6. Sound Waves

- Periodic motion → Motion which repeats itself after regular intervals of time
- Oscillatory motion →A body in oscillatory motion moves to and fro about its mean position in a fixed time interval.

- Period (*T*): It is the interval of time after which a motion is repeated. Its unit is seconds (s).

- Time period → Time required for one complete oscillation

$$T = \frac{1}{\nu}$$

where, ν → Frequency

- Frequency : Number of oscillations in one second. The unit is Hertz.

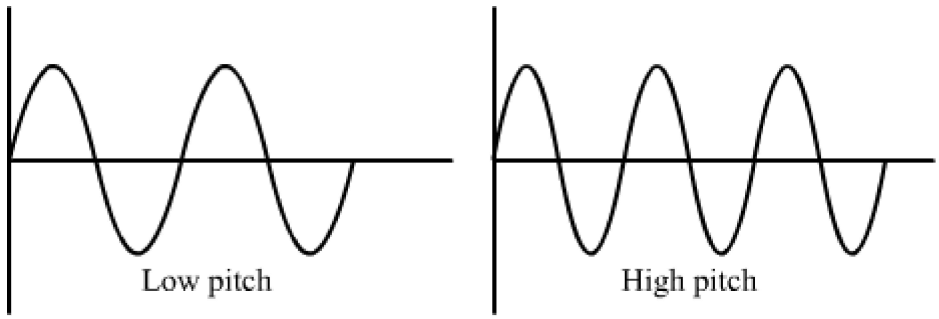
- Continuous disturbance that transfers energy without any net displacement of the medium particles is called wave.

- Different types of waves on the basis of their production are mechanical wave, electromagnetic wave and matter wave.

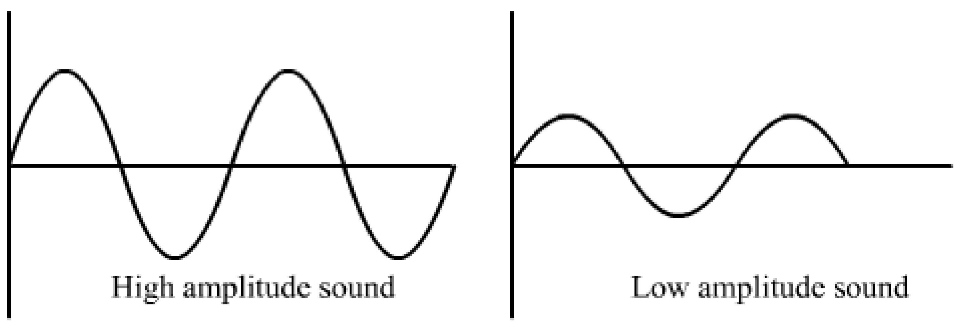
- Different types of mechanical waves on the basis of their propagation transverse wave and longitudinal waves.

- Mechanical waves need a medium for its propagation.

- **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 $v = \nu \times \lambda$
- 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
    - **Speed of longitudinal wave in a solid bar is given by,**

$$v = \sqrt{\frac{Y}{\rho}}$$

$\rho \rightarrow$ Density of the material of the bar

$Y \rightarrow$ Young's modulus of elasticity

- **Velocity of longitudinal wave in a liquid is given by,**

$$v = \sqrt{\frac{B}{\rho}}$$

$B \rightarrow$ Bulk modulus of elasticity

- **Newton's Formula :** The velocity of sound waves in air is given by,

$$v = \sqrt{\frac{P}{\rho}}$$

$P \rightarrow$ Pressure, $\rho \rightarrow$ Density of air

- Laplace corrected the formula for velocity of sound waves in air or gas. According to Laplace's formula, the velocity of sound waves in air or gas is given by

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Where, γ is the ratio of two specific heats, C_p/C_v

Factors affecting velocity of sound:

- Velocity of sound in a gas is directly proportional to the square root of absolute temperature.
- Velocity of sound in moist air is greater than velocity of sound in dry air.
- It is inversely proportional to the square root of density of gas.
- It is independent of pressure, provided temperature is constant.