Sound

Sound is due to vibration

Sound is a form of energy produced by vibrating matter. Vibrations of the body cause vibrations in the particles of the surrounding medium which travel in the form of waves with a certain speed. An example to demonstrate the above statement is the sound produced on plucking a tight string.

Example
Tuning Fork

The tuning fork consists of a handle and two prongs (tines). When the tuning fork is hit on a rubber pad, the prongs begin to vibrate. These vibrations in the form of sound are transmitted through the medium near it in the form of waves.
Definition
Waveform
Waveform of sound is the shape and form of the sound wave moving in a physical medium. Some examples of waveforms are rectangular, sinusoidal, triangular, etc.
Example
Vibrating Tuning Fork

Vibrating a tuning fork produces sound involving the to-and-fro motion of the prongs of the fork about the mean position.
When the vibrating prongs of the tuning fork moves forward, it pushes and compresses the particles in front when moving outwards, creating a region of high pressure, called compression.
If the prong moves backwards, it creates a region of low pressure, called a rarefaction.
Due to these series of compressions and rarefactions in the air between the fork and the listener, a sound wave propagates through the medium.
Example
Sound waves are longitudinal waves
Sound waves in air (and any fluid medium) are longitudinal waves. In sound waves, particles of the medium through which the sound is transported vibrates parallel to the direction that the sound wave moves.
Diagram
Compression and Rarefactions by vibrating slinky/speaker
Compression and rarefactions created by the speaker in the air are shown in the image.

Amplitude of vibration
The magnitude of the maximum disturbance of particles in the medium on either side of the mean value is called the amplitude of the wave. It is usually represented by the letter A. Its SI unit is metre (m).

Transverse waves and longitudinal waves

Transverse wave: If the vibrations of the particles of the medium conveying a wave are perpendicular to the direction of propagation of the wave, the wave is called a transverse wave.The wave travels in the form of crests and troughs. They travel through mediums with rigidity like solids.
Longitudinal wave: If the vibrations of the particles of the medium conveying a wave are to and fro and parallel to the direction of propagation of the wave, then the wave is called a longitudinal wave. The wave travels in the form of compressions and rarefactions.

Time period of vibration

The time taken to complete one vibration in the density of the medium is called the time period of the sound wave. It is represented by the symbol T. Its SI unit is second (s).
Definition

Frequency of vibration

The number of vibrations per unit time is called the frequency of the sound wave. It is represented by f or v. Its SI unit is hertz (Hz).
$f=1T$
where T: Time period

Factors affecting the pitch of sound

Pitch of the sound depends on the frequency of the sound wave. The pitch is affected by the source of production of sound wave. It also depends on the shape of the medium in which it travels. It does not depend on the properties of the medium.

Timbre

Timbre (or Quality) is the characteristic of sound wave that distinguishes two sound waves (generally produced from different sources) having same loudness and pitch. It depends on the shape of the waveform. For example, it is possible for a note produced by a flute and a piano to have same pitch and loudness, but always sound different.

Factors affecting the loudness of sound

Factors affecting the loudness of sound are amplitude of the wave, distance of the source from the ear, surface area of the vibrating body, density of the medium and the presence of resonant bodies.

Loudness of sound

Loudness is a sensation of how strong a sound wave is at a place. It is always a relative term. It is a dimensionless quantity. Its unit is decibel (dB). It is given by:
$L=\log(I)$
where I: Intensity of sound.
Difference of loudness, $L2-L1=10\log10(I1I0)$
Note:I□A2 where A: amplitude.

Echo

Echo is the sound heard after reflection from a distant obstacle after the original sound has ceased. It is often heard at high altitudes because of the large distances between the mountains.

Minimum distance required to hear an echo

An echo is heard only if the distance between the person producing sound and the rigid obstacle is long enough to allow the reflected sound to reach the person atleast 0.1 second after the original sound is heard. Otherwise, the echo is not distinguished even on reaching the ears. This value can be calculated and comes out to be 17.2 m for air and 70 m for water.

Reverberations

A sound created in a big hall persists by repeated reflections from the walls until it is reduced in intensity to an undetectable value. The repeated reflections that results in the persistence of sound are called reverberations. They are undesirable as the reflections interfere among themselves and make the sound difficult to understand. Reverberations are reduced by reducing the reflections from the walls of large halls by covering them by sound-absorbent materials like rough plaster and fibreboard.

Uses of multiple reflections of sound

Uses of multiple reflections of sound are:
Sound producing devices that uses a conical shape like megaphones to increase the intensity of sound waves in particular directions.
Stethoscope: Sound undergoes multiple reflections in the wires of the stethoscope.
Curved ceilings of halls and use of soundboards to evenly distribute the sound across the hall.

Differentiate between audible,ultrasonic and infra-sonic frequency range and give examples

Sound waves are divided into three categories that cover different frequency ranges. They are as follows:
(1) Audible waves are waves that lie within the range of sensitivity of the human ear. They can be generated in a variety of ways, such as by musical instruments, human vocal cords, and louds
(2) Infrasonic waves are waves having frequencies below the audible range. Elephants can use infrasonic waves to communicate with each other, even when separated by many kilometers.
(3) Ultrasonic waves are waves having frequencies above the audible range. Ultrasonic waves are used in medical imaging.

Applications of ultrasound

Ultrasound are used by bats to locate obstacles in their path, to drill holes in materials like glass, cleaning minute objects, detection of defects in metals, imaging human organs by ultrasonography and echo cardiography, remove cataract and in SONAR(Sound navigation and ranging) to detect and find distance of objects under water.

Audible Range of Sound

The human ear responds to sounds with frequencies in the range from 20 Hz to 20,000 Hz. This is called the audible range of the human ear. Drums, guitar strings, tuning fork, human vocal cords and diaphragms of loudspeakers are examples of audible range of sound
Audible sound waves whose frequencies are less than 20 Hz are in the infrasonic range. Sound produced by earthquakes, thunder, volcanoes are in Infrasonic range. Human Ear cant hear this sound but elephants and whales can hear this.
Frequencies above 20,000 Hz are in the ultrasonic range. The audible range of dogs, cats, moths and mice extends into ultrasound frequencies. They can hear very high frequencies that humans cannot.

SONAR

SONAR (Sound navigation and ranging) is a method used in submarines and ships to detect far away objects and obstacles in water. It is based on the principle of reflection of ultrasound waves. It has various applications like echo depth sounding (to find the depth of the sea), detecting enemy submarine etc.
Distance (d) of an object can be obtained as:
$d=vt/2$ where v is speed of ultrasound and t is the time between sending the ultrasound and receiving its echo.