Sound 13

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INTRODUCTION

We hear many types of sound everyday. We hear the sound of our friends and parents talking, the sound of buses and other automobiles running on the street the chirping of birds, the barking of dogs, the cries of street vendors, the screeching of brakes, the zooming of aeroplanes overhead, the clatter of pans in the kitchen and so on. In the night, when most sounds are at ease, we can still hear the buzzing sounds of mosquitoes. Each type of sound is a characteristic of the object producing it.


Bell


Mridangam


Guitar


Veena


Flute

Do the following

1. Press your fingers against the front of your throat and recite a poem or sing a song or speak.
2. Hold a plastic scale firmly at the edge of a table. Strike the loose end with your finger. It produce a sound ? What kind of motion can you observe in the scale ?
3. Attach one end of a rubber band to a fixed support like a nail or hook on the wall. Hold the other end with your finger. Stretch the rubber band and pluck at its middle part. Is a sound produced ? What kind of motion can you observe in the rubber band ?
4. Blow across the mouth of a bottle which is half filled with water. Repeat with different amounts of water in the bottle. Record you observation.

5. The object which produce sound could be anything, could be the vocal chord of a person, a string of a musical instrument or a metal plate that has slipped out of your hand. They all produce different kinds of sounds but they have one common feature. These objects vibrate to produce sound. When water is poured into a bottle, a sound is produced as the air in the bottle begins to vibrate on being expelled from the bottle.

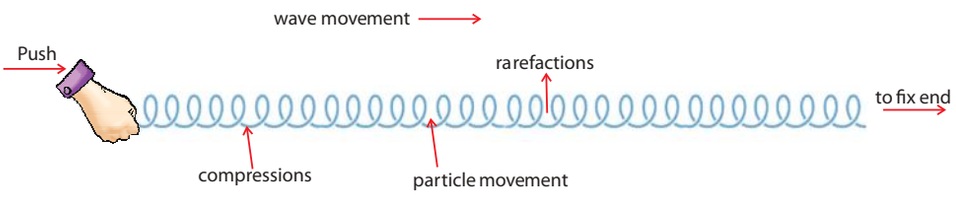
How does Sound Travel?

Sound travels from its source to your ears. For example when you hear a musician playing a flute, the sound of the flute travels some distance to reach your ears.

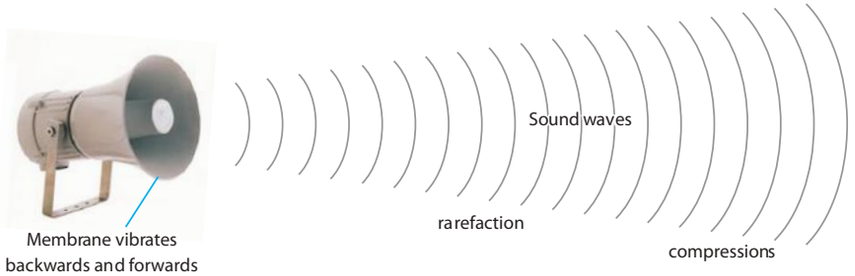
When an object vibrates, it produces sound. The vibrating object in turn vibrates the particles of air that surround it.

The vibrating particles of air push the other particles of air that are adjacent to them. This process continues and gives rise to round waves.

If you drop a Pebble in a Puddle of water, it creates ripples of small waves that spread in every direction on the water. Sound waves too spread in a similar manner. We cannot see sound waves but when an object vibrates to produce sound its vibration spreads in every direction like the ripples on the water.



Propagation of sound waves in air



Propagation of sound waves

The vibrations that produce sound, vibrate air particles that surround the loudspeaker. The vibrating air particle then vibrates the other air particles adjacent to it. This process gives rise to sound waves.

Sound waves in the air spread in every direction. On reaching the ear, the sound waves vibrates the delicate membrane inside your ear. The membrane in the ear is known as the ear drum. The vibrations are picked up by special types of cells in the inner ear. These cells are attached to nerve fibers which transmit the vibration to the brain. The brain processes the information and helps you to recognize the sound.


Water bottle shaking with pebbels

When you strike a metal spoon on a metal tumbler, both the spoon and the tumbler vibrate. The vibrations that produce sound quickly spread in every direction through the matter that surround these metal objects.

If two different kinds of matter, air and water surround the source of sound. Vibrations that are transferred to air cannot be seen but these vibrations carry the sound to your ears. The vibrations which are transferred to the surrounding water are seen as ripples in the water even though not heard.

Sound Needs a Medium to Travel

Sound needs a medium to travel. The medium can be air, water or a solid such as a metal wire. Sound cannot travel through vacuum. Vacuum has no air in it. If an electric bell is placed on a sound proof material in a glass jar with vacuum, the bell will not be heard. This proves that sound needs a medium to propagate. There is complete silence in space because it does not have air.

SPEED OF SOUND

Sound travels faster in a denser medium. For example, it travels faster through a metal wire than through air which is a lighter medium.

Similarly, sound travels faster in water than in air. This is because the particles in a denser medium are densely packed. A long time ago people living far away from each other used to communicate through beats of drums. The drums were called talking drums. They use to place their talking drums close to a water body so that the sound could travel faster and further.

The speed of sound increases with temperature. This is because heat is a form of energy. Particles at a higher temperature vibrate faster because they have more energy. Therefore, at higher temperature, sound travels faster. At 30° C sound travels at 350 metres per second and at 21° C it travels at about 344 metres per second.

Sound Waves

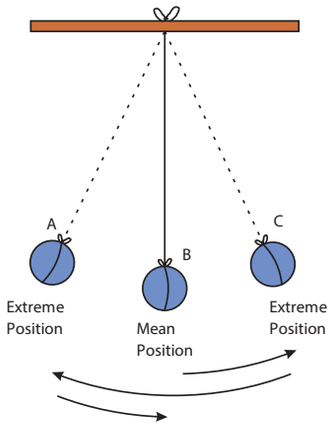
So far we have learnt that sound is produced by vibrations. We have also learnt that the vibrations that produce sound are transferred to the particles of matter that surround the source of sound. The vibrating particles of the matter then propagate sound in every direction. Most sounds that we hear travel by vibrating air particles that surround the source of a sound.

Frequency and Amplitude of a Sound Wave

When a particle of matter vibrates to produce sound, it follows a certain pattern. It vibrates with a frequency and has an amplitude. Let us understand how particles of air vibrate in a sound wave.

The vibration of a particle in a sound wave is similar to the movement of a pendulum. A pendulum moves on either side of a fixed point.

Such a movement is known as oscillation. As known in an oscillation that begins at B completes one oscillation when it travels from 'B' to



A simple pendulum

'C' then comes back to 'B' then moves up to A and returns to 'B'. The frequency of an oscillating particle is the total number of oscillation made by the particle in one second. An oscillating particle also has amplitude. Amplitude is the maximum distance travelled by pendulum towards any one side from its initial position. It could be a distance from B to C or B to A.

Importance of Amplitude of a Sound Wave

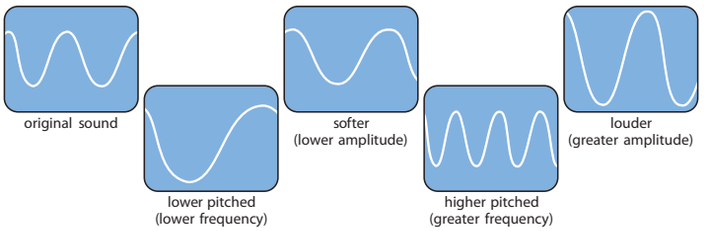
Amplitude of a sound wave determines the loudness of the sound. As the amplitudes increases the loudness of the sound increases. If the amplitude is very small, the sound is faint and cannot be heard. For the human ear to hear a sound, it should have a creation of minimum amplitude.

Do You Know ?

The sound produced by the blue whale is the largest recorded sound from a living source and measures 188 dB.

Loud and Soft Sound

When particles vibrate to produce sound they use energy. To produce a sound, the particles have to vibrate futher away. To oscillate particles to a greater distance, more energy is required. This explains why a drum makes a louder sound if you beat it harder. In doing so you use more energy. As a result, the particles vibrate with greater amplitude and therefore, produce a loud sound.



These are pictorial representations of sound waves when the sound is soft, loud, low-pitched and high-pitched

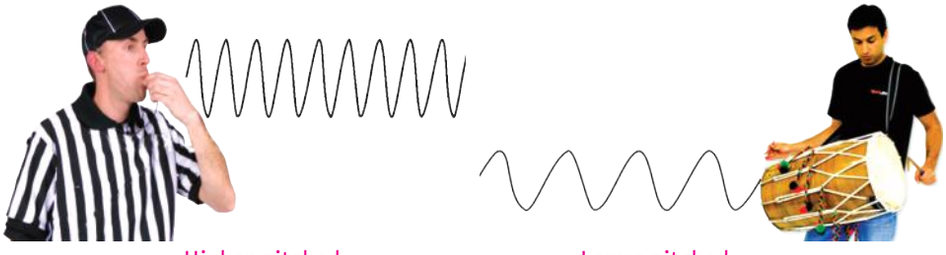
What is the Importance of Frequency of a Sound Wave?

You have learnt that the frequency of a sound wave refers to the number of complete back – and – forth vibrations of a single particle of matter (air) per second. The unit used to measure the frequency of sound is hertz (Hz), where 1 hertz = 1 oscillation (vibration) in a second.

The loudness of a sound depends on the amplitude of a sound wave. Does frequency too have any effect on the sound ? Yes, it does. Frequency determines the pitch of the sound.

What is Meant by Pitch of a Sound?

Beside being loud or soft, sound has one more characteristic. It has pitch or shrillness. Every sound has a pitch. Most girls have a high-pitched voice. A high-pitched voice produces a shrill sound most men have low-pitched voice. A low pitched voice produces a deep tone.



Higher pitched Lower pitched

High-pitch of a sound should not be confused with loudness. similarly, low-pitch is not a faeble sound. A high-pitch or a low-pitch sound can be loud or soft. Pitch and loudness are two different characteristics of sound.

The frequency of a sound wave determines its pitch. A sound whose particles vibrate with a higher frequency produce a sound of a higher pitch.

Low frequency sound wave produces a sound having a low pitch or a deep sound. For example a sound with frequency of 40 Hz will be of a lower pitch and of a deeper tone whereas a sound having a frequency of 1000 Hz will have a higher pitch and a shrill sound.

Pronounce the letter 'O' the sound produced is of a lower pitch. Now pronounce the letter 'E'. It will be of a higher pitch.

FREQUENCY OF VIBRATIONS AND QUALITY OF SOUND

We all like music while some sounds are disturbing. Why are some sounds pleasant and some not ? When a source of sound vibrates, it actually vibrates with many frequencies. The quality of sound depends on different frequencies in the sound wave. A musical note is produced by a combination of frequencies which are in a simple mathematical ratio of whole numbers with each other. For example any two sounds produced one after the other their frequencies are in the ratio of 2 : 3 will produce musical notes. Similarly, three sounds with frequencies 261.62 Hz, 523.24 Hz and 784.86 Hz produce musical notes when played together.

All objects do not produce pleasant sounds. This is because they vibrate at a set of frequencies which have no simple mathematical relationship between them. Such vibrations produce noise. When a metal plate is dropped on the floor, it vibrates with a number of frequencies, producing a complex sound wave which can be termed as noise set of frequencies produced by an object when it was dropped on the ground is given below. 190 Hz, 223 Hz, 329 Hz. These frequencies are not in all ratio of whole numbers, hence such sounds would produce noise.

People in India had perfected the science of producing musical notes much before modern science could explain it. They did not only made high quality musical instruments but were even able to construct stone structures designed to produce musical notes.

The 16th century Vitthala temple at Hampi in Karnataka had a magical feature. It has fifty –six pillars, each of which produce a different musical tone when tapped.

Musical Instruments

Music is a combination of sound waves in an orderly manner. Musical instruments are designed to produce pleasant sounds. To produce good music one has to learn to play a musical instrument so that sounds having a particular frequency can be produced, otherwise one ends up producing noise. Musical instruments can be classified into full types stringed, wind, percussion keyboard and electronic musical instruments.

Stringed Instruments

In a stringed instrument such as a box guitar sound is produced by the vibrating metal strings. Metal strings of different thickness and length are used to produce musical notes. A guitarist

is able to produce musical sounds by changing the length of the strings by pressing them at different lengths with the fingers and then plucking the strings. A box guitar also has a hollow chamber which increases the loudness of the sound.

Wind Instruments : A wind instrument like the flute produces by vibrating column of air. Various musical sound can be produced by modifying the length of the air column in the flute by closing or opening the holes.

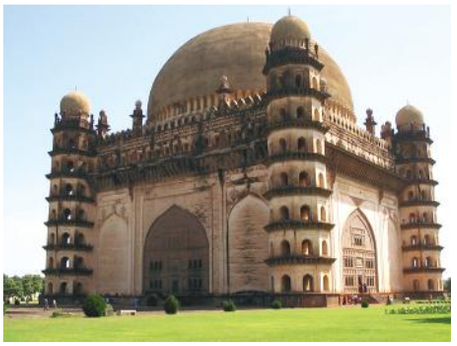
Percussion Instruments : The drum and tabla are percussion instruments they produce sound by vibrating the membrane with the fingers or palm.

Reflection of Sound

The sound waves like the rays of light get reflected after striking a surface. A reflected sound creates an echo. Echoes are reflected on walls or hard surfaces like mountains. To hear an echo or the reflected sound the original sound and the reflected sound should be separated by a time interval of at least one-tenth of a second. This means, if two sounds occur within one-tenth of a second, you will not hear them as separate sounds. This is because the human ear cannot distinguish such sounds if they are not separated by one-tenth of a second. Such sounds will be a noise to the human ear.

To hear an echo, a person should be a round 18 metres away from the object such as a wall that would reflect a sound. A sound produced from this distance, travel all together 36 meters when reflected. To travel, this distance, sound waves would take little more than one-tenth of a second. That is why you can hear an echo.

At Bijapur, Karnataka, there is a famous monument named Gol Gumbaz. It is an architectural marvel and is the second largest free standing dome in the world. Surrounding the dome is a balcony which is known as the whispering gallery. Even the slightest whisper from the gallery echoes itself around ten times. A sound whispered from one corner of the gallery can be heard clearly on the diagonally opposite side. What is amazing is that the echoes from certain spots can be continuously heard for 25 seconds.



Gol Gumbaz, Bijapur, Karnataka

Golconda Fort, Hyderabad

The Golconda fort in Hyderabad, Andhra Pradesh is another architectural wonder, known for its acoustical system. While entering from the main gate of the fort, if one claps below the Grand portico, echoes are heard in a Darbar Hall the highest point of the fort, some 128 metres away.

Example 1 : Amit starts 172 metres away from a steep wall of a fort. He calls his friend and hears the echo of his voice a second later. What is the speed of the sound wave per second ?

Answer :- The speed of the sound wave was 344 m/s.

Example 2 : Once Ajay was travelling with his mother in a car. On the way, they stopped near a hill. Ajay let out a shout to find out if he could hear an echo and he did. Ajay then shouted 4 times and his mother noted the time for each echo. The echoes were heard after 0.9s, is 0.8s and 0.9s. If the speed of the sound wave in the air is 342 m/s calculate the distance from Ajay to the nearby hill.

The average time taken by the echo = $\frac{0{\cdot}9 + 1{\cdot}0 + 0{\cdot}8 + 0{\cdot}9}{4}$ = 0.9s

Speed of sound is given as 342 m/s

Therefore, distance travelled by sound in 0.9s

= $\frac{95}{10}$ × 342m= 307·8m

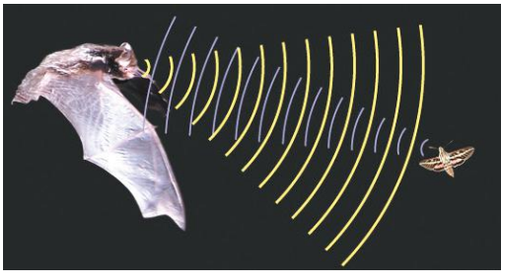
Echo is a reflection of sound

Therefore one way distance = $\frac{307.8\text{m}}{2}$ = 153.9m

Answer : The distance between Ajay and the hill is about 153.9 m.

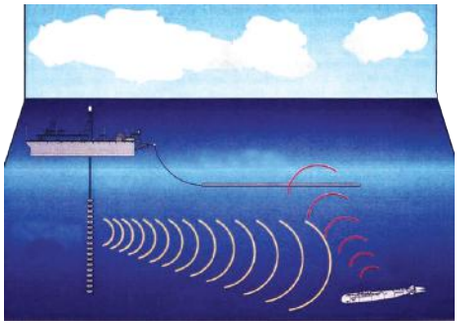
Applications of Echo : Echo has many useful applications. Animals like bats and dolphins have a fine sense of locating echoes. They produce high-pitched sounds. The sounds bounce off the objects they hit and return to them as an echo. By listening to how long it takes for echoes to bounce back, these animals are able to correctly judge the type of object, distance and direction of the object. For example, just by the type of echo produced, a dolphin is able to know the difference between hidden rocks and hidden fish. Even fish hidden under the sand are not safe. Such information helps them to locate food in darkness or poor light conditions. It also helps them to avoid objects in their path of movement.

Bats are able to locate objects in the darkness and fly safely at night. Bats that feed on insects are able to locate insects and feed on them while they are still flying.



Bats use sound waves that echo to help them hunt their prey

Sonar System



Sonar is used to detect underwater objects

Modern technology has also grined from the science of reflected sound. SONAR (Sound Navigation and Ranging) is used to locate objects. Under water sonar systems are of two types-active and passive. In active sonar, the system emits a sound and then receives the reflected sounds and processes the sounds. In passive sonar, the system receives and process sounds emitted by the object if is trying to locate it.

The sonar system that is used to map the sea floor or locate sunken vessels is based on active sonar system. The instrument is fired on a ship. It produces a large number of sounds in a short period of time. The sound is directed towards the sea floor. The sounds bounce off the sea floor at different angles and are received by the computers located on the ship. The information is then processed by the computer and converted into a detailed map of the sea floor. Some Sonar is also used to detect under water objects and shoals of fish by fishing boats.

Sonography

Sonography is a technique by which sound waves are bounced back from the human body and then reflections (echoes) are captured by a machine which transforms them into an image that can be seen on the screen.

Sonograpy is a safe method of studying the internal parts of the body including the well-being of a baby developing in the mother's womb.

What is Noise?

Unpleasant sound is called noise. Noise is produced by irregular and loud vibrations. The loudness of a sound is measured by a unit called decibel (db). A sound that can barely be heard by a person with good hearing is given the valve of 0 decibels (db).

Decibel ratings of some common sounds are given in the table.

A human ear can tolerate sounds up to 80 decibels. Exposure to sounds of higher decibel values can cause various health problems and damage to the ear.

Sound	Decibels
Whisper	10-20
Quiet office	20-40
Conversation	40-60
High traffic	40-60
Heavy traffic	70-80
Air drill machines	90-100
Thunder	110
Jet plane	140

NOISE POLLUTION

Noise pollution

Some sounds are disturbing. Such sounds are called noise. A disturbing sound need not always be very loud. We all know how disturbing a drop of water trickling into an empty bucket can be, dogs barking at night can be very annoying at night when every thing is quiet, the sound of a speeding motor vehicle can be eternally disturbing. Even loud music can add to the noise. Any unwanted sound can be disturbing. Unwanted sound gives rise to what is known as noise pollution. Sounds that are loud, annoying or harmful to the human ear contribute to noise pollution.

Effects of Noise Pollution

Noise pollution can effect our health and behaviour. Constant exposure to noise can have ill effects on a person. It can also make a person ill-tempered and restless and even lead to high blood pressure and heart problems. Excessive noise disturbs sleep, leads to lack of concentration especially among students. It can also cause headache and earache. A sudden loud blast can tear the ear drum and lead to permanent loss of hearing. It should be noted that constant use of ear phones, to listen to loud musician lead to hearing loss and can cause permanent damage to the ears.

An echo can also be detected by devices linked to computers. Echoes have several technological applications.

How to Lessen Noise Pollution?

Noise is mainly produced by motor vehicles, aircraft and machines.

Avoid using loud speakers during celebrations.

Do not play loud music.

Do not drive, motor vehicles at high speed in residential areas, near school or hospital.

Use horn only when necessary.

Avoid bursting fire works that make loud noise.

Plant, trees in your surroundings as they act as sound absorbers.

Know the Keywords :

Sound : Something we hear as a result of vibrations of a body.

Vibrations : Fast to and fro movements or the oscillatory motion of a body which may produce sound.

Frequency : The number of vibrations produced per second.

Hertz : The unit of frequency.

Time period : The time taken to complete one vibration.

Reflection of sound : Change of direction of the sound waves when they strike an object.

Point to Remember

- Sound travels from its source to our ears.
- Music is a combination of sound waves in an orderly manner.
- SONAR (Sound Navigation and Ranging) is used to locate objects.

EXERCISE TIME

A. Answer the following questions :

1. Write the different ways in which the sound can be produced.

2. When does an object produce sound ?
3. Explain amplitude of sound with a diagram.
4. What determines the loudness of sound ?
5. Draw a diagram to explain the frequency of sound.
6. What creates sound pollution ?
7. What is an echo ?
8. Why does a metal plate falling on the ground produces noise ?
9. Why is a person standing at 12m from a wall that produces an echo not hear it ?
10. How does a box guitar produce musical sounds ?

B. Fill in the blanks :

1. Sound cannot travel through _____.
2. Sound requires a _____ to travel.
3. The number of vibrations per second defines _____.
4. The S.I. unit of frequency is _____.
5. We cannot hear sounds below _____ Hz. These are called _____.

C. Tick (✓) the correct option :

1. Sound waves travel faster in :
   (i) air ◯ (ii) vacuum ◯ (iii) liquid ◯
2. Sounds having frequency less than 20 Hz are called :
   (i) ultrasonics ◯ (ii) sonar ◯ (iii) supersonic ◯
3. Unpleasant sound is called :
   (i) pitch ◯ (ii) echo ◯ (iii) frequency ◯
4. In sitar, sound is produced by :
   (i) rubbing ◯ (ii) blowing ◯ (iii) plucking ◯
5. A tuning fork of frequency 384 Hz produces a lower note than one of frequency :
   (i) 512 Hz ◯ (ii) 288 Hz ◯ (iii) 256 Hz ◯
6. The amplitude of the sound wave decides its :
   (i) speed ◯ (ii) loudness ◯ (iii) source ◯

Creative Work

- **Make a toy telephone and use it to experience how sound travels through solids.**