8 SOUND

Why are the sounds produced by the different strings of a Veena different? And why are fingers pressed and moved over the strings while this instrument is played?

Let's find answers for these questions raised by Ramesh.

You may know of several objects producing sound i.e. sources of sound. List some of them.

- Drum
-
-

How do they produce sound?

Source of sound

Let's try a few activities.

✶ Tap on the edge of a steel tiffin carrier with a metal spoon or some other metal object. Then fill three fourth of the tiffin carrier with water and tap again. What do you observe on the water surface?

✶ Excite a tuning fork and bring it near your ear. Then touch the pinna with one of the prongs of the tuning fork. What do you experience?

From these activities what are your conclusions about the production of sound?

Now let's do another activity. Excite the tuning forks of different frequencies given to you and listen to the sound from them. Note the frequencies marked on each tuning fork.

Fig. 8.1

★ Is the sound produced by all tuning forks identical?

- -

★ What about the frequencies marked on those tuning forks producing different sounds?

- -

Is there any relation between the frequency of a tuning fork and the sound it produces? Discuss the relation between the frequency of vibration of objects and the sound they produce. Reach a conclusion and record it.

Natural frequency

Every vibrating object has its own frequency. This is its natural frequency. This natural frequency does not change if it is allowed to vibrate freely.

Let's find the different factors influencing the frequency of vibration of the string of a Veena.

Stretch the wires mentioned below and fix them on a plank as shown in the figure.

- Steel and copper wires of the same length and thickness.
- A steel wire of greater thickness.
- Another steel wire of the same length and thickness as the first but with a different tension.
- A steel wire of greater thickness but of smaller length.

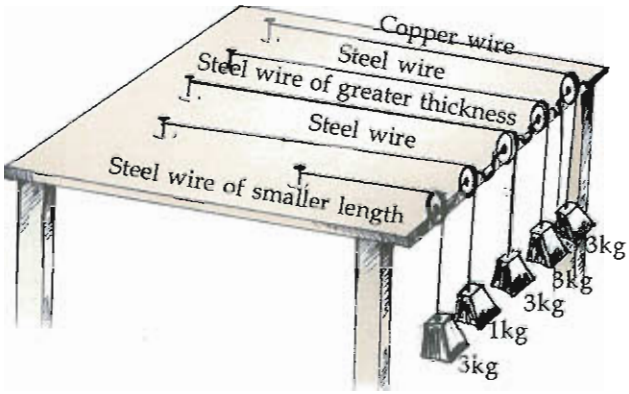


Fig. 8.2

To keep the wires stretched, suspend weights at the free end. Make sure that the wires do not touch the plank.

Now listen carefully to the sounds produced by each wire when they are plucked.

★ Do all the wires produce the same sound? What may be the reasons?

- -

Discuss the possible factors on which the frequency of a wire depends and record your findings.

- The nature of the material of which the wire is made.
-
-

Now can't you answer the questions raised by Ramesh, why fingers are pressed and moved over the wires when a veena is played and why different sounds are produced.

Transmission of sound

Have you ever thought why astronauts in space or on the moon use radios to talk to each other even when they are very close?

Try an activity.

- Take a flask. Tie a bell to a thin rod and fix it to the cork. Now close the flask tight with this cork so that the bell is inside it. Shake the flask gently. Do you hear the sound of the bell?

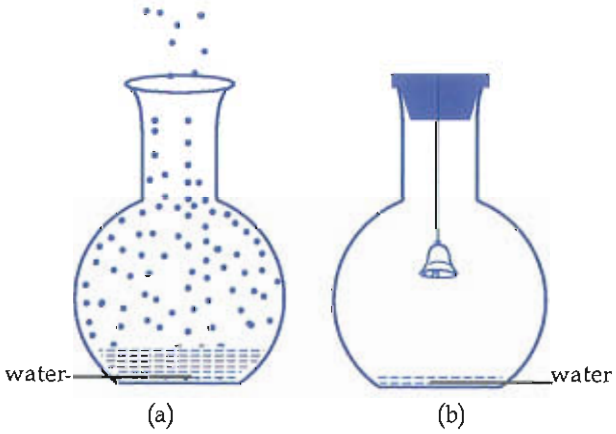


Fig. 8.3

Now open the flask, and take some water in it. Boil the water until the flask is filled with steam. Now close the flask with the cork as before, with the bell inside it. Following this pour cold water over the flask to cool it. Gently shake the flask and listen to the sound of the bell.

★ Is there any difference in the sound heard? If so, why?

★ What was the flask filled with in the first instance?

★ In the second instance what happens to the air in the flask when steam fills it?

★ When the flask is cooled, what happens to the steam inside?

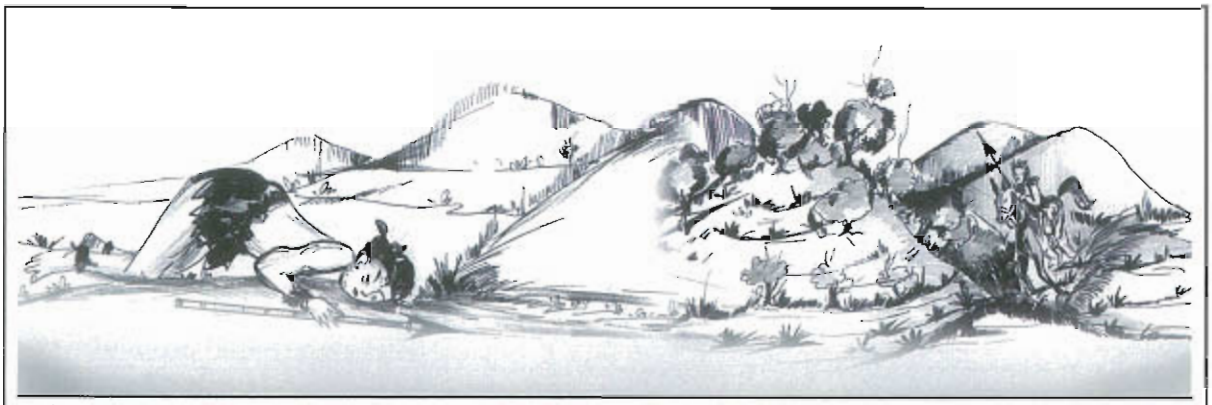
★ As a result what change occurs to the number of air molecules inside the flask?

★ Why was there a difference in sound in the two instances? Try to relate this to the quantity of the gases inside and discuss. Record your conclusions.

★ If the air in the flask is completely removed can sound be heard?

★ As you know, light does not require a medium to travel. What about sound? Record your findings in the light of this experiment.

★ Now explain why people need special arrangements for communication in space and on the moon?



Take note of the strategy employed by certain tribals of the ancient period to detect the approach of enemies even from a long distance. They could escape because they could hear the sound of the hooves of horses through the earth even before they heard it through air.

Does sound travel only through air?

* Press your ear at one end of a wooden desk. Let someone rub his finger at the other end of the desk. What do you feel?

- -

You are familiar with the toy-telephone made of a match box and string, aren't you?

Take some water in a bucket. Hold a steel tiffin carrier completely immersed in it. Tap the vessel while under water with a metal spoon.

* Can you hear the sound of tapping ?

- -

* Which are the media through which sound travelled to reach your ears in the two cases?

- -

Does sound travel with the same velocity in all media?

Medium	Velocity of sound m/s *(at room temperature)*
Aluminium	6420
Iron	5950
Steel	5960
Pure water	1498
Air	340

Table 8.1

Sample problem

The sound of hammering a railway track at a great distance is heard 4 seconds after its occurrence. If so, what will be the time taken by this sound to travel through the rail? (Use the data given in Table 8.1).

How is sound transmitted through a medium?

Observe the graph which depicts the pressure variations produced in a medium when the sound from a source passes through it.

* What type of wave is sound?

- -

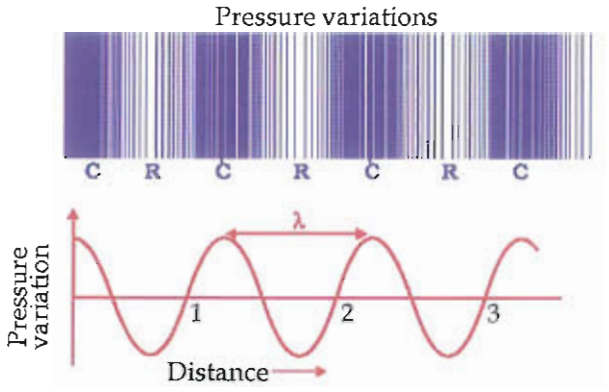


Fig. 8.4

★ What do points C and R represent in the figure?

- -

★ Find out the wavelength from the figure and note it down in your science diary.

- -

★ Write the relation between wavelength, frequency and velocity, that you have studied.

- -

★ If the velocity of this wave is 340 m/s what will be its frequency?

- -

Characteristics of sound
(Intensity, Loudness, Pitch, Timbre)

Make a diaphragm tying a stretched balloon at the mouth of a steel tumbler. Sprinkle some sand or mustard seeds on the diaphragm.

Why is there a difference in the sounds produced when the diaphragm is tapped gently and then with force?

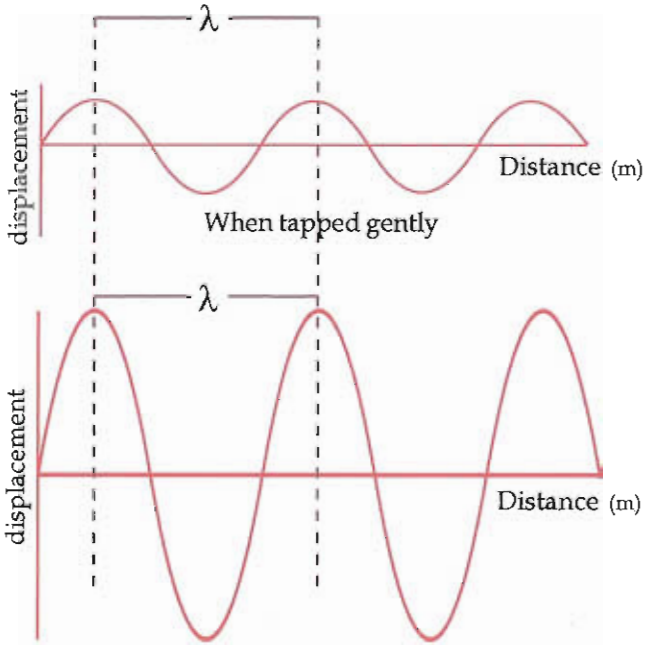
★ Does the natural frequency of the diaphragm change for the gentle and the strong taps?

- -

★ Will there be a change in the amplitude of vibration?

Answer these questions by studying the graphic representation of sound for the gentle tap and the strong tap at a particular time and observing the motion of mustard seeds at a particular time.

- -



When tapped strongly

Fig. 8.5

★ Is there any difference in the energy gained by the substance when it is tapped gently and then strongly? And what about the energy of the resulting sounds?

- -

★ If so, what is the relation of the sound energy with the amplitude of the wave? Write down your inference.

- -

The intensity of sound is proportional to the square of the amplitude of the sound. The intensity of the sound is the amount of energy passing through unit area per second perpendicular to the direction of propagation.

Its unit is W /m^2.

✶ Which of the waves shown in the graph is more intense?

✶ What change does the difference in intensity produce in the vibration of the eardrum and consequently in audibility?

If so, when two persons standing side by side hear a sound of the same intensity, will they have the same experience of hearing? Is audibility related to the efficiency of the ear? Discuss this on the basis of your experience and note down your conclusions.

Loudness is the measure of audibility produced by sound in a person. This depends on the intensity, frequency and efficiency of the ear. This is also called sound pressure level. The unit of sound level is decibel (dB). This can be measured by an instrument called the decibel meter. Sounds higher than 120 dB are painful to the ear.

Are you familiar with hearing impaired persons?

What may be the reasons for the deterioration of hearing in such people?

Interview a doctor and present a report on hearing infirmities.

What should be our attitude to such people? Discuss and prepare a note.

Haven't you understood that the amplitude of vibration of the source and efficiency of the ear influence loudness? What are the other factors influencing loudness?

- Press the stem of an excited tuning fork on a desk and listen to the sound.

Forced vibration is the phenomenon in which one object vibrates under the influence of another vibrating body with the frequency as that of the influencing body.

✶ On the basis of which factor did loudness change?

Now produce a continuous sound using a source. Slowly move away from the source.

✶ What is the change in loudness?

Notice the graphic representation of a sound wave as it advances.

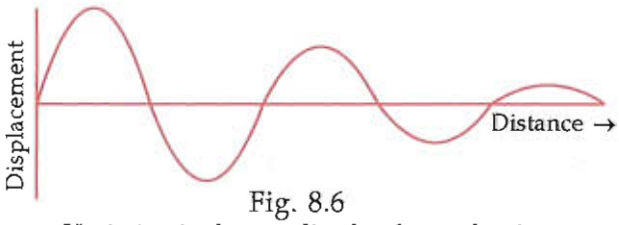


Fig. 8.6
Variation in the amplitude of sound as it advances from source

On the basis of the activity and the analysis of the graph, discuss and arrive at a conclusion about the relation between loudness and the distance from the source.

If the density of a medium increases or if there is flow of air in the path of the sound wave in the same direction, loudness increases. Note down the factors that affect loudness.

- Amplitude
-
-

Pitch

Don't you feel that the chirping of crickets has a penetrating effect on the ear? What peculiarity of sound produces this effect?

Shrillness of a sound felt by the ear is its pitch.

Let's see on what basis the pitch changes.

Stretch two copper wires of the same thickness. The tension of one wire should be less than that of the other. Now excite them.

- ✶ Of these, which one produces a sound of greater shrillness?

- ✶ Will the frequency of vibration be the same for both wires?

- ✶ What may be the relation between the frequency of vibration of an object and the pitch of the sound? Discuss and note down the conclusions.

Sounds of higher frequency or shrillness are sounds of high pitch.

Sounds of lower frequency or shrillness are low pitch sounds.

From the sounds familiar to you find those with low pitch and high pitch, and classify them in a table.

High pitch	Low pitch
• Chirping of crickets	•
• Whistles	• Quacking of a duck

Table 8.2

Bass and Treble

A group of sound waves of low pitch is bass. A group of sound waves of high pitch is treble.

Timbre or Quality

When the sounds of two friends talking from two sides of a high wall reach our ears with the same loudness and pitch, we can distinguish them from their voice. How is this possible?

- ✶ Which organ in our throat when vibrated produces sound?

- ✶ Will this vibration induce forced vibrations in other parts of the mouth?

- ✶ If so, does the sound from the mouth come from a single source?

Won't the voice of an individual be the combined form of sounds of many frequencies?

- ✶ Will the same combined form be produced by another person?

Though the loudness and pitch are the same it is the quality of sound (timbre) that distinguishes the sounds of two persons.

Doppler effect

Have you ever felt that there is an increase in frequency of the whistling from a fast train when it comes from a distance to the station and a decrease in frequency when the train passes us without stopping? Why does this happen?

The change in frequency experienced by the receiver either because of the relative motion of the source or the receiver or both is Doppler effect.

This phenomenon was first explained by the Austrian scientist Christian Andreas Doppler (1803 - 1853).

This effect is because of the increase or decrease in the number of cycles of sound waves reaching the receiver per second.

- When the sound source moves towards the receiver at rest, the frequency of the sound that is heard increases.
- When the sound source moves away from the receiver at rest, the frequency of the sound that is heard decreases. The reason for this is that the number of cycles received by the receiver in a second decreases.

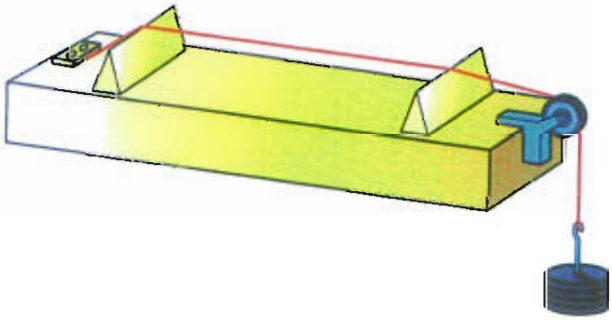
By measuring the change in frequency, the velocity of a moving source can be estimated. This principle is employed by the police to measure the speed of vehicles.

Resonance

Why is the sound produced by a string of a veena louder than that produced by a stretched wire?

Let's do an activity.

Keep the bridges of a sonometer close to each other. Place a paper rider on the wire between the bridges. Excite a tuning fork



and press its stem on the sonometer. Observe the paper rider.

Adjust the distance between the bridges. Find the instance when the paper rider is thrown away due to powerful vibrations. Repeat this several times. Why is the paper rider thrown away on these instances?

★ What is the frequency of the excited tuning fork?

- -

★ Which are the parts that may undergo forced vibration when the stem of the tuning fork is pressed on the sonometer?

- -

★ What is the frequency of vibration of these parts?

- -

★ Will their natural frequency be the same as the frequency of the tuning fork?

- -

★ When the bridges are moved, naturally the length of the wire between them changes. Will the natural frequency of that segment of wire change because of this?

- -

★ Is there any instance when the natural frequency of the segment of wire and that of the tuning fork be equal? If so, when?

- -

★ On this occasion, will there be a change in the amplitude of forced vibration of the wires? Discuss this in relation to the paper rider being thrown away.

- -

★ What change is brought about in loudness when the amplitude of vibration increases?

- -

Thus when the natural frequency of the body undergoing forced vibration becomes equal to the frequency of the

impressed vibration, the body undergoing forced vibration will vibrate with greater amplitude. In this state the two objects are said to be in resonance.

Now try another activity.

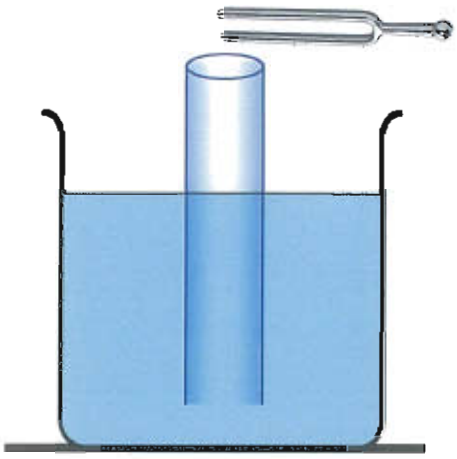


Fig. 8.7

Take a long pipe and dip it in water kept in a vessel, as in Fig. 8.7.

★ Excite a tuning fork and hold it close at the mouth of the pipe. Do you hear the sound of the vibrating fork?

Now repeat the activity immersing the pipe completely in water and slowly raising it.

★ Is there a difference in the loudness of sound?

Find the first instance when the sound is the loudest.

★ Is there any relation between the length of the air column inside the pipe and the increase in loudness? Compare it with the working of the sonometer and discuss. Make a note of your conclusion.

★ Which were the objects in resonance when loudness was at its maximum?

Now try to find more positions of resonance by raising the pipe thereby changing the length of the air column.

Beats

Take two tuning forks of the same frequency. Paste a little wax on one of the prongs of one of them. Now excite the tuning forks together and listen to the sound.

What peculiarity did you notice in the sound?

This peculiarity in sound is beats.

★ If so, write down what is meant by beats.

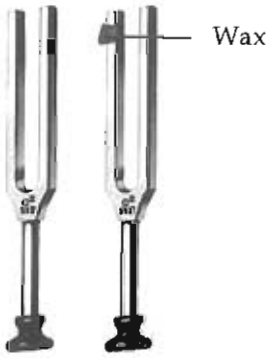


Fig. 8.8

Limit of audibility

Are all the sounds around us audible?

The limit of audibility depends on two factors.

- Intensity of sound
- Frequency of sound

For a normal person to hear a sound, the intensity of sound should be above a certain limit and the frequency should be within certain limits.

Normally a person can hear frequencies from 20 hertz to 20,000 hertz.

Sounds of frequency less than 20 Hz are infrasonic sounds and sounds of frequency greater than 20 kHz are ultrasonic sounds.

- Dogs, bats and dolphins can hear sounds above 20 kHz.
- Rhinoceroses can hear sounds of frequencies 5 Hz and above.
- Whales and elephants can produce and hear infrasonic sounds.

Discuss the following statements and prepare short notes.

- Bats can travel at night and catch prey.
- Certain types of rats and moths can escape from bats.
- High intensity earthquakes are usually preceded by infrasonic sounds.

Even though we cannot hear infrasonic and ultrasonic sounds, we use them for several purposes.

Uses of ultrasonic sounds

- To record the functioning of the heart (Echocardiography)
- To study the functioning of internal organs like liver, kidney, uterus (Ultrasonography)
- To crush small stones formed in the kidney
- To measure the depth of oceans (SONAR- Sound Navigation and Ranging)

Sonar

Reflection of sound

Multiple reflection

When we make sound in empty class rooms or vacant rooms in houses, does the sound persist? Why is this?

How can it be reduced?

You have studied earlier that sound gets reflected from objects.

Observe how the reflection of sound in a vacant room is depicted.

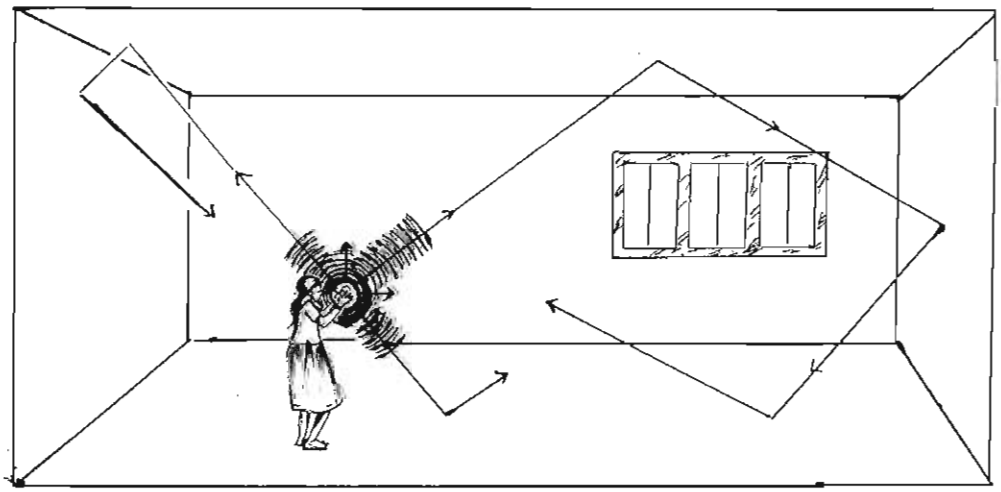


Fig. 8.9

✶ From which points do the sound waves from the source get reflected?

✶ Is there the chance of the reflected waves getting reflected again?

✶ Won't these repeatedly reflected waves reach the ear of a listener simultaneously?

✶ What will be the auditory sensation when the same sound falls on the ear continuously? Discuss this on the basis of the concept of persistence of hearing.

The sensation of hearing produced by sound is retained for a period of $\frac{1}{10}$ second. This peculiarity of the ear is persistence of hearing. If another sound reaches the ear within this interval of the time, simultaneous hearing is experienced.

The persistence of sound as a result of multiple reflection is reverberation.

Situations where multiple reflection is utilized.

Discuss how multiple reflection of sound is utilized by controlling the direction of sound in the following situations, and prepare a note.

Fig. 8.10

- Horns
- Stethoscope
- Curved ceilings of halls (Fig. 8.11)

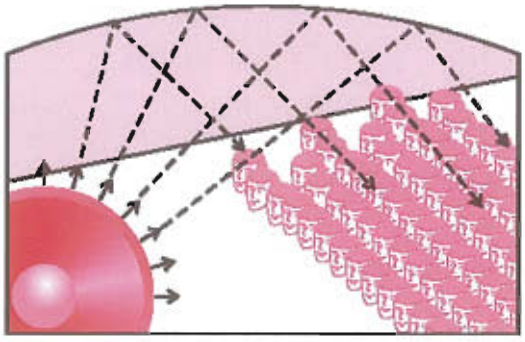


Fig. 8.11

- Sound boards.

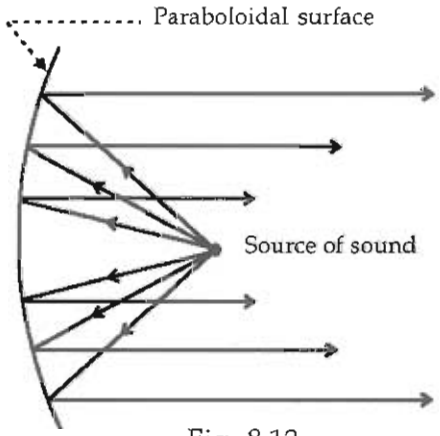


Fig. 8.12

Echo

If you clap your hands from a field or valley you clearly hear the same sound again a little later. Why is it so?

See the picture of a boy in a mountain valley clapping his hands.

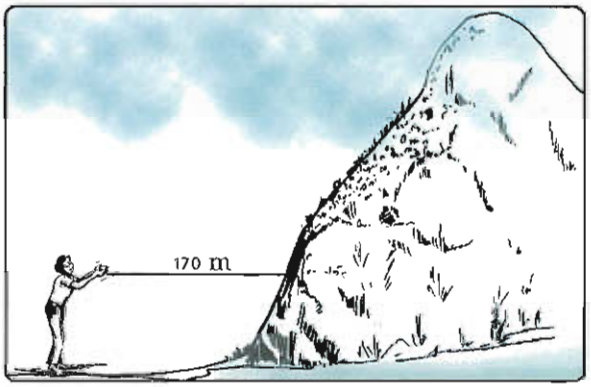


Fig. 8.13

Suppose sound travels at a speed of 340 m/s through air.

★ When will the sound of the clap reach the ear directly?

- -

★ How long will that sound persist in the ear?

- -

★ How long will the sound reflected from the mountain take to reach the ear?

- -

★ Can the second sound be heard distinctly?

- -

Echo is the same sound heard again after sound is heard. At what distance should the reflecting surface be, to experience the echo of a sound travelling through air at a speed of 340 m/s?

★ List the instances when you have experienced echo.

- -

Acoustics of buildings

Why are the walls of a cinema theatre made rough?

★ What are the possible effects of reflection of sound in a big hall?

- -

What can be done to minimise the disadvantages due to these phenomena?

Haven't you done an experiment in a previous class to demonstrate the reflection of sound using two PVC pipes, tuning fork, glass plate etc. arranged as shown in Fig. 8.14.

Now repeat the experiment replacing the glass plate by the substances given below. Listen to the change in the reflected sounds and tabulate them as substances that reflect sound and those which do not.

Fig. 8.14

- polished plank
- rough plank
- polished surface of tiles
- rough surface of tiles
- cloth
- wool
- jute sacks
- thermocol

On the basis of what has been learnt about reflection, discuss and prepare a note of what can be done regarding the following, so that sound can be heard clearly in a hall.

- Distance between the walls
- Material used for making the walls
- Smoothness of the walls
- Flooring
- Shape of the hall

Acoustics of buildings is the branch of science which deals with the conditions to be fulfilled in the construction of a hall for clear audibility.

Visit a hall in your neighbourhood and observe the steps taken there to ensure that sound is heard clearly. Prepare a note and present it in the class.

Sound pollution

Figure 8.15 is the sign board indicating that the use of horns is prohibited.

Fig. 8.15

★ Where are such boards displayed? What is its necessity?

★ What are the sounds you hear while walking in the city?

★ Does a sound of high decibel cause pain to your ears?

★ And what about when you hear a high pitch sound?

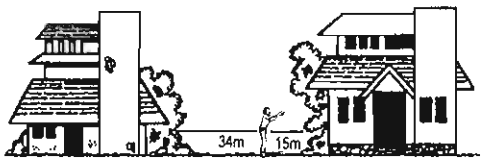
Consult a doctor and understand the adverse effects of sound pollution. There are laws to check sound pollution. Interview a traffic Sub Inspector in your neighbourhood, prepare a note and present it.

Discuss ways to minimise sound pollution in towns and note down your suggestions.

- Plant trees on the roadside.
-
-

Follow up Activities

1. A tuning fork of frequency 512 Hz is excited and its stem is pressed on a table.
   a) Now what will be the frequency of vibration of the table?
   b) What is the reason for increase in loudness?
   c) What is this phenomenon called? Explain.
2. Ramesh made a toy veena by taking three pieces from a long copper wire. There was no change in the sounds produced, when excited?
   a) What characteristic of the wire caused the sounds to be alike?
   b) What changes should be brought about in the wires to create a difference in sounds?
3. A small bomb explodes just below the water surface at a distance of 1500 m from a ship. Suppose a person on the ship hears the sound of the explosion.
   a) Which are the media through which the sound travels to reach the ship?
   b) If the speed of sound in water is 1500 m/s, how long will it take for this sound to reach the ship through water?
   c) Calculate the time the sound takes to travel the same distance through air (speed of sound in air is 340 m/s).
4. When a tuning fork of 256 Hz was excited and its stem was pressed on a sonometer board, the paper rider was thrown away when the bridges were adjusted at a particular instance.
   a) Why was the paper rider thrown away?
   b) What is this phenomenon known as?
   c) Explain the reason for this phenomenon.
5. A Galton whistle of 30 kHz is sounded.
   a) Can a person hear this sound? Why?
   b) What is this sound known as?
   c) Mention two occasions where this sound is used.
6. Notice the picture of a man standing between two buildings A and B.



   a) If he makes a sound can he hear its echo? If so, from which wall will he get the first echo?
   b) Explain how you will calculate the shortest distance to get an echo.
7. The sounds of a tabala, a guitar and a flute being played simultaneously are heard over the radio. Which characteristic of sound helps to distinguish them?