Sound

TALENT & OLYMPIAD

Introduction

Right from our birth we learn to recognize each other organisms with the help of the sound produced by them. We hear different sounds in our surroundings produced by the different organisms. A small baby recognize his/her parents from their sounds and responds to it. Thus, **we can say that sound is a form of energy which produce a sensation of hearing**.

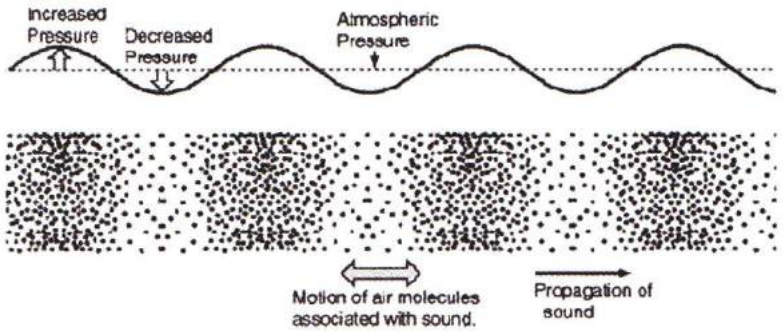
Production of Sounds

The most important question that comes to our mind when we study sound is that 'how is sound produced by different organisms?' The correct answer to this question is that whenever something vibrates due to disturbance produced in the medium, the sound is produced. Sound is produced whenever we speak, or whenever we strikes something with the help of hard objects. In each case the sound is produced due to vibration in the medium. The tunning fork is used to produced a specific type of sound. It is a U shaped steel device with a stem at base. Whenever it is strike against a rubber pad cause the prong to start vibration and these vibration produces sound.

Propagation of Sound

We know that sound is produced by the vibration in the medium, the substance through which sound is transmitted is called a medium. The medium may be solid, liquid or gas. When an object vibrates, it sets the particle of the medium around it in vibration. The particle do not move from its place. It's the disturbance that travels through the medium. A particle of the medium in contact with the vibrating object is first displaced from its equilibrium position, and then it exerts a force on the adjacent particles, as a result of which the adjacent particle gets displaced from its position of rest. After displacing the adjacent particles, the first particles comes back to its original position and this process continues in the medium, till the sound reaches our ear.

Thus, a wave is a disturbance which travels through the medium when the particles of the medium starts vibrating. The sound waves are characterized by the motion of particles in the medium and are called mechanical waves. Air is the most common medium through which sound travels. Whenever the vibration starts, it pushes air particles in front of it and creates a region of high pressure. This region of high pressure is called compression. The compression starts to move away from the objects. As the object moves backward, it creates the region of low pressure, which is called the rarefaction. When the object moves backward and forward very rapidly, a series of **compression and rarefaction** are formed. Thus, sound is propagated through the medium in the form of compression and rarefaction.



Commonly Asked QUESTIONS

What happens during the motion of the wave through a medium?

(a) Particles of the medium moves from one place to another

(b) Energy is transferred in a periodic manner

(b) Energy is transferred from one particle to another at a constant speed

(d) All the statements are correct.

(e) None of these

Answer: (b)

What is sound?

(a) Vibration of particles of the medium

(b) It is a form of energy which produces the sensation of hearing

(b) Particle vibrates along the direction of propagation

(d) A form of disturbance

(e) None of these

Answer: (b)

How is sound produced?

(a) Vibration of particle of the medium

(b) It is a form of energy which produces the sensation of hearing

(b) Particle vibrates along the direction of propagation

(d) Sound is produced due to disturbance created in a medium

(e) None of these

Answer; (d)

What is compression?

(a) The region of high pressure created in the medium when the sound travels through the it.

(b) The region of low pressure created in the medium when the sound travels through the it.

(b) The medium through which disturbance travels

(d) The medium without disturbance

(e) None of these

Answer: (a)

Sound Needs Medium

We know that sound is a **mechanical wave** and needs a material medium to travel. It cannot travel through vacuum. We cannot hear the sound of any other person when we go into outer space, as their is no medium in the outer space through which disturbance can travel. We can demonstrate this with the help of the following activities.

Take a glass jar and place an electric bell inside it and connect it with vacuum pump. If we press the switch of the electric bell and simultaneously start the vacuum pump, we observe that the sound gets fainter and fainter as the air molecule is pumped out of the jar with the help of pump. When all the air are removed from the jar we do not hear the sound of the electric bell any more. This shows that sound needs medium to travel and cannot travel through vacuum.

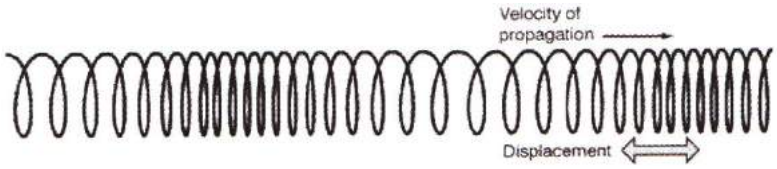
Types of Waves

There are different types of waves:

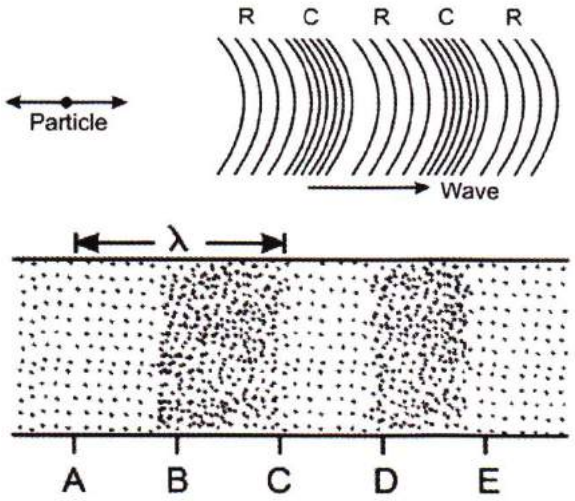
- Mechanical Waves
- Electromagnetic waves

Mechanical Waves

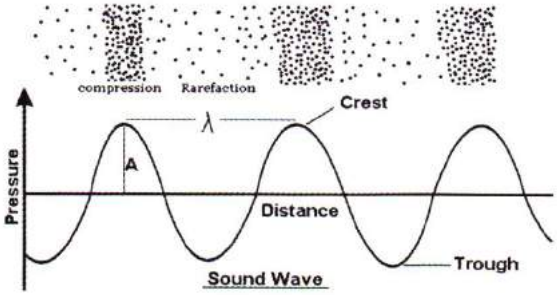
The wave which can be produced or propagated only in a material medium is called **mechanical wave**. It is of two types **Longitudinal waves and Transverse waves**.



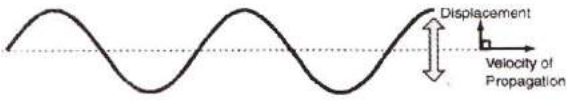
- **Longitudinal Waves: The** waves, in which particle of the medium vibrates in the direction of propagation, are called the longitudinal waves.
  For example, the sound wave is a longitudinal waves. These Wave travels through a medium in the form of compressions or rarefactions.
- **Compressions:** It is the region in which the particles come closer because the distance becomes less as compared to normal distance. Thus volume decreases and density increases.



- **Rarefactions:** It is the region in which the particles get farther away as compared to normal case. Thus, volume increases and density decreases.



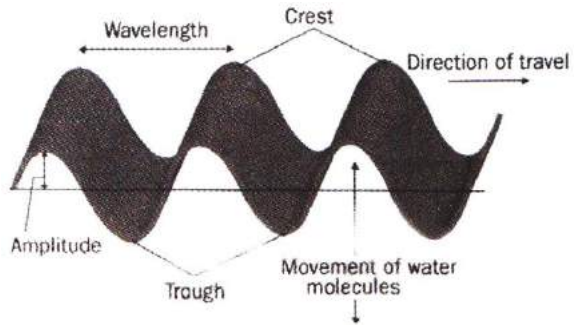
- **Transverse Waves:** The wave in which particle of the medium vibrates in the direction, right angle to the direction of propagation are called **transverse waves**.



For example, the light waves are transverse waves.

Properties of a Transverse Wave

A transverse wave travels through a medium in the form of crests and troughs.



Electromagnetic Waves

The wave produced by magnetic effect of current are called electromagnetic waves. These waves do not require any medium for their propagation. For example, radio waves, microwaves, x rays, etc.

Commonly Asked QUESTIONS

Which one of the following is a transverse wave?

(a) Horn
(b) Sound of table
(b) Light
(d) Sound of wood
(e) None of these

Answer: (b)

Which one of the following is common in both Sound and light waves?

(a) Have similar wavelength
(b) Obey the laws of reflection
(b) Travel as longitudinal waves
(d) Travel through vacuum
(e) None of these

Answer: (b)

Which of the following will remain unchanged when a sound wave travels in air or in water?

(a) Amplitude
(b) Wavelength
(b) Frequency
(d) Speed
(e) None of these

Answer: (b)

The speed of sound in medium depends upon:

(a) Amplitude
(b) Wavelength
(b) Frequency
(d) Properties of the medium
(e) None of these

Answer: (d)

Sound cannot travel through which one of the following medium?

(a) Air
(b) Water
(b) Vacuum
(d) Steel
(e) None of these

Answer: (b)

Sound waves are __.

(a) Longitudinal

(b) Transverse

(b) Partly longitudinal and partly transverse

(d) Sometimes longitudinal and sometimes transverse

(e) None of these

Answer: (a)

Sound

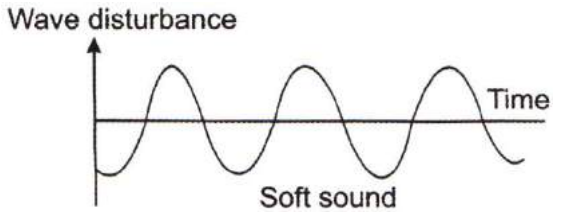
It is the form of energy that produces sensation of hearing in our ears.

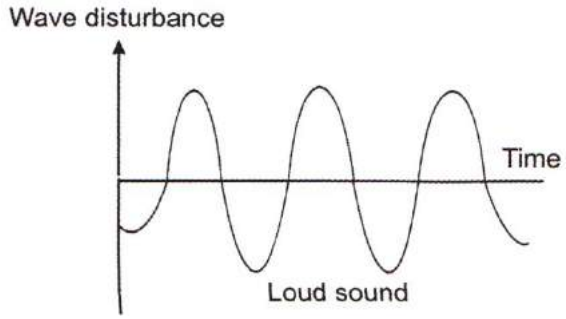
Properties of the Sound

Sound needs a medium to travel. Sound waves are longitudinal waves i.e., particles of the medium vibrate in a direction parallel to the direction of propagation of the wave. During the vibration of particles of the medium, regions of compression and rarefaction are formed. Compression is a region of high density and pressure, whereas the rarefaction is a region of low density and pressure.

Characteristics of a Sound Wave

A sound wave is represented graphically as follows:





Soft sound has small amplitude and louder sound has large amplitude.

Here, crests denote the compressions and troughs denote the rarefactions.

- **Frequency:** It is the number of vibrations made by a vibrating object per unit time. It is represented by the symbol of **'f'** and measured in **hertz (Hz)**.
  It tells us how frequently an event occurs. It decides the pitch of the sound.

It is given by $f = \frac{1}{T}$

- **Amplitude :** It is the maximum distance upto which a vibrating particle moves from its original equilibrium position. It is represented by 'A'. Its unit is meter. It determines the loudness of the sound.
- **Time period :** It is the time taken by the wave to complete one oscillation. It is denoted by T.
- **Wavelength :** It is the distance between two successive compressions or two successive rarefactions. It is represented by the symbol ' λ ' and its unit is meter.
- **Speed :** The distance travelled by a sound in unit time is called its speed. The speed of sound is different in different media. Sound travels fastest in solids and slowest in gases.

A sound of single frequency is called **tone** and a sound made of several frequencies is called **note**. The amount of sound energy passing through unit area is called the intensity of sound.

Relation between Wavelength, Frequency and Speed

Let 'v' be the speed of the sound ' λ ' is the wavelength and T is the time period, then the relation is given by

$v = \frac{\lambda}{T}$ Or, $v = \lambda \times f$

Sonic Boom

When the speed of any object exceeds the speed of sound, then it is said to be travelling with supersonic speed. When the sound producing source moves with a speed higher than the speed of sound, it produces shock waves in air.

These shock waves carry a large amount of energy. The air pressure variation associated with this type of shock waves produces a very sharp and loud sound called the sonic **boom**.

Commonly Asked QUESTIONS

Which of the following is not a characteristic of a musical sound?

(a) Pitch (b) Wavelength

(b) Quality (d) Loudness

(e) None of these

Answer: (b)

The amplitude of a wave is ____.

(a) The distance the wave moves in one second

(b) The distance the wave moves in one time period of the wave

(b) The maximum distance moved by the medium particles on either side of the mean position

(d) The distance equal to one wave length

(e) None of these

Answer: (b)

The physical quantity, which oscillates in most waves, is:

(a) Mass
(b) Energy
(b) Amplitude
(d) Wavelength
(e) None of these

Answer: (b)

The frequency which is not audible to the human ear is:

(a) 30 Hr
(b) 300 Hz
(b) 3000 Hz
(d) 30000 Hz
(e) None of these

Answer: (d)

A sound source sends waves of 100 Hz. It produces waves of wavelength 3 m. The velocity of sound waves is:

(a) 100 m/s
(b) 300 m/s
(c) 10000 m/s
(d) 3000 km/s
(e) None of these

Answer: (b)

The time period of a vibrating body is 0.05 s. The frequency of waves it emits is:

(a) 2 Hz
(b) 20 Hz
(c) 100 Hz
(d) 300 Hz
(e) None of these

Answer: (b)

A source of frequency of 500 Hz emits waves of wavelength 0.4 m, how long does the waves take to travel 600 m?

(a) 3s
(b) 5s
(c) 8s
(d) 9s
(e) None of these

Answer: (a)

Reflection of Sound

Sounds bounces off when it strikes the solid or liquid surfaces. As in case of ball bounces off when it strikes the wall or the surface of earth. It follows the same laws of reflection as it is followed by the light. The, bouncing back of sound when it strikes a polished surface is known as the **reflection of sound**.

There are two phenomenon of reflection of sound, that is. **Echo and Reverberation**.

Echo

The successive reflection of sound from a number of reflecting surfaces is called Echo. Whenever we shout or clap near a reflecting surfaces such as tall building or mountain or in an empty hall, we will hear the same sound again a little later. This sound we hear is called echo. The sensation of sound persist in our brain for nearly 0.1 second. Thus, to hear the distinct echo, the time interval between the original sound and the reflected one must be at least 0.1 second. The speed of sound in air at 20°C is almost **344 m/sec**. Hence the total distance from the point of production of sound to the target and again return back must be atleast **344 x 0.1 = 34.4 meters**. Thus, for hearing distinct echo the minimum distance should be atleast **17.2 meters**.

Reverberation

The persistence of sound due to repeated reflection and its gradual fading away is called reverberation of sound.

This situation some time occurs in a big hall, such as auditorium, where excessive reverberation is undesirable. To reduce the reverberation of sound, the roof and wall of hall and auditorium are generally covered with sound absorbent materials like compressed fiberboard, rough plaster or draperies.

The seat material are also selected on the basis of their sound absorbing properties.

Application of sound:

- The property of reflection of sound is used in **megaphones, loudspeakers, horns, trumpets, etc**.
- It is used in stethoscope used by the doctors to check the heart beat and impulse.
- The ceiling of concert halls, cinema halls, are curved so that sound after reflection reaches all corners of the halls evenly.

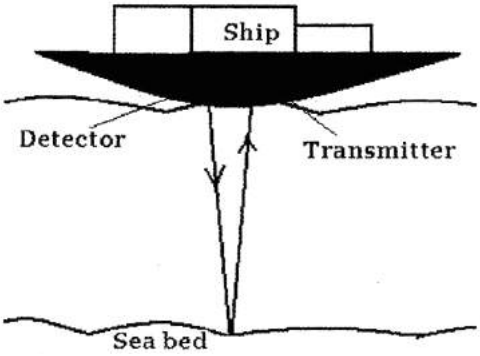
Types of sound

The sound is classified into three categories on the basis of their frequency. They are Audible sound, Infrasound, and Ultrasound.

- **Audible sounds:** The sounds having frequency between 20 Hz to 20,000 Hz. The sounds within this range can be heard by the human beings.
- **Infrasound:** The sounds having frequency less than 20 Hz, Sounds produced by the vibrations of the wings of the bee, sounds produced by whales and elephants are the examples of infrasound's.
- **Ultrasound:** The sounds having frequency more than 20,000 Hz. Sounds produced by dolphins, bats and porpoises are the examples of ultrasounds.

Applications of ultrasounds

- It is used in electrocardiography to view the image of the heart.
- It is applied in **ultrasonography (ultrasound)** for examination of various internal organs like, kidney, etc and to detect abnormalities in the foetus during pregnancy.
- It is used in **SONAR (Sound Navigation and Ranging)** to determine the depth of the sea and to locate underwater objects like sunken ships, hills, icebergs, etc. The formula used is:



$2d = v \times t$

Where, d = depth of the sea

v = velocity of the sound in the medium

t = time interval between transmission and reception of the ultrasounds.

It is used to detect cracks and flaws in metal blocks.

Commonly Asked QUESTIONS

The persistence of audible sound due to the successive reflections from the surrounding objects even after the source has stopped to produce that sound, is called _____.

(a) Reflection
(b) Echo
(c) Reverberation
(d) Rarefaction
(e) None of these

Answer : (c)

Which of the following quantities is transferred during wave propagation?

(a) Energy
(b) Matter
(c) Mass
(d) Speed
(e) None of these

Answer: (a)

The minimum distance between the source and the reflector so that an echo is heard is approximately equal to ____.

(a) 34.4m
(b) 18.5m
(c) 20.2m
(d) 17.2m
(e) None of these

Answer: (d)

Bats detect the obstacles in their path by receiving the reflected _____.

(a) X- rays (b) Ultrasonic waves
(c) Electromagnetic waves (d) Infrasonic waves
(e) None of these
Answer: (b)

The method of detecting the presence, position and direction of motion of distant objects by reflecting a beam of sound waves is known as ___.

(a) SONAR (b) MIR
(c) CRO (d) RADAR
(e) None of these
Answer: (a)

Human Ear

Human ear is one of the most important sense organ which enables human to hear the sound distinctly, also to recognize the sound. The human ear is divided into three parts **outer ear, middle ear and inner ear**.

The outer ear consist of the pinna and ear canal. It collects the sound from the surrounding and transmit it to the middle ear. The middle ear consist of eardrum and three interconnected bones called hammer, anvil and stirrup. These three bones amplifiy the sound several times and transmit it to the inner ear. The inner ear consists of a liquid filled coiled tube called the cochlea. It converts these sounds into electrical signals and then send to the brain via auditory nerve. The brain interprets the sound and reacts accordingly.

Commonly Asked QUESTIONS

The vibrations or the pressure variations inside the inner ear are converted into electrical signals by the_____.

(a) Cochlea (b) Anvil
(c) Hammer (d) Stirrup

(e) None of these

Answer: (a)

Vibrations inside the ear are amplified by the three bones namely the _____ in the middle ear.

(a) Hammer, Anvil and Pinna (b) Auditory bone. Anvil and Stirrup

(c) Hammer, Cochlea and Stirrup (d) Hammer/Anvil and Stirrup

(e) None of these

Answer: (d)

SUMMARY

- Disturbance created in the medium is called **waves**.
- Sound is a **longitudinal** waves,
- The distance between two consecutive crest or trough is called **wavelength**.
- The number of vibration per second is called **frequency**.
- The maximum upward or downward displacement about the mean positon is called **amplitude**.
- The reflection of sound after striking the surface after some time is called echo.
- The persistence of sound after repeated reflection is called **reverberation** of sound.
- Ultrasound can be used in medical science for **ultrasonography** and **echocardiography**.
- Ultrasound can be used to find the distance of underwater objects.

Self Evaluation TEST

Duration 10 Minutes

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1. Which one of the following is an example of mechanical wave?

(a) Radio wave
(b) Light wave
(c) Infrared radiation
(d) Sound wave
(e) None of these

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2. If a vibrator strikes the water 10 times in one second, then the frequency of wave is _____.

(a) 10 Hz
(b) 5 Hz
(c) 1Hz
(d) 0.5 Hz
(e) None of these

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3. The distance between a compression and the next rarefaction of a longitudinal wave is _____.

(a) $\frac{\lambda}{2}$
(b) $\frac{\lambda}{3}$
(c) $\frac{\lambda}{4}$
(d) λ
(e) None of these

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4. What is the unit of wavelength?

(a) Erg
(b) Dyne
(c) Angstrom
(d) Newton
(e) None of these

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5. The technique used by bats to find their way or to locate food is __.

(a) SONAR
(b) RADAR
(c) Echolocation
(d) Flapping
(e) None of these

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6. An ultrasonic wave is sent from a ship towards the bottom of the sea. It is found that the time interval between the sending and receiving of the wave is 1.6 s. What is the depth of the sea, if the velocity of sound in the seawater is 1400 m/s?

(a) 980 m
(b) 1240 m
(c) 1054 m
(d) 1120 m
(e) None of these

7. **The relation between wave velocity V, frequency 'f ', and wavelength T is____.**

(a) $v = \frac{f}{\lambda}$ (b) $v = f\lambda$

(c) $v = \frac{\lambda}{f}$ (d) $v = \frac{1}{f\lambda}$

(e) None of these

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8. **The frequency of a wave travelling at a speed of 500 ms1 is 25 Hz. Its time period will be ____.**

(a) 0.04 s (b) 0.05 s

(c) 0.02 s (d) 0.01 s

(e) None of these

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9. **The eardrum is a:**

(a) Bone (b) Tube

(c) Fluid (d) Stretched membrane

(e) None of these

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10. **The term that describes how brain interprets the frequency of a sound is called:**

(a) Pitch (b) Note

(c) Tone (d) Quality

(e) None of these

Answers – Self Evaluation Test																			
1.	D	**2.**	A	**3.**	A	**4.**	C	**5.**	C	**6.**	D	**7.**	B	**8.**	A	**9.**	D	**10.**	A