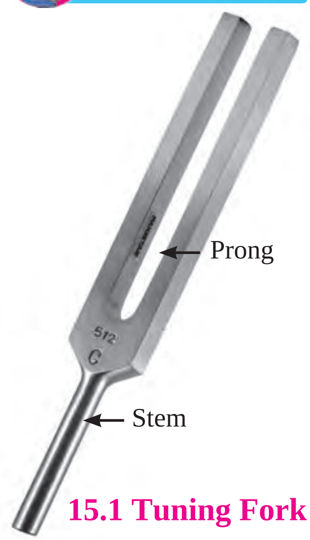
15. Sound

Can you recall?

How is sound produced ?



15.1 Tuning Fork

Production of Sound

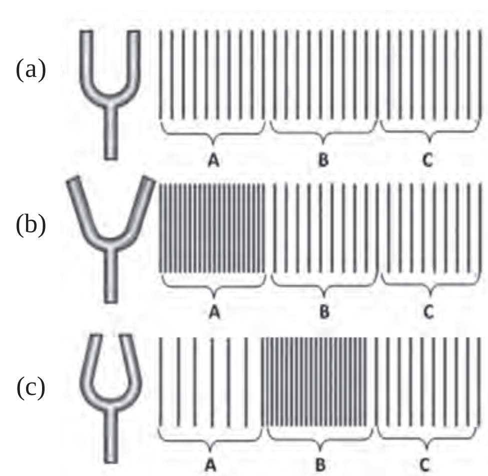
We have learnt that sound can be generated from a vibrating object.With an example of tuning fork, we will now learn about how a sound is produced due to such vibrations. A photograph of tuning fork is shown in Figure 15.1.

A tuning fork is made of two prongs and a stem. Keeping the stem steady, if the prongs are struck, they start vibrating.

Figure 15.2 (a) shows a stationary tuning fork. To show the state of air around the tuning fork, vertical lines are used. Here, the vertical lines are equally spaced. It indicates that the average distance between the air molecules is the same everywhere and the average air pressure in three regions ‘A’, ‘B’ and ‘C’ is also the same.

If the stem is kept steady and the prongs are struck, the prongs are set into vibrations. It means that they are set into periodic motion in forward and backward direction. We will see, step by step, the result of such a motion.

If during the vibration, the prongs of the tuning fork go away from each other, as shown in Figure 15.2 (b), the air outside the prongs is compressed and the pressure there increases. Such a state of high pressure is created in region A in the figure. The region in which air is at high pressure and high density is called compression. In the next step of vibration, the prongs of the fork come close to each other, as shown in Figure 15.2 (c). In this case, the air molecules near the prongs get more space to move away from each other. As a result, the air pressure in this region (Region A) decreases. Such region in which air is at low pressure and low density is called rarefaction.

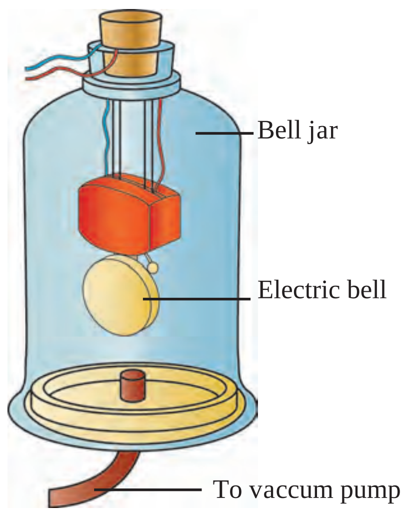


15.2 Production of sound by tuning fork

However, the air molecules in this region, which were in compressed state earlier (Figure 15.2 (b), region A) transfer their energy to the air molecules in the next region (region B). So, the air in that region goes to compressed state (See Figure 15.2 (c), region B). Such a periodic motion of the prongs creates compression and rarefaction in the air and these are propagated away from the prongs. These are nothing but the sound waves. When these waves reach our ear, the ear-drum vibrates. Accordingly, specific signals reach the brain and we get a sense of hearing a sound.

Use your brain power

If sound waves are generated in air, what moves away from the source? Is it the air itself or the state of compression and rarefaction created in the air?



15.3 Medium is necessary for propogation of sound

Propagation of sound and Medium: We have learnt in the sixth standard that sound travels through some material medium like solid, liquid or gas and reaches us. But what if such medium does not exist between the source of sound and our ear?

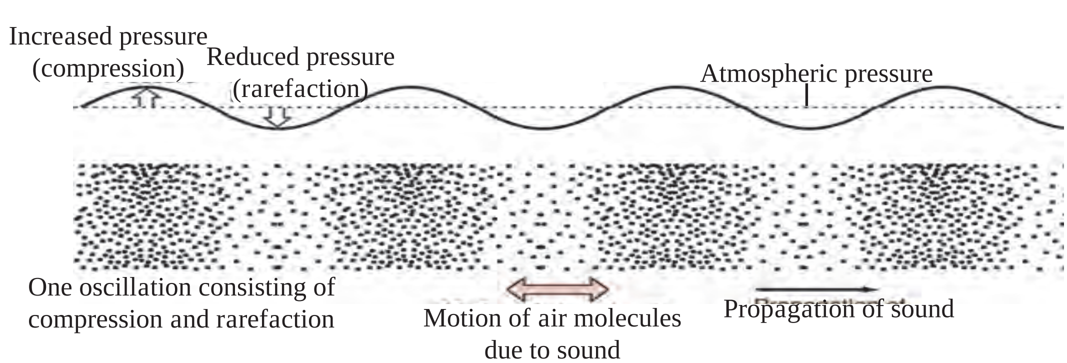
Sound generation and propagation needs medium like air. A simple experiment can prove this. The experimental arrangement is shown in Figure 15.3. In this experiment, a vaccum tight bell jar is placed on a smooth horizontal surface. The bell jar is connected to a vacuum pump via a tube. We can remove air inside the bell-jar, using the vacuum pump. As shown in the figure, the bell jar contains an electric bell, which is connected to the power supply through the lid of the bell jar.

At the start of experiment, the vacuum pump is off and the bell-jar contains air. If the key to electric bell is now switched on, the bell start ringing and the ringing can be heard from outside the bell jar. Now, if the vacuum pump is switched on, it starts removing the air from the bell jar. As the quantity of air inside the bell jar decreases, the level of ringing sound heard outside also decreases. If the pump is operated for sufficiently long period, the quantity of air like inside the bell jar will be low. At this point the level of ringing sound will also be very low. This experiment demonstrates that sound generation and propagation needs a medium. If the air inside the bell jar is totally removed, will we be able to hear the sound of ringing bell? Why?

Always remember

Two astronauts on the moon talking to each other directly, will be unable to listen to each other, even if they are very close to each other. The moon does not have atmosphere. Since there is no medium which is necessary for generation and propagation of sound, between the astronauts, direct sound propagation between them is not possible. Therefore, the astronauts use some technology like the one used in our cell-phones to communicate with each other. The waves used in cell-phone do not need any medium for propagation.

Frequency of Sound Waves : Using figure 15.2, we learnt about how the vibrations of tuning fork result in generation of compressions and rarefactions in air. More detail observation shows that, the actual variation in the air density and pressure are as shown in Figure 15.4. If any object vibrates in the air, such sound waves are produced in the air.



15.4 Cycles of compression and rarefaction in a sound wave and change in air pressure

As shown in the Figure 15.4, one compression and one rarefaction together forms one cycle of the wave. The number of cycles formed in the air in one second will be decided by the number of times the prongs of the tuning fork (or any other vibrating body) vibrates back and forth i.e. the number of vibrations of the tuning fork in one second.

Number of such cycles that are produced in the air (or other medium) per second is called as the frequency of the sound wave. The frequency is measured in Hertz. If one cycle is completed in one second, the frequency is said to be 1 Hz. For example, the tuning fork in Figure 15.1 shows its frequency to be 512 Hz. It means that the fork vibrates 512 times per second. These vibrations will set 512 cycles of compression and rarefaction in the air, per second. Thus, the sound generated by the fork will have a frequency of 512 Hz. The frequency of a tuning fork is decided by the dimensions of the prongs (length, thickness) and the material used for making the fork.

Try this

Take 6-7 glass cups. Arrange them in a line and fill them with water with gradually increasing water level from one end to other. Take a pencil and strike the cups sequentially. The sound generated by each cup will be different. Why it is so?

When a cup is struck, waves are set up in the air column above the water level in the cup. The frequency of the generated wave depends on the height of the air column inside the glass cup. Since the water level in each glass is different, the height of the air column in each glass is also different. Therefore, the frequency of sound generated by each glass cup will also be different. So, the sound generated is different.

An 'app' for measurement of sound frequency may be available on cell-phones. With the help of your teacher, use the app to measure the frequency of the sound generated from each glass cup. Do you observe any relation between the frequency of generated sound and the height of the air column in the glass-cup? This is your simple 'Jal-tarang'! Can this experiment be performed with stainless steel pots of different sizes?

Use of ICT

Download videos of Jaltarang from youtube and send them to your friends by email.

Sound and Music

From the above activity, it is clear that if the frequency of sound wave is changed, different sound is produced. Sound waves of different frequencies produce different sound notes. In the field of music, various musical instruments are used for creation of sound notes. This includes instruments like sitar, violin, guitar which use strings for production of sound and instruments like flute, shehnai which use air blown into pipes for the production of sound.

In string based instruments, the frequency of vibration of the string is changed by changing the tension on the string and/or by changing the vibrating length of the string using fingers. This results in generation of different notes.

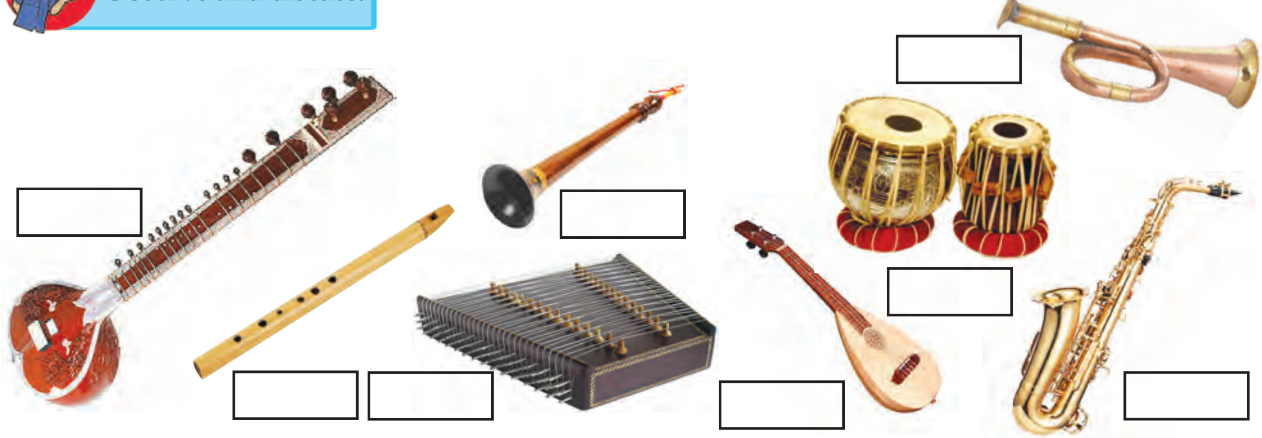
In musical instruments like flute, the holes on the flute are opened or closed to change the length of vibrating air column in the flute. The frequency of waves, therefore, changes and it results in the production of different notes. In flute, different notes can be generated by changing the way of air-blowing also.

Do you know?

What are the frequencies of musical notes 'sa', 're', 'ga', ma', 'pa', 'dha', 'ni' in the 'madhya saptak'?

Note	Frequency (Hz)
sa	256
re	280
ga	312
ma	346
pa	384
dha	426
ni	480

Observe and discuss. Identify the instruments and discuss sound production in them.



Try this 'Apps' for generation of different sound notes (sound note generator app) may be available on cell-phones. With the help of your teacher, using such an app, generate sound notes listed in the table.

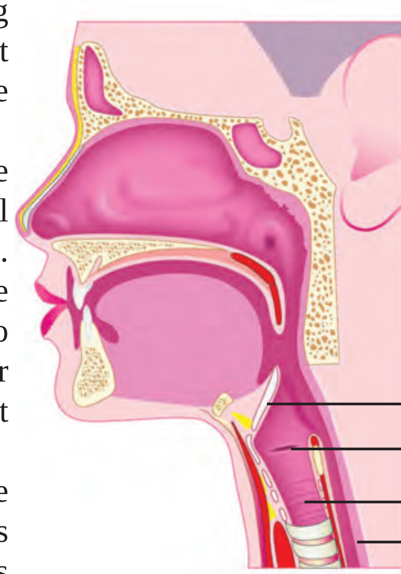
Sound Produced by Human

Either speak a little loudly or sing a song or produce humming sound like a bee and put your fingers on your throat. Do you feel some vibrations?

In the humans, sound is produced in the larynx. While swallowing food, we can feel with our finger a hard bump that seems to move. This is nothing but larynx. As shown in Figure 15.5, it is at the upper end of the windpipe. Two vocal cords, are stretched across the voice box or larynx in such a way that it leaves a narrow slit between them for the passage of air.

When the lungs force air through the slit, the vocal cords vibrate, producing sound. Muscles attached to the vocal cords can make the cords tight or loose. When the vocal cords are tight and thin, the type or quality of voice is different.

Take two rubber strips out of an unused bicycle tube. Place these two pieces one above the other and stretch them tight. Now blow air through the gap between them. As the air blows through the gap between the rubber strips, a sound is produced. Human larynx works in a similar way.



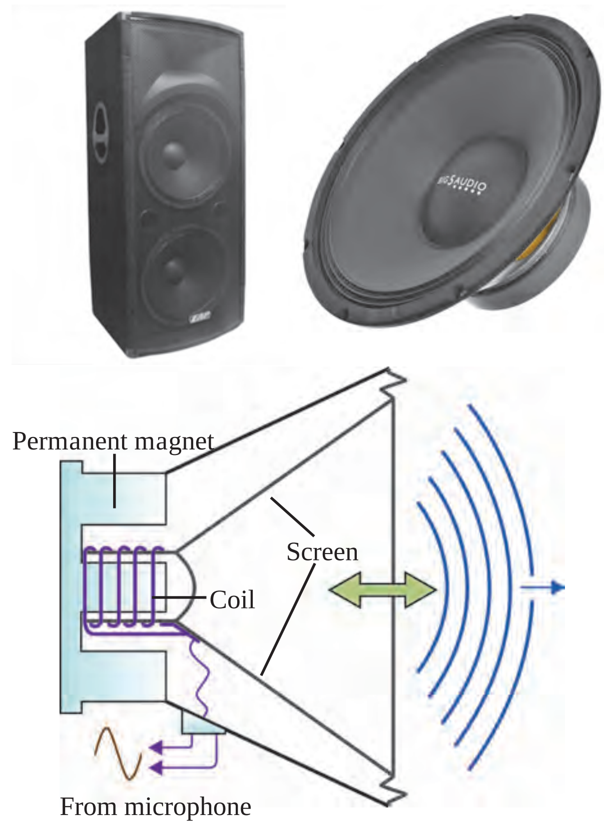
15.5 : Larynx in human

Vocal cords are 20 cm in length in male, about 15 cm in female and even smaller in children. Therefore the voice of male, female and children are different.

Try this Produce a sound 'bho…bho..' just like a dog-barking and 'meow.. meow..' just like a mewing cat. Carefully notice the tension on the vocal cords, when you produce these sounds. Do you feel that the tension on the vocal cords changes when you produce these two different sounds?

Sound generation by loudspeaker : You know that sound can be produced using loudspeaker. The internal arrangement in the loudspeaker is shown in the form of cross-sectional view in Figure 15.6. It consists of a permanent magnet. A coil is wound around it and if a current flows through this coil, it also generates magnetic field. This you have learnt in earlier chapter in this book.

You must have seen that if two magnets are brought near each other, they move depending on their positions. In the same way, here, depending on the magnetic field created due to the coil, the coil moves back and forth. The frequency and amplitude of the movement of the coil depends on the variation in the current flowing through the coil. As the coil moves, the conical screen of the loudspeaker, which is attached to the coil, also moves back and forth.



15.6 Internal construction of a loudspeaker

We have seen that due to back and forth motion of the prongs of the tuning fork, sound waves are produced. In the same way, here, due to back and forth motion of the loudspeaker screen, sound waves are produced in air.

You can feel these vibrations of the loudspeaker screen, just by gently touching the screen of a loudspeaker, which is producing sound. Very loud sound can be produced by using a loudspeaker. Therefore, loudspeakers are used in public places. However, as we have learnt last year, if sound level is around 100 decibels, the sound can be harmful to us. Therefore, although the loudspeaker can generate very loud sound, there must be limit on its loudness.

Try this

An ‘app’ may be available on cell-phones to measure the loudness of sound in decibel. With the help of your treacher, use the app to measure the sound level of a sound from a loudspeaker at some public place. Measure the sound level at different distances from the loudspeaker. Do you observe some relation between the distance from the loudspeaker and the sound level?

Always remember

We should take care that others are not disturbed when we study sound and its production. Sound pollution is a major cause affecting the environment and social health. Hence we should find ways to avoid sound pollution.

Exercises

1. Fill in the blanck with approriate word:

a. The region in a sound wave, with higher pressure and density is called .... and that with low pressure and density is called...........

b. Medium is ....for generation of sound.

c. The total number of compressions and rarefactions produced per second in a sound wave is 1000. The frequency of the sound wave is .....

d. Different sound notes have different ....

e. In loudspeaker,........energy is coverted into ....energy.

2. Give scientific reasons :

a. It is essential to change the tension on the vocal cords, as we produce different sound notes from our larynx.

b. Astronauts on the moon can not hear each other directly.

c. As the sound wave propagates from one place to the other in air, the air itself is not required to move from one place to the other.

3. How are different sound notes generated in musical instruments like guitar, which uses strings for sound generation, and flute, which uses blown air for sound generation?

4. How is sound produced in a human larynx and a loudspeaker?

5. Explain the experiment, with neat diagram, to prove the following :

'Sound needs material medium for propagation.'

6. Match the following:

Human larynx	Vibrations of metal arms
Loudspeaker	Vibrations in air column
Jal-tarang	Vibrations in vocal cords
Tuning fork	Vibrations in strings
Sitar	Vibrations of screen

Project :

1. Take two plastic glasses and tie a thread between them to make a toy phone. Does the voice of your friend reach you through the thread? Take metal wire instead of the thread and also change the length of thread/ wire and repeat the activity. Discuss with your friends and teacher about your conclusions.
2. Take a plastic or tin can or a plastic glass. Remove its bottom. Stretch a piece of rubber balloon across one end and fix it with a rubber band. Put a few grains of say ragi or bajra on the stretched rubber. Now ask your friend to shout 'Hoorrey..... Hoorrey.....' from the open end of the glass. Observe the dancing of the grains up and down. Discuss the reason behind this.

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