18. Sound : Production of Sound

Let's recall.

Some events are given below. Put a tick mark '✓' in the box if you have experienced the event. If not, put a cross '✕' in the box.

1. Clapped your hands together.
2. Played a musical instrument.
3. Burst a fire cracker.
4. Knocked on a closed door.
5. Whistled using the cap of a pen.
6. Placed your palm on a mobile that is ringing.
7. Swung the clapper of the bell and the bell rang.
8. A metal utensil fell down with a clatter.
9. There was a thunderclap in the sky.
10. Put your hand on a speaker which is producing sound.

It is seen from the above examples that sound is generated due to a variety of events. In some examples, sound was generated due to the vibration of an object, for example, the bell, or the strings or diaphragm of a musical instrument; while in some examples like bursting a cracker, clapping, a lightning strike, vibrations are not actually felt. However, vibrations are produced in those cases as well. All these vibrations are imparted to the molecules in the air and sound is produced. You might have seen that, when a stone is thrown into the calm water of a lake, waves are generated and they reach up to the banks of the lake. Vibrations reach our ears through the air in a similar way and the sound is heard.

Use your brain power !

When a singer tunes the musical instruments before he starts singing, what exactly does he do? He ensures that the *tanpura* will produce the required notes, by adjusting the tension in its strings i.e. he 'tunes' the *tanpura*. A ***tabla*** player tunes the ***tabla*** by hammering the pegs to adjust the tension in the diaphragm of the ***tabla***. The harmonium accompanist finds out beforehand the key in which the singer will sing. To tune an instrument is to adjust how high or low the pitch of the notes produced will be. The pitch of a sound depends upon its frequency. In Indian music, the musical notes, ***Sa, Re, Ga, Ma, Pa, Dha, Ni,*** are of increasingly higher pitch. In scientific terms frequency is a measure of pitch.

You have learnt how sound is generated, how it reaches us on travelling through some medium and is heard by us. You have also seen that vibration of an object is necessary for generation of sound.

In the present lesson we will learn more about vibration, pitch, intensity and level of sound.

When the string of a musical instrument such as a *tanpura* is plucked, the string can be seen to vibrate but the two ends of the vibrating string are still. As it vibrates, the string moves to one side of the central position and comes back to the central position. This motion of the string is repeated again and again at fixed intervals of time. Such motion is called periodic motion.

18.1 Tuning the instruments

Always remember –

Sound is generated by the rhythmic vibration of an object. We can hear the sound as long as the object vibrates. But, when we touch the vibrating object with our hand, the vibrations stop and we no longer hear the sound. Sometimes we can see the vibrations, but sometimes, the vibrations are so minute that we cannot see them with our eyes.

Try this.

Make a list of musical instruments you are familiar with. Find out which part of the instrument vibrates and produces the sound.

Such vibrations, that produce sound, can be studied with the help of a simple ‘oscillator’.

Oscillator, oscillation and oscillatory motion

You must have seen children playing on a swing in a garden. Observe carefully the motion of the swing. Go to a swing at rest in a garden and mark its position on the ground below it. You can call this mark the central position of the swing. Now pull the swing to one side and let it go. Observe how it swings.

The swing will be seen to cross the central position again and again as it moves from one end to the other of its swing.

A swing that moves back and forth like this, is an **oscillator**. When the swing moves from one end to the other and returns to its starting point, it is said to have completed one **oscillation**. The back and forth motion of an oscillator on either side of a central position is called oscillatory motion.

Take an empty porcelain bowl or an empty steel glass. Stretch a rubber band and fix it on the bowl or glass as shown in the picture. Now give a jerk to the rubber band. Repeat this action applying a smaller or greater force. While doing this, observe the farthest distance to which the rubber band is stretched. Take note of the sound generated.

When the rubber band is stretched and released it vibrates. Compare the vibrations with the figure alongside. When the rubber is stretched from the original position A and comes to position B, it is seen to be curved. The maximum distance between the original position A and the position B on stretching the rubber, is called the **amplitude** of vibration.

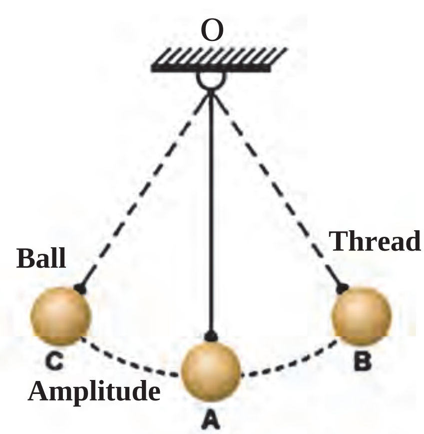
When a greater force is applied to the rubber, it is stretched further, meaning that the amplitude increases. On releasing it, a louder sound is generated. When a smaller force is applied, the rubber is stretched less. Then the amplitude is smaller and the sound is softer, too.

Take a strong thread, about half a meter long. Tie a small iron or wooden ball to it and suspend it from a support as shown in the figure. Such an oscillator is called a pendulum.

Give an oscillatory motion to the pendulum. The maximum distance between the original positions A of the pendulum and the extreme position B or C is called the amplitude of oscillation. In the figure, AB or AC is the amplitude of oscillation.

18.1 Oscillation of a swing

A rubber band stretched over a porcelain bowl



18.2 Oscillatory motion and amplitude of oscillation

Do you know ?

1. A stretched rubber returns to its original state when it is released. This property is called elasticity.
2. When a stretched rubber band vibrates, elasticity is at work.
3. All the while that the pendulum oscillates, earth's gravitation is at work.

Time period of oscillation and frequency

The time required by an oscillator to complete one oscillation is called the time period of the oscillator. In the previous activity, the oscillator traverses the distance from the extreme position B to central position A and from there to the position C, then back again to A and from A to B. The time required by the oscillator to traverse this distance B-A-C-A-B, is the time period of oscillation (T) of the oscillator. The number of oscillations completed by an oscillator in one second is called the frequency of oscillation.

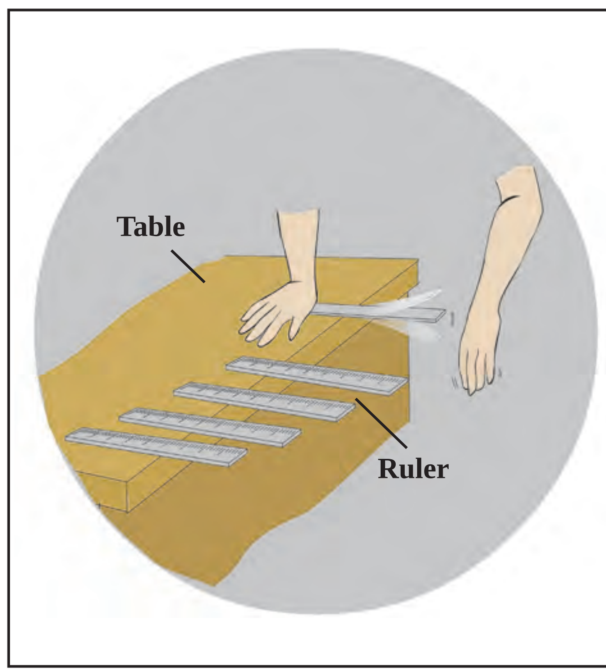
The total motion B-A-C-A-B in the previous activity is one oscillation.

$$\text{Frequency (n)} = \frac{1}{\text{time period of oscillation (T)}} = \frac{1}{T}$$

Frequency is the number of oscillations occurring in one second. The unit of frequency is Hertz (Hz). 1 Hz means there is one oscillation in one second; 100 Hz means hundred oscillations in one second.

Try this.

Take a plastic ruler and hold one of its ends pressed down on the table, as shown in the picture, so that a large portion of the ruler is off the table. Now ask your friend to press the free end of the ruler down and release it. Observe what happens. Now press the ruler with your finger at such a point that it stops making any sound. Now pull in 10 cm more of the ruler onto the table and repeat the action. Listen to the difference in the first and the second sound. Take note of the difference in the frequency and pitch of the sounds. Also, take note of what happens by further decreasing the length of the free part of the ruler little by little.



18.3 Vibration of the ruler and the sound produced

Use your brain power!

1. Will a sound be generated no matter how the ruler is kept on the table?
2. Is there any correlation between the length of the free part of the ruler and the sound generated?
3. If the ruler is plucked while it is held with 25 cm of it off the table, does it make any sound? If there is no sound, look for the reason why it is so.

Try this.

Take a strong thread of sufficient length. Tie a wooden or metal bob to one of its ends to make a pendulum. Measure the length of the thread in centimetres and make a note of it. Suspend the pendulum freely from a support. Now swing the pendulum and with the help of a stop-watch record how many seconds are required for 20 oscillations. Repeat this procedure 4 or 5 times, decreasing the length of the pendulum by 10 cm every time. Record your observations in the following table. Deduce the time period of oscillation and the frequency of the pendulum by making use of the given formula.

S.No.	Length of the oscillator (in cm)	Time required for 20 oscillations, t (in seconds)	Time period of oscillation T = t/20 sec	Frequency n(Hz) =1/T (Hz)
1.				
2.				
3.				
4.				
5.				
6.				

1. What can we infer from these observations?
2. What is the relationship between the frequency and the length of the pendulum?
3. Explain what is meant by low frequency and high frequency?

Now keep the length of the pendulum fixed at 30 cm but, varying the amplitude, measure the time required for 20 oscillations, in each instance. Deduce the time period of oscillation and frequency of the pendulum in each case. Use the following table for this purpose.

S. No.	Length of the pendulum in cm	Amplitude	Time required for 20 oscillations, t (in seconds)	Time period of oscillation T (s)	Frequency n (Hz)
1.	30	small			
2.	30	a little larger			
3.	30	larger			
4.	30	even larger			
5.	30	very large			

The time period of oscillation (T) depends on the length of the pendulum. The time period of oscillation increases if the length of the pendulum is increased.

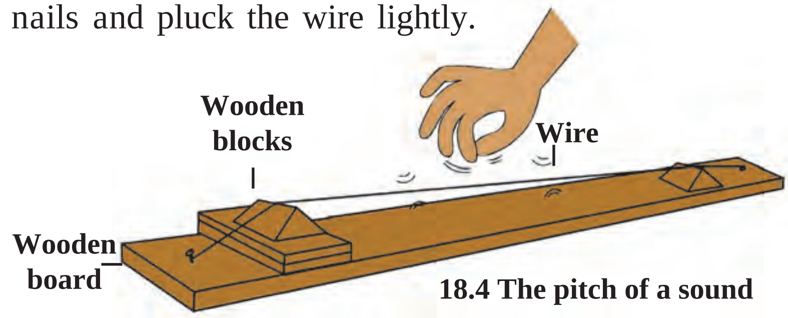
The frequency remains the same even if the amplitude decreases or increases.

High and low pitch of sound

Try this.

Take a wooden board, 80 to 90 cm long and 5 cm wide. Hammer two nails into it, each a few centimeters away from its two ends. Tie the ends of a thin metal wire to the nails so that the wire is stretched tightly between them. Insert a wedge-shaped wooden or plastic block under the wire near each of the nails and pluck the wire lightly.

Did you hear any sound? Observe whether the wire vibrates. Now insert two or three small rectangular blocks below the wedge-shaped block on one side in such a way that the length of the wire does not change. Observe whether there is any change in the tension in the wire. Now pluck the wire with your finger and listen to the sound. Also watch its vibration. Note the difference you perceive in its frequency. What can you infer from this? When tension in the wire is increased, the frequency is seen to increase and when it is reduced, frequency is also seen to decrease. We also perceive a difference in the sounds generated. When the tension is increased the resulting sound is shriller. When the tension is reduced the sound is also less shrill. This is what is called the high and low pitch of sound.



18.4 The pitch of a sound

1. Which of the sounds, the roar of a lion or the hum of a mosquito has the higher pitch?
2. What structures in the sitar help to produce higher or lower pitched sounds?

Intensity of sound – sound level

Loudness or softness of sound is indicated by two terms, namely, intensity of sound and sound level. Sound level is the intensity of sound as perceived by our ears. The intensity of sound is proportional to the square of the amplitude of vibration. For example, if the amplitude is doubled the intensity of sound becomes four times as much.

The **decibel** (dB) is the unit for measuring sound level. It was named decibel in honour of the work of the scientist Alexander Graham Bell. The magnitude of sound level, 'decibels' can be deduced from the intensity of the sound using a mathematical formula. When intensity of sound becomes ten times the original, the sound level increases by 10dB.

Do you know?

Decibel levels of some common sounds

1. Begining of audible sound – 0 dB
2. Normal breathing – 10 dB
3. Murmuring from 5 metres away – 30 dB
4. Normal conversation (between two persons) – 60 dB
5. Heavy traffic – 70 dB
6. Ordinary factories – 80 dB
7. Jet engine – 130 dB
8. Start of ear-splitting sound – 120 dB

Hearing is temporarily affected by sounds of frequency greater than 1000 Hz and levels higher than 100 dB. This can result in temporary deafness. Workers who work near aeroplane engines experience this.

Use your brain power!

What would be the difference perceived between hearing only two pupils in the class talking to each other and all the children talking to one another at the same time?

Audible sound

The frequency of the sound audible to human beings is between 20Hz and 20,000 Hz. We can only hear sounds in this frequency range.

Infrasonic sound

Have you ever heard the sound of the movement of our hands or of the movement of leaves falling from a tree?

Try this.

Take a oscillator and swing an oscillator which makes 3-4 oscillations in a second, and listen carefully for any sound it makes.

That the oscillator makes 3 to 4 oscillations in one second means that the frequency of the sound is 3 to 4 Hz. Humans cannot hear sounds of frequency less than 20 Hz.

In all the above examples, oscillations did take place, but no sound was heard. It means that this sound is of a frequency less than 20 Hz. A sound with a frequency less than 20 Hz is called infrasonic sound. Sounds with a frequency less than 20 Hz are produced by some animals, namely, whales, elephants and rhinoceros.

Ultrasonic sound

A sound with a frequency higher than 20,000 Hz is called ultrasonic sound. Human beings cannot hear such sounds. However, some animals, for example, a dog, can hear such sounds.

Find out.

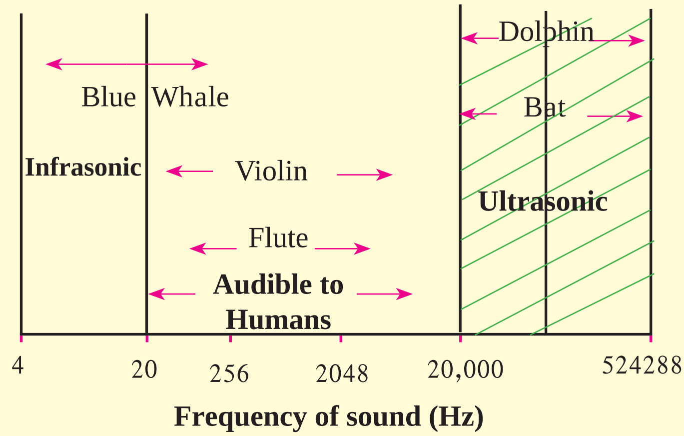
There is evidence that elephants communicate with each other over distances of up to 10 km using infrasonic sound inaudible to us. It is also believed that dogs and other animals can receive ultrasonic sound signals in advance of an impending earthquake. Find out more about this from the internet.

Uses of ultrasonic sound

1. To clean delicate ornaments and the tiny parts of a watch.
2. To observe internal organs of the body.
3. To detect tumours in the brain.
4. To detect faults in a metal.
5. In RADAR systems.
6. To kill certain microbes and insects.
7. SONAR (Sound Navigation And Ranging) is used to locate the seabed or the position of a ship.

Do you know?

The pitch of sound is directly related to the frequency of sound. From the graph alongside we get further information about the frequency of sound and infrasonic, audible and ultrasonic sound.



Exercise

1. Fill in the blanks.

(a) Sound is generated by the rhythmic …….. of any object.

(b) The frequency of sound is measured in ……………. .

(c) If ……….. of sound is decreased, its loudness also decreases.

(d) A medium is necessary for …………. of sound.

2. Match the pairs.

Group 'A'	Group 'B'
(a) Flute	(1) Frequency less than 20 Hz
(b) Frequency	(2) Frequency more than 20000 Hz
(c) Sound level	(3) Vibrations in the air
(d) Ultrasonic sound	(4) Measured in Hz
(e) Infrasonic sound	(5) Decibel

3. Give scientific reasons.

(a) In earlier times, people used to listen for the arrival of a distant train by putting their ear to the rail.

(b) The sounds generated by a *tabla* and a *sitar* are different.

(c) If you were both on the moon, your friend will not be able to hear you call.

(d) We can hear the movement of a mosquito's wings but we cannot hear the movement of our hands.

4. Write answers to the following questions.

(a) How is sound produced?

(b) What does the intensity of sound depend upon?

(c) Explain how the frequency of oscillation is related to the length of a pendulum and the amplitude of its oscillation.

(d) Explain the two ways by which the pitch of the sound generated by a stretched string can be changed.

Project :

The bat, a mammal, flies during the night manoeuvering with the help of the ultrasonic sounds it produces. Find out more about this.

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