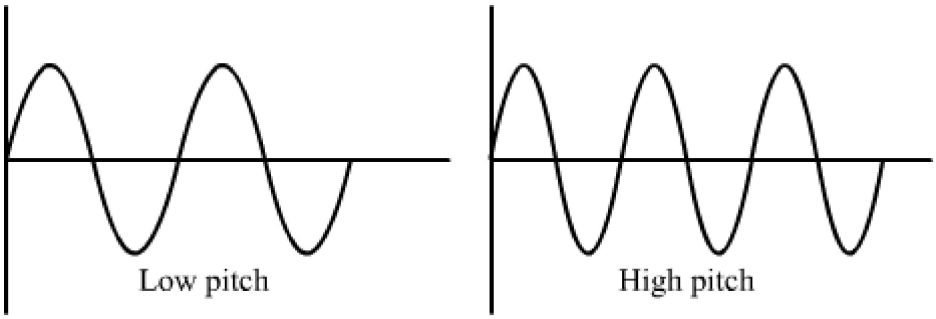
12. Study of Sound

- Vibrating body produces sound.
- Vibration motion– to-and-fro or back-and-forth or up-and-down motion of a body.
- Sound is a form of energy that is produced by producing vibration in an object.
- Sound cannot move through vacuum; sound waves are longitudinal waves.

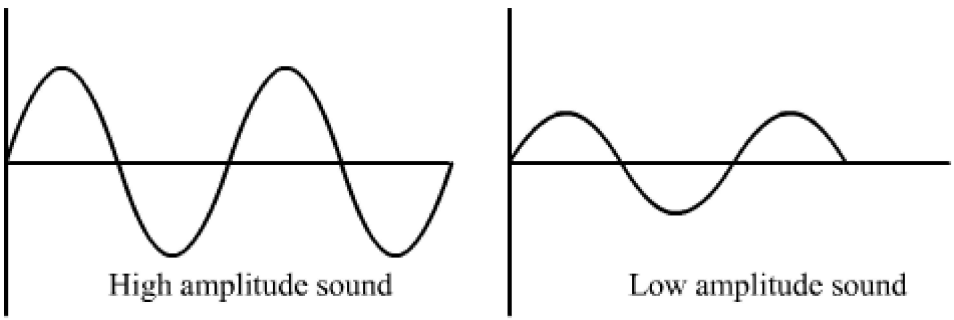
- Sound requires **material medium** for propagation.
- Sound can travel through solid, liquid or gas.
- Sound cannot travel through vacuum.
- No sound can be heard in outer spaces.

- Sound is a form of energy that is produced by producing vibrations in an object.
- Sound cannot move through vacuum.
- Sound is a wave that requires a medium for its propagation. The medium particles vibrate only to and fro. They do not move with the sound.

- **Characteristics of sound waves**
    - **Amplitude** – Magnitude of maximum displacement from mean position
    - **Wavelength (λ)** – Distance between two consecutive compressions or two consecutive rarefactions
    - **Frequency (Unit - Hertz, Hz)** – Number of oscillations per unit time
    - **Time period** – Time taken by two consecutive compressions or rarefactions to cross a fixed point
        - Frequency = 1Time period
- **Pitch** – Higher the frequency, higher the pitch



- **Loudness** – Determined by amplitude



- **Tone** – Sound of a single frequency
- **Quality or timbre**

Differentiate between two sounds of same pitch and loudness

- If the notes produce an unpleasant sound in the ear, then it is a **dischord** or **dissonance**.
- **Harmony -** Harmony is the pleasant effect produced due to concord, when two or more notes are sounded together.
- **Melody -** Melody is the pleasant effect produced by two or more notes when they are sounded one after another.
- **Musical intervals -** Musical interval is the ratio of frequencies of two notes in the musical scale.
- **Musical scale -** Musical scale is the series of notes separated by a fixed musical interval. Keynote is the starting note of a musical scale.
- **Diatonic** scale
- When two notes are sounded simultaneously and produce pleasant sensation in the ear, then it is **concord** or **consonance**.
- It contains series of eight notes.
- **Octave** is the interval between the keynote and the last tone.
- **Advantages of a diatonic scale**

- This scale provides the same order and the duration of chords and intervals, which succeed each other, that are required for a musical effect.
- This scale can produce musical compositions with the lower and higher multiples of frequencies of the notes.

Speed of sound

- Speed of sound $v = v \times \lambda$
- Speed in solid > Speed in liquid > Speed in gas
- Speed depends on temperature, pressure, humidity and nature of the material of the medium.
- Speed increases with increasing temperature.
- In air, speed of sound is 344 m s^{-1} at 22 °C
- Supersonic – The rate of distance travelled by the object is more than the speed of sound.
- Sonic boom - loud noise produced by supersonic object is sonic boom

The speed of sound (v) in a medium depends upon the following factors:

1. E, elasticity of the medium
2. ρ, density of the medium

Relation between speed of sound, elasticity of the medium and density of the medium

$v=E\rho$ .....(1)
For gas $E = P$,

$v=P\rho$ .....(2)

Laplace amendment, $v=\gamma P\rho$

Speed of sound in different media

Medium		Speed of sound (in m s^{-1})
Gases	Air Hydrogen Carbon dioxide	330 1270 260
Liquids	Alcohol Turpentine Water	1210 1325 1450
Solids	Copper Steel Glass Granite	3560 5100 5500 6000

Factors affecting speed of sound in gas

1. Density: The speed of sound increases with decrease in density of the gas.
2. Temperature: The speed of sound increases with increase in temperature of the gas
3. Humidity: The speed of sound increases with increase in humidity of air.
4. Direction of wind: The speed of sound increases or decreases in accordance with the direction of the wind. If the direction of propagation of sound is along the direction of wind, then its speed increases otherwise the speed of sound decreases.

Factors not affecting the speed of sound in gas

1. Pressure: speed of sound does not depend upon pressure.
2. Amplitude of wave: speed of sound does not depend upon the amplitude of sound wave.
3. Wavelength or frequency of wave: speed of sound does not depend upon the wavlength or frequency of sound wave.

Difference between sound wave and light wave

Sound Wave	**Light Wave**
They can not travel in vaccum.	They can travel in vacuum
They can travel in air at a speed of 330 ms^{-1} .	They can travel in air at a speed of 3×108 ms-1
There speed increases with increase in density of the optical medium.	There speed decreases with increase in density of the optical medium.
These are longitudinal mechanical waves.	These are transverse electromagnetic waves.

- **Range of hearing for humans**: 20 – 20000 Hz
- Rhinoceroses use infrasound (<20Hz) and bats use ultrasound (>20000Hz)
- **Hearing Aid**

  It is a device that amplifies sound and enables hearing impaired hear. It consists of a microphone, an amplifier, and a speaker.

- **Laws of reflections of sound:**

  (i) The incident sound, the reflected sound, and the normal to the screen at the point of incidence – all lie in the same plane.

  (ii) The angle of reflection of sound is always equal to the angle of incidence.

- **Echo**
  - Reflection of sound
  - Sensation of sound persists $\frac{1}{10} = 0.1s$ in the human brain
  - Minimum distance to hear echo

    $\frac{344 \times 0.1}{2} = 17.2$ m

- **Reverberation**
  - Persistence of sound by repeated reflection

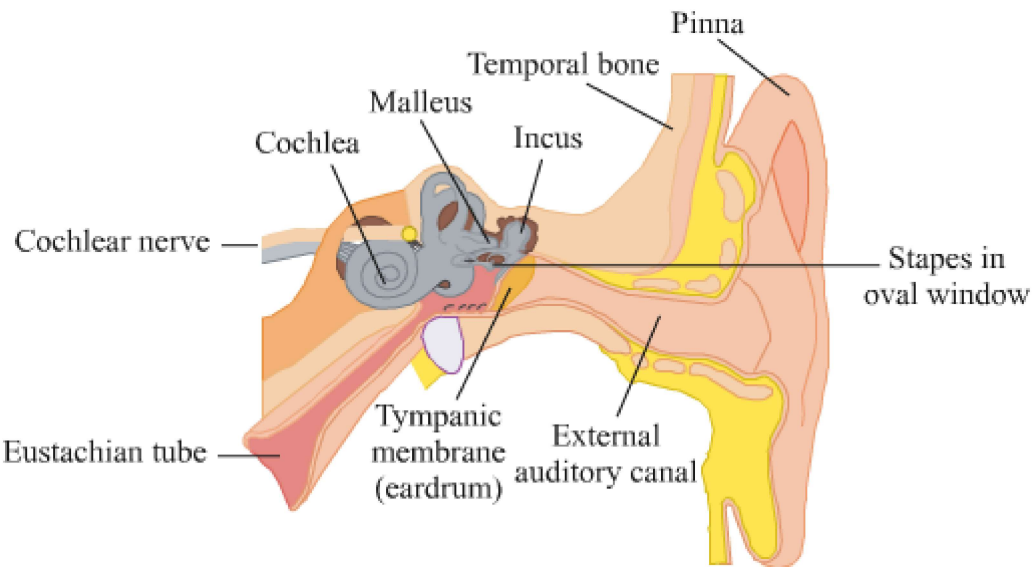
- Sound is a longitudinal wave which needs material to travel. Its velocity (v), frequency (f) and wavelength (λ) are related as, v = fλ

- **Properties of ultrasound**

  Ultrasonc waves are high-frequency sound waves that cannot be heard or sensed by humans. These are so energetic that they can penetrate human muscles

- **Application of ultrasound**
  - Cleaning, detecting defects in metals, echocardiography, ultrasonography, to break small kidney stone
  - **SONAR**(Sound navigation and Ranging): Used by ships and submarines to navigate, communicate or detect under water.

- Human ear has three parts outer, middle and inner.



- Shape of the outer part of the ear is like a funnel.
- In human ear, the eardrum vibrates and passes vibration to the inner ear.
- The eardrum is like a stretched rubber sheet.
- Sound vibrations make the eardrum vibrate, from there the signal goes to the brain.
- Noise level of 85 dB can damage the human ear.