SOUND

Sound

- Sound is **mechanical energy,** which produces sensation of hearing.
- Sound is produced due to vibration of different objects.
- A **material medium** is essential for the propagation of sound as it cannot travel in vacuum.
- A region of compressed air (increased density or pressure) is called a **compression** and that of rarefied air (decreased density or pressure) is called a **rarefaction.**

Longitudinal and Transverse Waves

- A **wave motion** is a form of disturbance (a mode of momentum and energy transfer) which is due to repeated vibrations of the particles about their mean positions and the motion is transferred from one particle to the other without any net movement of the medium. A wave motion is of two types: (i) Longitudinal (ii) Transverse.
- Sound waves are **longitudinal waves.** Light waves, on the other hand, are **transverse waves.**
- Sound wave propagates as compressions and rarefactions (i.e., as variation in density or pressure) in the medium.
- As sound propagates, it is the sound energy that travels in the medium and not the medium itself.

- The change in density (or pressure) from the maximum value to the minimum value and again to the maximum value is called an **oscillation.**
- The number of complete oscillations per second is called the **frequency (ν)** of the sound wave. The unit of frequency is called **hertz (Hz).**
- The time taken for one complete oscillation in density (or pressure) of the medium is called the **time period (*T*)** of the wave.
- The distance between two consecutive compressions (or crests) or two consecutive rarefactions (or troughs) is called the **wavelength. The unit of wavelength is meter (m).**
- The distance travelled by a sound wave in its periodic time is also called **wavelength (λ)** of the wave.
- The relation between frequency (ν) and time period (*T*) is $\nu = \frac{1}{T}, T = \frac{1}{\nu}$ or $\nu T = 1$.
- The **speed of sound** depends mainly on its nature and the temperature of the medium through which its propagates.
- The **relation** between speed of the sound wave (v), its frequency (ν) and wavelength (λ) is $v = \nu \lambda$.
- The **sound wave** is described by: (i) its speed, (ii) its frequency (or wavelength) and (iii) its amplitude. These are called the **characteristics of a sound wave.**
- In general, speed of sound in solids > speed of sound in liquids > speed of sound in gases. However, this relation is not always valid.

- Sources that move faster than the speed of sound are said to have **supersonic speeds.** Bullets, jet aircrafts etc. travel at supersonic speeds.
- A **shock wave** is produced when sound producing source moves with a speed higher than the speed of sound.
- It is not necessary for an object to be a vibrating source of sound to produce a shock wave.
- A shock wave carries a large amount of energy.
- **Sonic boom** is a very sharp and loud sound produced by pressure variation associated with a shock wave.

Echo

- Like light waves, sound waves are also reflected from a surface on which they fall. The laws of reflection of sound are the same as those of light.
- The **echo** is the phenomenon of repetition of sound of a source by reflection from an obstacle.
- The time interval between the incident sound and the reflected sound for hearing a distinct echo is 0.1 s. This is due to the reason that the sensation of sound lasts in our brain for 0.1 s and this property is called **persistence of hearing.**
- For hearing a distinct echo, the **minimum distance** of the obstacle from the source of sound should be 17.2 m. This distance changes with change of temperature.

Multiple Echo

- **Multiple echoes** are heard when sound is repeatedly reflected from a number of obstacles at suitable distances.
- Megaphone, stethoscope, ear trumpet, hearing aid etc. are based on the phenomenon of multiple reflection of sound.

Reverberation

- **Reverberation** is the phenomenon of persistence or prolongation of audible sound after the source has stopped emitting sound.
- Reverberation is reduced by (i) carpeting the floor (ii) upholstering furniture and (iii) creating false ceilings with a suitable sound absorbing material.
- The **ceilings of concert halls are curved** to enable the sound in reaching all corners of the hall.
- **A sound board** is used to evenly spread the sound throughout the width of the hall.
- The **audible range** of hearing for average human beings is in the frequency range of 20 Hz to 20 kHz. Children under the age of five can hear upto 25 kHz whereas aged people become less sensitive to higher frequencies.

Infrasound and Ultrasound

- **Infrasound (or Infrasonic)** has a frequency below 20 Hz.
- **Ultrasound (or ultrasonic)** has a frequency above 20 kHz.

Applications of ultrasound

(i) Industry

(ii) Medical science

(iii) Communication

(iv) SONAR.

- In **industry,** ultrasound is used in (i) cleaning instruments and electronic equipments (ii) plastic welding (iii) detecting flaws and cracks in metal blocks used in constructing big structures.

- In **medical science,** ultrasound is used in (i) echo-cardiography (ii) ultrasonography (iii) surgery (iv) therapeutics.

- **SONAR** is Sound Navigation and Ranging and is used to measure distance, direction and speed of objects lying under sea. It is also used in ship-to-ship communication.

Human Ear

- The **human ear** can be divided into three parts: (i) **the outer ear** which collects sound waves (ii) the **middle ear** which amplifies the sound waves about 60 times and (iii) **the inner ear** which converts the amplified sound energy into electrical energy and conveys to the brain as nerve impulses for interpretation.