JSR IAS ACADEMY

GENERAL SCIENCE

PHYSICS

SOUND - 2

Characteristic of wave motion

- In wave motion, only the energy is transferred not the particles.
- The velocity of the wave motion is different from the velocity of the vibrating particle.

Properties of Sound

- All sounds that you hear are not the same.
- There are some properties that differentiate one kind of sound from another.

Distinguishing different Sounds

Sounds can be distinguished from one another in terms of the following three different factors.

1. Loudness
2. Pitch
3. Timbre (or quality)

1. Loudness and Intensity

- Loudness is a quantity by virtue of which a sound can be distinguished from another one, both having the same frequency.
- Loudness or softness of sound depends on the amplitude of the wave.
- It is defined as the characteristic of a sound that enables us to distinguish a weak or feeble sound from a loud sound.
- When a drum is softly beaten, a weak sound is produced. However, when it is beaten strongly, a loud sound is produced.
- The unit of loudness of sound is decibel (dB).

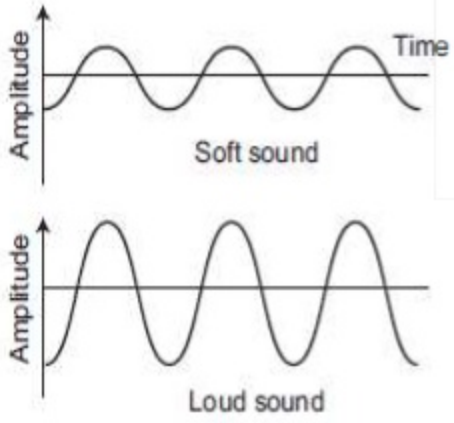


Figure 8.4 Soft and loud sound

- The loudness of a sound depends on the intensity of sound wave.
- Intensity is defined as the amount of energy crossing per unit area per unit time perpendicular to the direction of propagation of the wave.

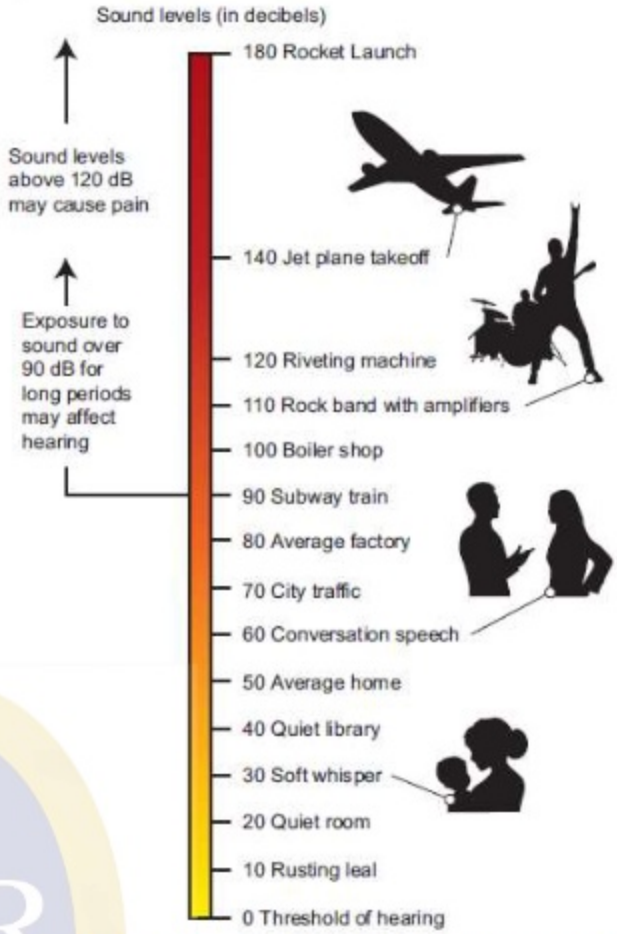


Figure 8.5 Intensity level of sound

The intensity of sound heard at a place depends on the following five factors.

i. Amplitude of the source.
ii. Distance of the observer from the source.
iii. Surface area of the source.
iv. Density of the medium.
v. Frequency of the source.

- It is named in honour of the Scottish-born scientist Alexander Graham Bell who invented telephone.

DO YOU KNOW?

The seismic wave formed during earthquake is an example for a longitudinal wave. Waves travelling through the layers of the Earth due to explosions, earthquakes and volcanic explosions are called seismic waves. Using a hydrophone and seismometer one can study these waves and record them. Seismology is the branch of science that deals with the study of seismic waves.

2. Pitch

- Pitch is one of the characteristics of sound by which we can distinguish whether a sound is shrill or base.
- High pitch sound is shrill and low pitch sound is flat.
- The sound produced by a whistle, a bell, a flute and a violin are high pitch sounds.
- Normally, the voice of a female has a higher pitch than a male.
- That is why a female's voice is shriller than a male's voice.
- Some examples of low pitch sound are the roar of a lion and the beating of a drum.

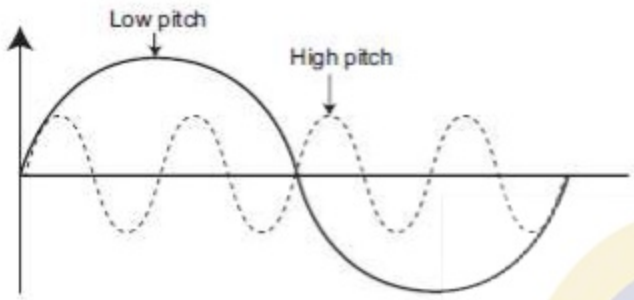


Figure 8.6 Low pitch and high pitch sounds

3. Timbre or Quality

- Timbre is the characteristic which distinguishes two sounds of same loudness and pitch emitted by two different instruments.
- A sound of single frequency is called a tone and a collection of tones is called a note.
- Timbre is then a general term for the distinguishable characteristics of a tone.

Musical Instruments

Music is produced by the regular patterns of vibrations.

Musical instruments are categorized into four types as given below.

- Wind instruments
- Reed instruments
- Stringed instruments
- Percussion instruments

Wind instruments

- In a wind instrument the sound is produced by the vibration of air in a hollow tube.
- The frequency is varied by changing the length of the vibrating air column.
- Trumpet, Flute, Shehnai and Saxophone are some well-known wind instruments.

Reed instruments

- A reed instrument contains a reed.
- Air, which is blown through the instrument, causes the reed to vibrate, which in turn produces the specific sound.
- Examples of reed instruments include Harmonium and Mouth Organ.

Stringed instruments

- Stringed instruments make use of a string or wire to produce vibrations and hence the specific sound.
- Violin, Guitar, Sitar are some of the examples of stringed instruments.
- These natural frequencies are known as the **harmonics** of the guitar string.
- The natural frequency, at which an object vibrates, depends upon the tension of the string, the linear density of the string and the length of the string.

Percussion instruments

- Percussion instruments produce a specific sound when they are struck, scrapped or clashed together. They are the oldest type of musical instruments.
- Percussion instruments like the drum and tabla consist of a leather membrane, which is stretched across a hollow box called the resonator.

Sound produced by Humans

- In a human being, the sound is produced in the voice box, called the larynx, which is present in the throat.
- It is located at the upper end of the windpipe.
- The larynx has two ligaments called 'vocal cords', stretched across it.
- The vocal cords have a narrow slit through which air is blown in and out.
- When a person speaks, the air from the lungs is pushed up through the trachea to the larynx.
- When this air passes through the slit, the vocal cords begin to vibrate and produce a sound.
- By varying the thickness of the vocal cords, the length of the air column in the slit can be changed. This produces sounds of different pitches.
- Males generally have thicker and longer vocal cords that produce a deeper, low pitch sound in comparison with females.

Figure 1.9 Structure of Larynx

MECHANISM OF HUMAN EAR

- The human ear picks up and interprets high frequency vibrations of air.
- Ears of aquatic animals are designed to pick up high frequency vibrations in water.

Figure 8.10 Human ear

Structure of Human Ear

- We are able to hear with the help of an extremely sensitive device called the ear.
- It allows us to convert pressure variations in air with audible frequencies into electric signals that travel to the brain via the auditory nerve.
- The auditory aspect of human ear is discussed below.
- The outer ear is called 'pinna'. It collects the sound from the surroundings.
- The collected sound passes through the auditory canal.
- At the end of the ear is eardrum or tympanic membrane.
- When a compression of the medium reaches the eardrum the pressure on the outside of the membrane increases and forces the eardrum inward.
- Similarly, the eardrum moves outward when a rarefaction reaches it.
- In this way the eardrum vibrates.
- The vibrations are amplified several times by three bones (the hammer, anvil and stirrup) in the middle ear.
- The middle ear transmits the amplified pressure variations received from the sound wave to the inner ear.
- In the inner ear, the pressure variations are turned into electrical signals by the cochlea.
- These electrical signals are sent to the brain via the auditory nerve and the brain interrupts them as sound.

Hearing Loss

- Ear ache
- A feeling of fullness or fluid in the ear.
- Ringing in your ears

Hearing loss is caused by various reasons. Some of them are listed below.

- Aging
- Ear infections if not treated
- Certain medicines
- Genetic disorders
- A severe blow to the head
- Loud noise

Audibility and Range

According to the frequency we can classify the sound into three types. They are:

- Audible sound
- Infrasonic sound
- Ultrasonic sound

Audible sound

- Sound with frequency ranging from 20 Hz to 20000 Hz is called sonic sound or audible sound.
- These sounds can be heard by the human beings only.
- Human ears cannot hear sounds with frequencies below 20 Hz or above 20000 Hz. So, the above range is called as audible range of sound.

Infrasonic sound

- A sound with a frequency below 20 Hz is called as subsonic or infrasonic sound.
- Humans cannot hear the sound of this frequency, but some animals like dog, dolphin, etc., can hear.
- waves produced during earth quake, ocean waves, sound produced by whales, etc.

Uses of infrasonic sound are given below.

- It is employed in the Earth monitoring system.
- It is also used in the study of the mechanism of the human heart.

Ultrasonic sound

- A sound with a frequency greater than 20000 Hz is called as ultrasonic sound.
- certain creatures like mosquito, dogs, bats, dolphins can detect these waves. e.g., waves produced by bats.

Uses of ultrasonic sounds

- It is extensively used in medical applications like 'sonogram'.

- It is used in the SONAR system to detect the depth of the sea and to detect enemy submarines.
- It is also employed in dish washers.
- Another important application of ultra sound is the Galton's whistle. This whistle is inaudible to the human ear, but it can be heard by the dogs. It is used to train the dogs for investigation.
- dogs can hear ultrasonic sound. Ultrasonic whistles are used in cars to alert deer to oncoming traffic so that they will not leap across the road in front of cars.
- An important use of ultrasound is in examining inner parts of the body.
- The ultrasonic waves allow different tissues such as organs and bones to be 'seen' or distinguished by bouncing of ultrasonic waves by the objects examined.
- An echogram is an image obtained by the use of reflected ultrasonic waves.
- It is used as a medical diagnostic tool.
- Ultrasonic sound is having application in marine surveying also.
- Ultrasounds can also be used to detect cracks and flaws in metal blocks.
- Ultrasound may be employed to break small 'stones' formed in the kidney into fine grains. These grains later get flushed out with urine.

A bat can hear the sounds of frequencies higher than 20,000 Hz. Bats produce ultrasonic sound during screaming. These ultrasonic waves help them to locate their way and the prey.

Animals, such as bats, dolphins, rats, whales and oil birds, use echolation, an ultrasound technique that uses echoes to identify and locate objects. Echolation allows bats to navigate through dark caves and find insects for food. Dolphins and whales emit a rapid series of underwater clicks in ultrasonic frequencies to locate their prey and navigate through water.

SONAR

SONAR stands for SOund Navigation And Ranging.

Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects.

Sonar consists of a transmitter and a detector and is installed at the bottom of boats and ships.

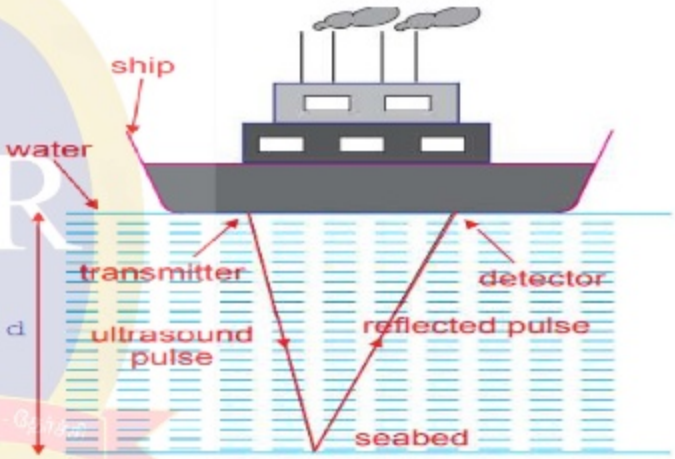
The transmitter produces and transmits ultrasonic waves.

These waves travel through water and after striking the object on the seabed, get reflected back and are sensed by the detector.

The detector converts the ultrasonic waves into electrical signals which are appropriately interpreted.

The distance of the object that reflected the sound wave can be calculated by knowing the speed of sound in water and the time interval between transmission and reception of the ultrasound.

Let the time interval between transmission and reception of ultrasound signal be 't'. Then, the speed of sound through sea water is $2d/t = v$.



Electrocardiogram (ECG)

- The electrocardiogram (ECG) is one of the simplest and oldest cardiac investigations available.
- It can provide a wealth of useful information and remains an essential part of the assessment of cardiac patients.
- In ECG, the sound variation produced by heart is converted into electric signals.
- Thus, an ECG is simply a representation of the electrical activity of the heart muscle as it changes with time.
- Usually it is printed on paper for easy analysis.
- The sum of this electrical activity, when amplified and recorded for just a few seconds is known as an ECG.