Chapter

8 Sound

Quick Review

➤ **Types of Waves:**

Waves

- **Mechanical Waves**
  They require a medium to propagate.
  Example: Sound wave.
- **Electro–magnetic Waves**
  The waves generated due to periodic oscillation of mutually perpendicular electric and magnetic fields.
- **Progressive Wave**
  Waves in which a disturbance created at one place travels to distant points and keeps travelling unless stopped by an external force are known as travelling or progressive waves.
  - Types
    - **Transverse waves**
      Particles of the medium vibrate in a direction perpendicular to the direction of propagation of the wave.
      Example: Light waves
    - **Longitudinal wave**
      A wave in which particles of medium vibrate in a direction parallel to the direction of propagation of the wave is called longitudinal wave.
      Example: Sound Waves
- **Matter Waves**
  The waves associated with a moving particle are called matter wave.

Characteristics of Waves

Phase	The state of oscillation of a particle is called its phase.
Double periodicity	Wave is periodic in time and space.
Frequency (n)	The number of vibrations performed by a particle per second
Wavelength (λ)	The distance between two successive particles which are in the same state of vibration
Period (T)	The time taken by the particle of a medium to complete one vibration.
Velocity (v)	The distance covered by a wave per unit time.
Amplitude (A)	The largest displacement of a particle of a medium through which the wave is propagating, from its rest position

➤ **Factors affecting velocity of sound:**

Factors affecting velcoity of sound

1. **Pressure**
   Independent of pressure if temperature is constant
2. **Humidity**
   Speed increases with moistness of air.
3. **Temperature**
   $v \propto \sqrt{T}$
   As T ↑, v ↑

➤ **Common characteristics of a medium transmitting sound wave:**

CHARCTERISTICS

- **Inertia:** This helps particles to store energy and oscillate about their mean position.
- **Uniform density:** This helps waves to have a unifom velocity.
- **Elasticity:** This helps particles to return to their mean position after being displaced.
- **Less friction:** This helps particles not to lose energy.

➢ **Phenomena based on sound:**

Phenomena based on sound

1. **Echo** (Repetition of sound due to reflection)
2. **Reverberation** (Multiple reflections of sound)
3. **Doppler effect** (Apparent change in frequency of sound heard by listener due to relative motion between source and listener)

➢ **Qualities of sound:**

Qualities of sound

- **Pitch** (high frequency, high pitch)
- **Timbre** (quality of sound)
- **Loundness** (measure of intensity of sound)

Formulae

1. Relation between v, n and λ:

i. $v = n\lambda$ ii. $v = \frac{\lambda}{T}$

2. Wavelength:

i. $\lambda = \frac{v}{n}$ ii. $\lambda = vt$

3. Velocity of sound wave:

i. Newton's formula: $v = \sqrt{\frac{E}{\rho}}$

ii. Laplace's formula:

$v = \sqrt{\frac{\gamma P}{\rho}}$ (In gases) where $\gamma = \frac{c_P}{c_V}$

iii. $v = \sqrt{\frac{\gamma PV}{M}} = \sqrt{\frac{\gamma nRT}{M}}$

4. Factors affecting velocity of sound:

i. Density: $v \propto \frac{1}{\sqrt{\rho}}$ i.e., $\frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}}$

ii. Temperature: $v \propto \sqrt{T}$

i.e., $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{273+t_1}{273+t_2}}$

5. Velocity of sound at t °C: $v_t = v_0\sqrt{\left(1+\frac{t}{273}\right)}$

6. Loudness of sound:

$L_{bel} = \log_{10}\left(\frac{I}{I_0}\right)$

7. Doppler formula for apparent frequency:

i. Source approaching a stationary Lis

$n = n_0\left(\frac{v}{v - v_S}\right)$

ii. Source receding from a stationary observer,

$n = n_0\left(\frac{v}{v + v_s}\right)$

iii. Listener approaching a stationary so

$n = n_0\left(\frac{v + v_L}{v}\right)$

iv. Listener receding from a stationary so

$n = n_0\left(\frac{v - v_L}{v}\right)$

v. Both source and Listener approaching each ot

$n = n_0\left(\frac{v + v_L}{v - v_s}\right)$

vi. Both source and Listener receding from each other, $n = n_0\left(\frac{v - v_L}{v + v_s}\right)$

Shortcuts

To find the velocity of sound at any temperature t °C use the formula, $v = v_0 + (0.61)t$

When listener or source moves towards other, there is a **shift up** in frequency and whenever they move away from other , there is a **shift down** in frequency.

Mindbenders

A mechanical wave shall be transverse or longitudinal depending on the

nature of the medium ii. mode of excitation of vibration

For example, in solids, both transverse and longitudinal waves can propagate. This is because solids can sustain both, the shearing strain as well as compressional strain. On strings, mechanical waves are always transverse. Gases can sustain only compressional strain and not the shearing strain. Therefore, only longitudinal waves can pass through air and other gases.

Ripple is neither transverse wave nor longitudinal wave but occurs due to combination of these two waves.

If two or more persons are speaking simultaneously, we hear each of them due to an important property that "when two or more waves cross each other they are not affected in any way."

If two sounds of equal frequency are sounded together we hear a loud sound of constant frequency.

Sound produced in air is not heard by the diver inside the water because majority of sound energy is reflected from the water surface.

For sound waves $v_w > v_a$. Therefore, in travelling from air to water, a beam of sound bends away from normal, whereas a beam of light bends towards the normal.

The formula for velocity of sound does not involve frequency or wavelength. Hence sound of any frequency or wavelength travels through a given medium with the same velocity.

Although the densities of solids and liquids are higher than gases, speed of sound in solids > speed of sound in liquids > speed of sound in gases. This is because liquids and solids are less compressible than gases, i.e., liquids and solids have much greater bulk modulus than that of gases.

Doppler shift is a little greater when the source is approaching to the listener than when the listener is approaching to the source with the same speed.