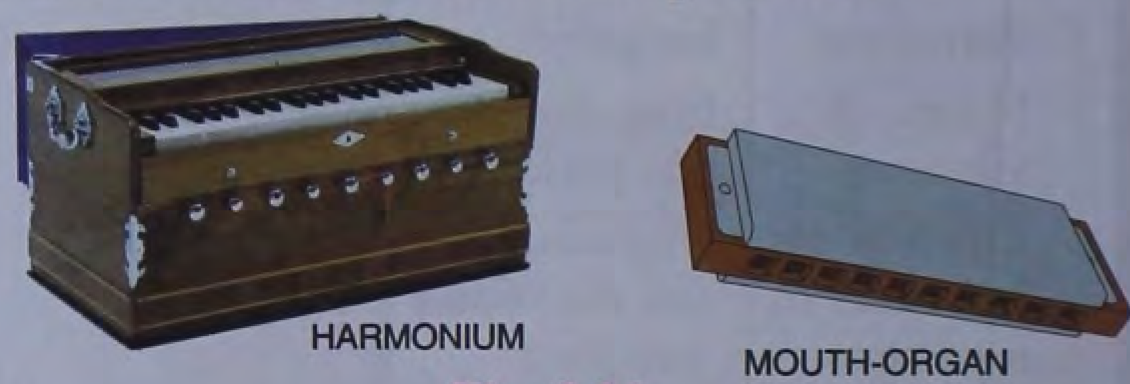


Fig. 3.16

ACTIVITY 10

You may think of making and improvising some instruments of your own, *for example*,

Take seven cups of equal sizes and two sticks. Fill water in each cup at different levels. By adjusting the levels and striking the cups with the sticks, you can get a set pattern of musical sound. This instrument is known as "Jal Tarang". Similarly, think about other instruments you can make.

Conculsion : The pitch of the sound depends upon its frequency of vibration.

3. Human Sound

Have you ever observed the vibrations in the throat while talking ? If not then put your fingers on your throat and try to talk. You will feel the vibrations. Vibrations are produced when air is blown over the vocal cords.

Our throat has a **larynx**. The voice is produced in the larynx. Larynx is also called the *voice box*. It is designed to produce voice. It is a box like structure with walls of tough tissues. Inside two folds of the tissue, there is a gap in-between. They are the **Vocal Cords**. When we breathe, the vocal cords become loose and the gap between them increase. When we talk, shout or sing, the cords become tight and hence they vibrate, thus making sound.

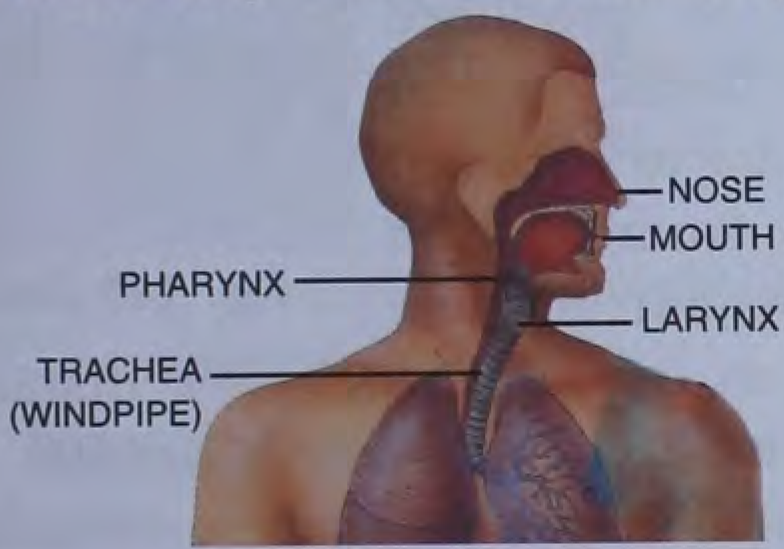


Fig. 3.17 Parts which vibrate to produce sound

ACTIVITY 11

How humans produce sound ?

Hold the fingers of your palm gently against your throat. Recite your favourite poem or try to talk to your friend. Your fingers will feel the vibrations in the throat. How are these vibrations produced ? There are two elastic membranes in the larynx (windpipe), called the vocal cords. When we talk or sing, we blow air over them which causes them to vibrate and sound is produced. Some animals also make sounds with the help of their voice-boxes.

Intext Questions

1. Define sound.
2. What are vibrations ?
3. Write names of some musical instruments.
4. What are vocal cords and where are they located ?
5. In which media (solids, liquids and gases) does the sound travel with the highest and the lowest speeds ?
6. How is frequency of a sound wave related to its time period ?

REFLECTION OF SOUND

Very similar to light, when sound travels through a medium, it gets reflected, refracted or absorbed. To understand the reflection of sound, let us take the following example.

Take a glass container and keep a ticking clock inside as shown in Fig. 3.18. You will not be able to hear the ticking sound very clearly when the container is closed. Now slowly lift the lid from one end. You will notice that when the lid is at a particular angle, the sound is heard most distinctly. Why does this happen ? It happens because, just like light, sound reflects at a certain angle and if the ear is exactly along the same line of reflection, we hear the sound most clearly.

Fig. 3.18 Reflection of sound waves

In a small room, when a person speaks, the sound spreads in all directions.

The listener of the sound hears this sound in two ways (i) directly and (ii) through reflection. Since the speed of sound is very fast, the listener is unable to distinguish the difference between direct sound and the reflected sound. This is so because both the sounds reach the eardrum of the listener almost at the same time.

Two sounds can be heard distinctly if they reach our ear at an interval of at least 0·1 s (or $\frac{1}{10}$ s).

In smaller rooms, the reflected sound reaches us in less than 0·1 second of the original sound heard, so the reflected sound and the original sound cannot be heard separately. But in a big hall, the reflected sound may reach our ear after 0·1 sec from the original sound, so the two sounds can distinctly be heard.

The characteristic property of the human ear due to which it cannot distinguish between the two sounds, if it reaches the ear within 0·1 second is known as **persistence of hearing**. Actually, effect of every sound reaching to our ear remains for 0·1 s. If any other sound reaches to our ear within 0·1 s, the sounds cannot be heard distinctly.

Bats emit high frequency sound signals of short duration called **squeaks**.

If a bat flies near some obstruction such as a flying insect, an echo from the squeaks bounces back to the bat's ears. The bat immediately produces back a huge number of squeaks as many as 200 in a single second. Thus, the time taken by the reflected sound or echo makes the bat aware of the distance, size and shape of the object and also, whether it is stationary or moving nearer or farther away.

GOOD AND BAD REFLECTORS

Sound waves get reflected best from hard, smooth surfaces, *e.g.*, steel, concrete, and other dense materials. Bad reflectors are those which can absorb sound. Materials that absorb sound are generally soft, fluffy, and light, *e.g.*, clothes, paper, carpets, curtains, and furniture. Music recording studios use sound absorbing materials on their walls to eleminate any undesired or outside sounds, during recording. If you use cover for your house with thick curtains, you will be able to block the sound coming from outside.

ECHO

Echo is produced when two distinct sounds are heard due to reflection of sound from a rigid smooth distant surface.

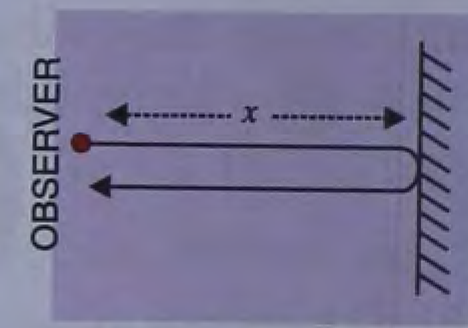


Fig. 3.19 Echo

Now let us see the minimum distance required to hear an echo. Consider an observer producing a sound at a distance x from a rigid surface. The person hears the first sound as soon as it is produced and next when it travels through a total distance of $2x$ *i.e.* $(x + x)$ for approaching the surface and for returning to the observer. Since the standard speed of sound in air is 332 m s^{-1} and to hear the two sounds distinctly *i.e.*, for formation of echo, the minimum time required is 0·1 second. Accordingly,

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{or} \quad \text{distance} = \text{speed} \times \text{time}$$

$$2x = 332\frac{\text{m}}{\cancel{\text{s}}} \times 0{\cdot}1\,\cancel{\text{s}}$$

$$x = \frac{332 \times 0{\cdot}1}{2}\ \text{m}$$

$$x = \frac{33{\cdot}2}{2} = 16{\cdot}6\ \text{m}$$

Therefore, we conclude that to hear a clear echo the minimum distance of reflecting surface required is 16·6 m.

You must have observed that sometimes, the echo is heard a number of times. Such multiple echoes are known as **Reverberations**.

SONAR

Determining the distance of a sound-reflecting surface by producing echo is called echo-sounding. This method is also called Sound Navigation and Ranging (SONAR).

Echo-sounding (or sonar) is used

- for determing the depth of a sea
- by ships to detect submarines
- by bats and dolphins to locate any obstacle in their path.
- for medical diagnosis by ultra-sonography.

Sonar sends out waves towards the bottom of the sea. The reflected sound waves from the sea-bed is received and the time for the sound to reflect back is noted. With this, we determine the depth of the sea.

Fig. 3.20 Sonar

A pulse of ultrasonic wave is sent through water from the sonar. An echo of the same frequency will be received after reflection from the solid objects which the waves meet in their path. Thus, time taken by the sound signal to travel from the ship to the reflecting object and vice-versa is determined. If 'h' is the distance of the object and 't' is the time taken to travel the distance $2h$ then,

speed of sound in sea water, $s = \frac{2h}{t}$

$\therefore$ Distance of the object, $h = \frac{s \times t}{2}$

Knowing s and t, the distance of the object h can be determined.

Example 1 : Sound waves are sent from a ship towards the bottom of a sea. It is found that the time interval between the sending and receiving of the sound is 1·8 second. If the speed of sound in water is 1440 m s^{-1}, find the depth of the sea.

Solution :

Given $s = 1440 \text{ m s}^{-1}$

and $t = 1{\cdot}8$ sec

If the depth of the sea is h m, distance travelled by sound = $2h$ m.

$$\text{Since, speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{distance} = \text{speed} \times \text{time}$$

$$2h = 1440\frac{\text{m}}{\cancel{\text{s}}} \times 1{\cdot}8\,\cancel{\text{s}}$$

$$\therefore \quad h = \frac{1440 \times 1{\cdot}8}{2} \text{ m}$$

$$= 1440 \times 0{\cdot}9 \text{ m} = 1296{\cdot}0 \text{ m}$$

$\therefore$ Depth of the sea is 1296 m.

Example 2 : A boy hears his own echo from a distant hill after one second. The speed of sound in air is 332 m/s. What is the distance of the hill from the boy ?

Solution :

Let x be the distance of the hill from the boy.

Total distance travelled by the sound to move forward and returning back = $2x$.

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{Speed} \times \text{Time} = 2x$$

$$332\frac{m}{s} \times 1\text{ s} = 2x$$

$$x = \frac{332}{2}\text{ m} = \mathbf{166\text{ m}}$$

Example 3 : A ship on the surface of water sends a signal and receives it back after 4 seconds from a submarine inside water. Calculate the distance of submarine from the ship. (Speed of sound in water is 1450 m/s)

Solution :

Let the distance between submarine and ship = x.

∴ Total distance travelled by the sound = $2x$.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Speed} \times \text{Time} = 2x$$

$$1450\frac{m}{s} \times 4\text{ s} = 2x$$

$$x = \frac{1450\times 4}{2}\text{ m}$$

$$= 2900\text{ m} = \mathbf{2{\cdot}9\text{ km}}$$

TERMS RELATED TO WAVE

Sound is energy which travels in the form of waves. A wave, graphically, is represented as follows :

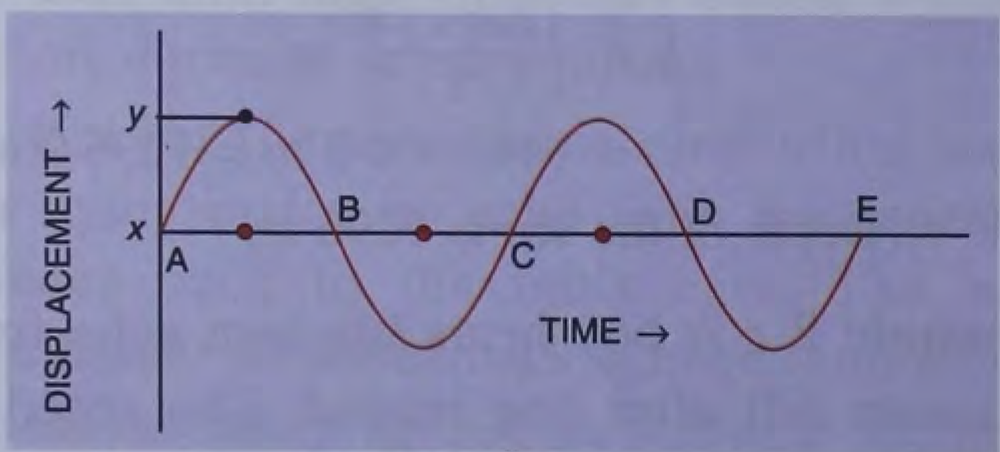


Fig. 3.21 A wave

The terms related to a wave are as follows :

1. **Oscillation :** The to and fro motion which constitutes one full wave is known as one *oscillation*. A wave starting from A and reaching upto C constitutes one oscillation (Fig. 3.21).
2. **Wave length :** The length of a wave corresponding to one oscillation is known as its *wave length*. In Fig. 3.21, AC is the wave length. It is represented by the symbol lambda (λ). It is measured in Å (Angstrom unit).

   $1\text{Å} = 10^{-10}\text{ m} = 10^{-8}\text{ cm}$.
3. **Amplitude (A) :** The maximum displacement of a wave on either side of its mean position is known as the *amplitude*. In Fig. 3.21, *xy* is the amplitude of the wave.
4. **Time period (T) :** The time taken by a wave to complete one oscillation is known as its *time period*. It is always denoted by T and is measured in second.
5. **Frequency :** The number of oscillations made by a wave in one second is known as its *frequency*. It is denoted by f or v. The unit of frequency is *hertz* which is denoted by the symbol *Hz*.

   Note that frequency and time period are related as follows :

$$f\ (\text{or } v) = \frac{1}{T}$$

1 Hz = 1 cycle per second.

Knowledge bank

- For a body oscillating in the air, the amplitude of oscillation gradually decreases due to the air - resistance.
- For small amplitude of oscillations, a pendulum takes equal intervals of time to complete one oscillation.

Audible and Inaudible sound

The human ear can hear the sounds having frequencies between 20 Hz to 20,000 Hz. This is called the audible range. Thus, the audible range of a normal human ear is 20 Hz to 20,000 Hz.

- The sound in the audible range (20 Hz to 20,000 Hz) is called **sonic sound**. An infant (about 1 year old) can hear sounds upto 35,000 Hz. This limit gradually comes down to 20,000 Hz for an adult.
- The sound of frequencies greater than 20,000 Hz is called **ultrasonic sound**.
- The sound of frequencies lower than 20 Hz is called **subsonic or infrasonic sound**.

Less than 20 Hz	20 Hz to 20,000 Hz	Greater than 20,000 Hz
Subsonic sound	Sonic sound	Ultrasonic sound

- Human ear neithor respond to ultrasonic sounds nor to infrasonic sounds.
- Certain animals such as dog, leopard, monkey and deer can hear ultrasonic sounds.
- Certain birds like bat can produce sounds of very high frequency. A bat is able to locate any obstacle or its prey in its path due to reflection of the ultrasonic waves from the object.
- Dolphins use ultrasonic sound to locate their prey.
- Galton whistles, which emit ultrasonic sound inaudible to human ears are used by police to direct the dogs to catch hold of criminals.
- Ultrasonic vibrations are used in dish washers. In these machines water and detergent are vibrated alongwith ultrasonic vibrations. The vibrating detergent particles vibrate against dirty utencils and clean them.
- Ultrasonic vibrations are used for imaging internal organs of human body.
- Ultrasonic vibrations are used for homogenising milk *i.e.* larger particles are broken drown to smaller particles.
- Ultrasonic vibrations are used for relieving pain in joints and musceles.

CHARACTERISTICS OF SOUND

There are three characteristics of sound – loudness, pitch and quality or timbre.

Loudness

The loudness of a sound depends mainly on the amplitude of the sound. The other factors that affect the loudness are distance between the source and the observer, surface area of the vibrating body, atmospheric pressure, humidity, wind velocity, etc. The shorter the distance between the listener and the source, the louder the sound heard by the listener. Higher is the amplitude, louder is the sound. See Fig. 3.22 (a) and (b). Wave B produces louder sound as its amplitude a_2 is greater than the amplitude a_1 of wave A.

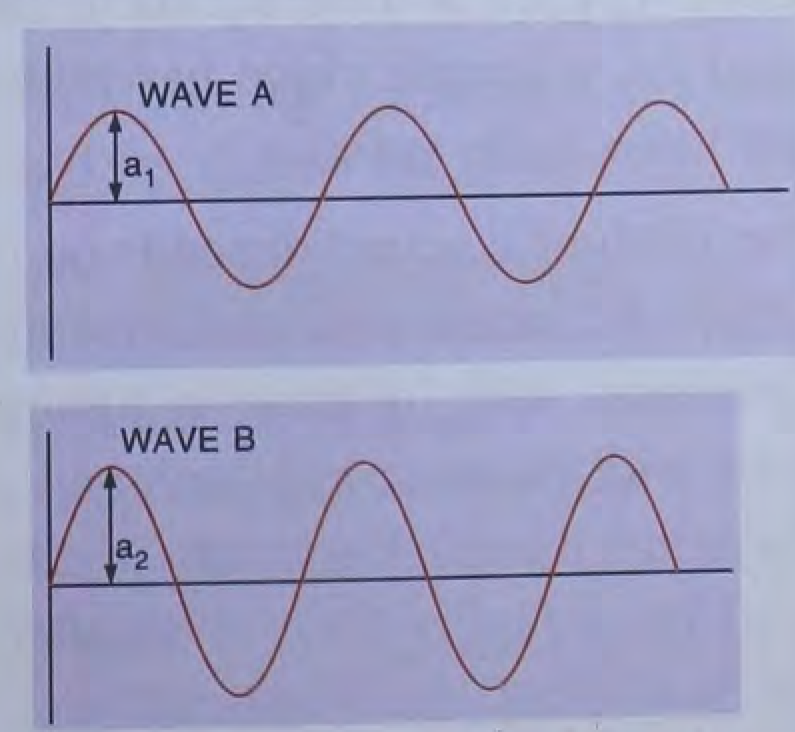


Fig. 3.22 Loudness depends on the amplitude of the sound

ACTIVITY 12

To show that the loudness of sound depends upon the amplitude of vibration.

Material required : A ping-pong ball, a drum and drum stick.

Procedure : Place a ping-pong ball on the membrane of a drum. Beat the membrane gently with a drum stick. What happens ? The ball hops up and down. Now beat the membrane harder with a drum stick. What happens ?

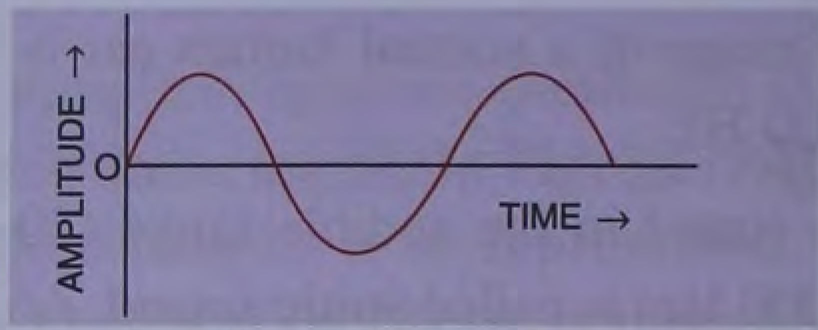
The drum produces louder sound and the ball jumps higher.

Conclusion : This experiment shows that harder you strike the drum, louder is the sound and the ball jumps higher due to the increased amplitude of the vibrations.

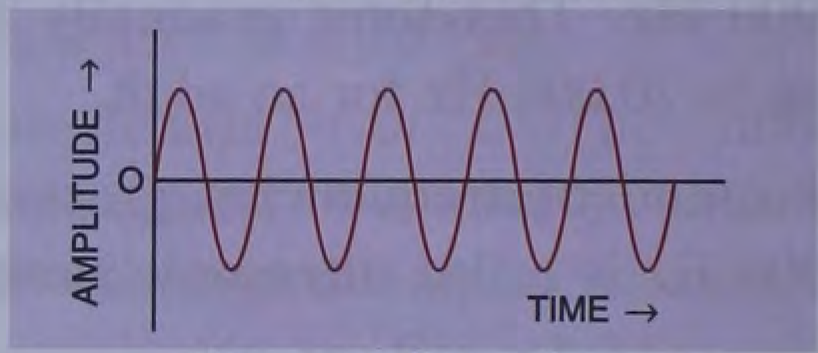
Pitch

It is that characteristic of sound which differentiates an acute or shriller sound from a flatter sound. It depends on the number of vibrations per second. This makes the pitch of a crying baby higher than that of a crying adult. A female voice is shriller, in general from a male voice. **Pitch depends on frequency**. Higher is the frequency, shriller is the sound *i.e.* a female voice has higher pitch compared to a male voice.

The pitch of a sound depends on the size, tightness, and mass of the vibrating body. Pitch increases with increase in tightness and decreases with increase in length and mass of the vibrating object. The pitch of the sound produced by a tuning fork of smaller length will be more than that produced by a tuning fork with larger length.



Wave with lower frequency,
(Low pitch sound)



Wave with higher frequency,
(High pitch sound)

Fig. 3.23 Figure to differentiate pitch of two sound waves.

Quality or Timbre

It is that characteristic property of sound which distinguishes one sound from the other, although both the sounds may have the same frequency and same wavelength. Consider the sound produced by a guitar and a sitar. Both may have the same frequency (*i.e.*, pitch) and the same loudness (*i.e.*, amplitude), but still one can easily distinguish between the two sounds without actually looking at the instruments. It is due to the fact that both the instruments have a different sound effect and to say in the words of physics, a different pattern of waves. No two instruments can have the same wave pattern.

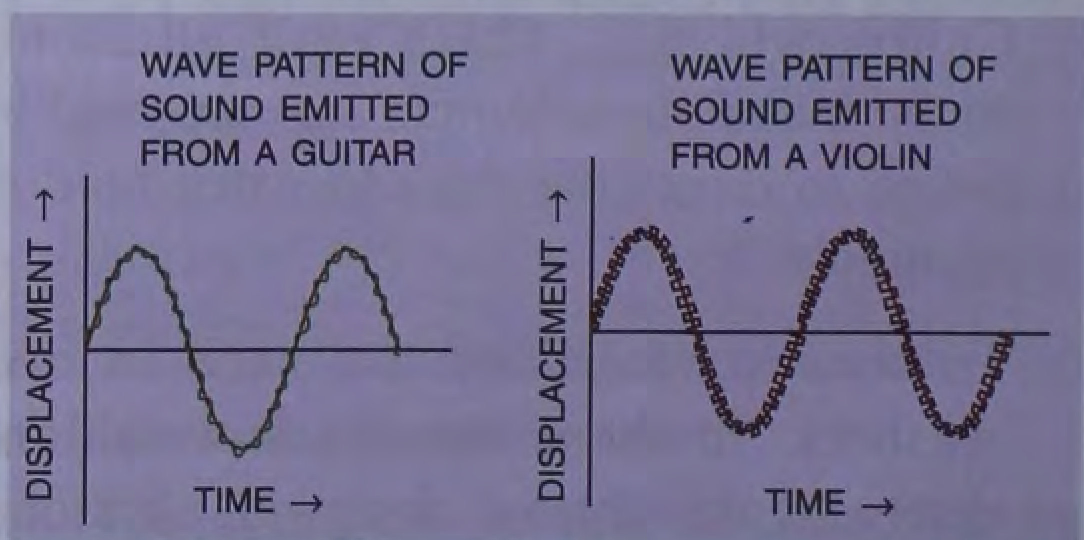


Fig. 3.24 To show the difference in quality

UNIT OF SOUND — DECIBEL

The loudness of sound is measured on a special scale called the *decibel scale*. Note that 1 dB = one-tenth of bel where bel is the unit of loudness level, named after the scientist Alexander Graham Bel, who invented one of the most useful devices viz, telephone.

Different objects have different levels of loudness (in dB). This is presented in the following Table 3.2.

Table 3.2 : Loudness level of different objects

Source of sound	Loudness level (in dB)	Loudness
Rocket at take off	200	Dangerously loud
Aircraft engine	100-200	Painfully loud
Pneumatic drill	100	Very loud
Heavy traffic	90	Very loud
Record player	70	Loud
Ordinary conversation	40-60	Moderate
Quiet home	30	Faint
Whisper	20	Very faint
Rustling of tree leaves	10	Very faint

Noise pollution

Today's world is a much noisier place than before. Fast moving vehicles, ships, trains, aircraft, sound produced by loudspeakers during religious, cultural and political functions, loud music, etc. are responsible for **noise pollution**.

Noise — A health hazard

Loud and harsh sound is called noise. Noise is produced by irregular vibrations.

The disturbance caused by an undesirable and non-periodic loud sound of different kind is called noise pollution.

The hazards of noise pollution are as follows :

1. Constant exposure to high pitch noise increases blood pressure.
2. Sound of 180 dB can cause heart attack.
3. Sudden exposure to high noise level can cause permanent damage to ear.
4. Noisy environment can cause headache and inability to concentrate on work and studies.

Prevention of noise pollution

The noise pollution can be minimised by adopting the following steps :

1. Vehicles should have proper silencers.
2. Use of amplifiers and loudspeakers should be restricted.
3. At noisy places, people should use ear plugs.
4. Cushions and curtains should be used in rooms as they absorb sound.
5. Planting of trees along the roadside help to reduce noise.
6. Soundproof rooms like song studios help to record songs or music, *etc.*, with more clarity.
7. Noise making factories and airports should be shifted far away from the city.

Intext Questions

1. What is the use of sonar ?
2. How can you produce an echo ?
3. What denotes amplitude in the context of sound ?
4. Write *two* differences between noise and music.
5. How can *one* prevent noise pollution ?

6. Which sound has a higher pitch ?
   (a) low frequency sound
   (b) high frequency sound
7. What kind of sound is produced by musical instruments ?

LIGHTNING AND THUNDER

The huge masses of clouds get electrically charged due to rubbing of the clouds with the air and due to the presence of dust, carbon and other charged particles in the air. When the two clouds carrying, opposite charges aproach each other, a large quantity of electric charge flows rapidly from one cloud to the other through the air. When this happens, an intense spark of electricity is seen in the sky.

Such rapid flow of charge through the air between the two oppositely charged clouds is called electric discharge or lighting.

Due to heat produced at the time of lighting, the air gets heated up and expands suddenly. This rapid expansion of air sends a disturbance through the air producing loud sound. This loud sound is heard as thunder.

You must have observed that during a thunderstorm, you see the lightning and then after a moment or two, you hear the thunder. This is because light travels much faster than sound.

TEST YOURSELF

A. Tick the most appropriate answer :

1. Sound travels fastest in
   (a) liquids (b) solids
   (c) gases (d) none of these
2. Fast back and forth motion of a particle is called
   (a) vibration (b) displacement
   (c) friction (d) acceleration
3. Sound cannot travel through
   (a) solids (b) liquid
   (c) vacuum (d) none of these
4. Wavelength is measured in
   (a) kg (b) sec
   (c) litre (d) angstrom
5. The speed of sound in water is
   (a) 332 m/s (b) 1440 m/s
   (c) 5000 m/s (d) 1000 m/s
6. The loudness level (in dB) of sound produced by the rocket during its takeoff is
   (a) 60 (b) 90
   (c) 100 (d) 200
7. Violin is
   (a) string instrument (b) wind instrument
   (c) reed instrument
   (d) percussion instrument
8. The echo of sound produced can be heard only if it reaches our ear after
   (a) 1/25 of a second (b) 1/30 of a second
   (c) 1/5 of a second (d) 1/10 of a second.
9. The characteristic of sound which distinguishes a female voice from a male voice is called
   (a) loudness (b) pitch
   (c) music (d) noise

10. The audible range of frequency is
    (a) 200-2000 Hz
    (b) 20-20,000 Hz
    (c) 20-23,000 Hz
    (d) 220-20,000 Hz

B. Fill in the blanks :

1. Sound can be produced by a body if it ....
2. Sound requires a .... for propagation.
3. Sound travels faster in .... than in liquids.
4. .... is heard by reflected sound.
5. .... produces sensation in ears.
6. The maximum displacement of particles on either side of its mean position is called ....
7. The number of oscillations produced in one second is called ....
8. The unit of frequency is .... or ....
9. The .... or .... is that characteristic which differentiates two sounds of the same pitch and the same loudness.
10. The pitch of a sound depends on ....

C. Write *true* or *false*. Rewrite the false statement correctly.

1. Sound can travel in vacuum.
2. Sound is a form of energy.
3. Sound can be produced by vibrating bodies.
4. Larger is the amplitude, lesser is the sound.
5. The frequency is measured in Hertz.
6. Loudness depends on frequency.
7. Quality of two different stringed instruments can be the same.
8. Female voice is shriller than male voice.
9. A ticking clock sounds less when heard through a metal.
10. Echo can be heard only in the mountains.

D. Match the following :

1.	Vibrations cause	(a)	Measure depth of sea at a place
2.	A shriller sound is	(b)	Second
3.	Unit of frequency	(c)	Sound production
4.	Unit of time period	(d)	A sound of high pitch
5.	Sonar is used for	(e)	Hertz

E. Answer the following :

1. What do you mean by reflection of sound ? Explain with an experiment.
2. Why a female voice is different from a male voice ?
3. Describe an experiment to prove that sound cannot travel in vacuum.
4. A boy stands at a distance of 168 metres from a high wall. He produces a sound and hears the echo after 1 second. Calculate the speed of sound in air. **Ans. 336 m/s**

F. Short Answer Questions

1. Give *two* examples to show that sound is produced due to the vibration of objects.
2. How is sound propagated through air ?
3. Explain the reflection of sound with the help of an example.
4. The time period of a wave is 0·25 sec. Find its frequency. **Ans.** 4 Hz
5. An echo is heard after 3·5 sec from a hill. Find the distance of the hill from the observer. Speed of sound in air is 340 m/sec. **Ans.** 595 m
6. The frequency of sound wave is 500 Hz. Find its time period. **Ans.** 0·002 s

G. Long Answer Questions

1. Explain the factors on which the loudness of sound depends.
2. Which sound travels faster — the roaring sound of a lion or the buzzing sound of a mosquito ? And why ?
3. What is the velocity of sound ?

4. What is an echo ? When is an echo heard ?
5. What is noise ? Describe the effects of noise.
6. With the help of a diagram discuss the terms:
   (a) Amplitude (b) Time period
   (c) Frequency of a sound wave
7. Define the follwoing terms :
   (a) Speed of sound (c) Audible range
   (b) Loudness of sound (d) Noise pollution

H. Tick (✓) the odd-one out giving reason

1. Eardrum, oval window, multiple refraction, auditory nerves.
2. Sound, water, vacuum, steel, air.
3. Amplitude of vibration, quantity of vibrating air, frequency, decible.
4. Hearing loss, high blood pressure, physical pain, noise.

I. Write one word for the following

1. The hard lump on your throat.
2. The waves that can travel through any medium but not through vacuum.
3. The sound of frequencies greater than 20 kHz.
4. The maximum displacement of an oscillating body from its mean position.
5. The quantity that describes the pitch of a sound wave.

RECAPITULATION

- Sound is a form of energy which produces the sensation of hearing.
- Sound cannot travel in vacuum, it requires a medium to travel.
- Sound is produced by a virbating body.
- Sound travels in all directions.
- Noise pollution is a health hazard and leads to mental tension and hence should be controlled.
- Sound travels faster in solids than in liquids or gases. It has the maximum speed in solids, lesser in liquids and the least in gases.
- When the sound gets repeated after reflection from a distant body, it is called echo.
- Multiple echoes are called reverberations.
- SONAR is a method used to measure the depth of a sea and is based on the principle of reflection of ultrasonic wave.
- Sound is classified into two groups called music and noise.
- Music is pleasant to hear and is caused by the periodic vibrations.
- Noise is irritating and is produced by an irregular pattern of waves.
- The three characteristics of sound are loudness, pitch and quality or timbre.
- Loudness depends on many factors such as amplitude, distance, surface area of vibrating body, humidity, pressure, wind velocity, etc.
- Pitch depends on the frequency of sound. Higher is the pitch, shriller is the sound.
- In humans sound is produced by the larynx or voice box present inside the throat.
- Loudness of sound is measured in decible (dB) unit.
- Quality of a sound is also called its timbre.
- A human ear can hear sounds having frequencies between 20 Hz and 20,000 Hz. This range is called audible range.