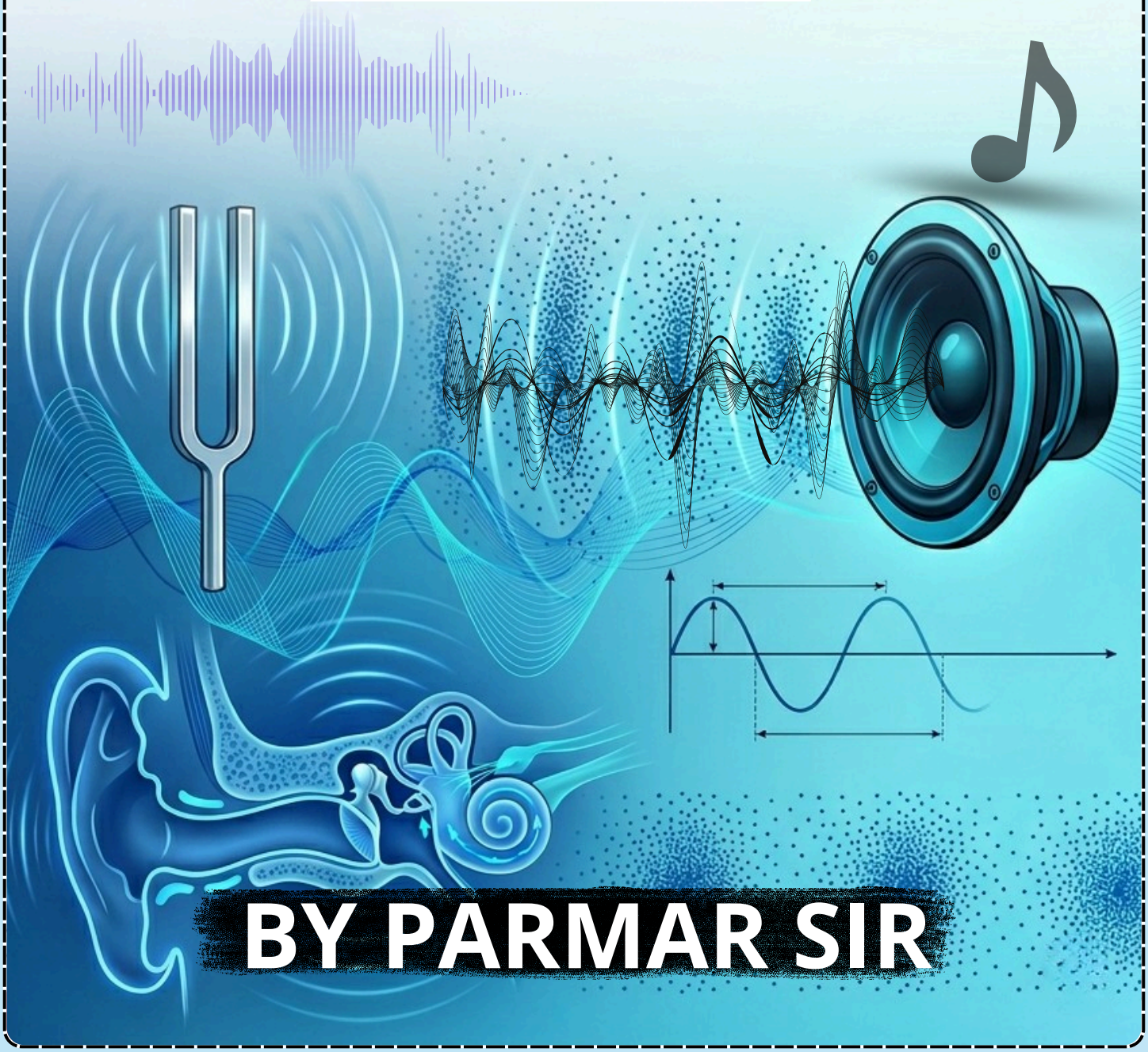
PARMAR SSC

SOUND

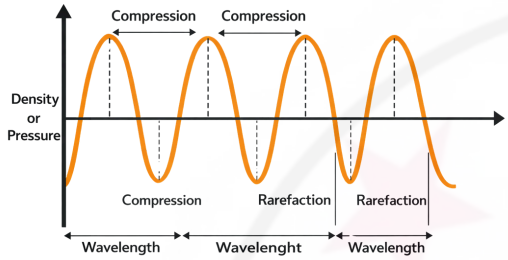
Lecture - 4



BY PARMAR SIR

SOUND

- Sound is a form of energy, a vibration that travels through a medium (like air, water, or solids) as a mechanical wave, and is perceived by the human ear as an audible sensation.
- Sound is produced when an object vibrates, creating a pressure wave. This pressure wave causes particles in the surrounding medium (air, water, or solids) to have vibrational motion.
- As the object vibrates back and forth, it creates areas of high pressure (compressions) and low pressure (rarefactions) in the medium.
- Sound cannot travel in a vacuum.



- Compression in a longitudinal wave is a region where the particles are the closest together.
- Rarefaction in a longitudinal wave is a region where the particles are spread out.

Sound in Different Media

Air

Sound travels as longitudinal waves in air, where the vibrations are parallel to the direction of wave propagation.

Water

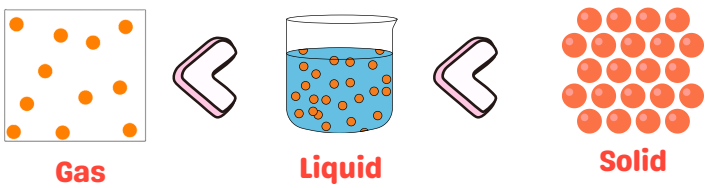
Sound also travels as longitudinal waves in water.

Solids

Sound can travel as both longitudinal and transverse waves in solids.

Speed of Sound

- Sound travels fastest in solids, slower in liquids, and slowest in gases.
- The particles in solids are tightly packed and can transfer energy (sound) quickly, leading to faster propagation.



Speed of Light = 3×10^8 m/s

Speed of light is more than speed of sound (343 m/s)

The speed of sound increases with increasing temperature.

State	Substance	Speed in m/s
Solids	Aluminium	6420
	Nickel	6040
	Steel	5960
	Iron	5950
	Brass	4700
	Glass (flint)	3980
Liquids	Water (sea)	1531
	Water (distilled)	1498
	Ethanol	1207
	Methanol	1103
Gases	Hydrogen	1284
	Helium	965
	Air	346
	Oxygen	316
	Sulphur dioxide	213

Sound Waves

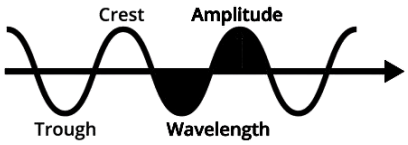
- Sound waves are disturbances that travel through a medium (like air, water, or solids) as a result of vibrations.
- **Types of Waves:** Mechanical Waves and Non-Mechanical Waves.

Mechanical Waves	Non-Mechanical Waves
Medium is required to propagate	No medium is required to propagate
E.g. Sounds waves	E.g. Light waves

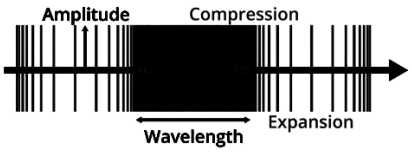
Types of Mechanical Waves

Transverse Waves

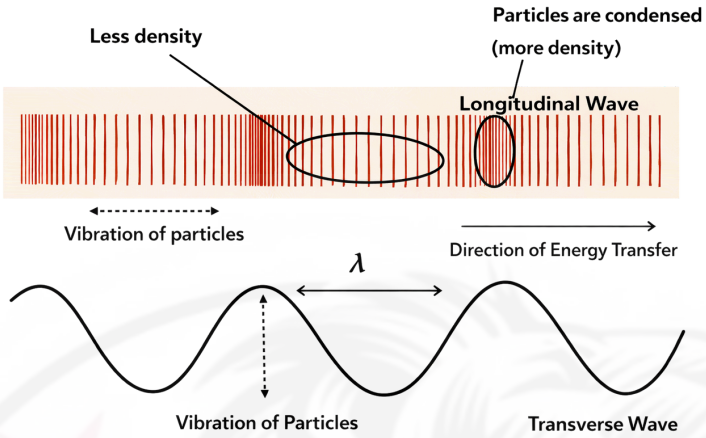
- Transverse waves are waves that moves perpendicularly to the direction of its propagation. This means that the wave forms a right angle with the direction it travels.
- **E.g.** Light (Electromagnetic Waves).



Longitudinal Waves

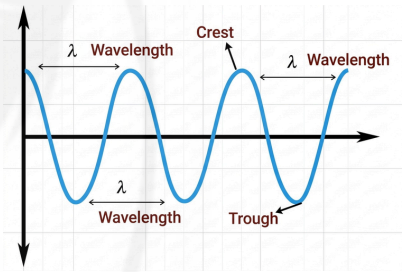


- Longitudinal waves are waves where the particles of the medium vibrate parallel to the direction of its propagation,
- E.g. sound waves or pressure waves.



Characteristics of Sound Waves

Wavelength

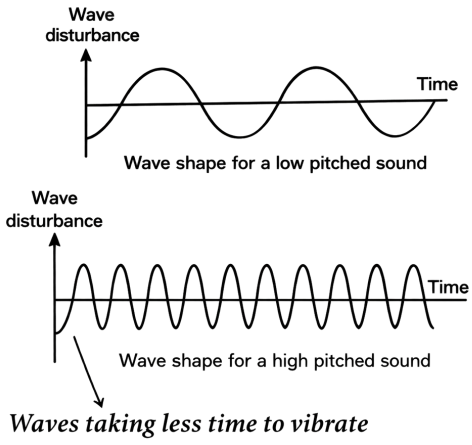


- The physical distance between two successive crests or troughs of a wave is called wavelength.
- In the case of a longitudinal wave, it is the distance between two successive compressions or rarefactions.
- The SI unit of wavelength is meter (m)

Frequency

- The number of times a sound wave cycles per second, which determines its pitch of the sound.
- Girls have high pitched voice, high shrillness (their vocal cords, vibrate quickly).
- The S.I. unit of frequency is s^{-1} or **Hertz**.

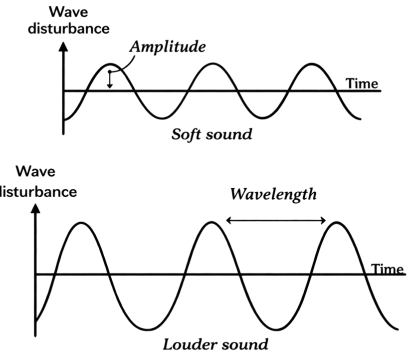
$$Frequency\ (\nu) = \frac{1}{Time}$$



- A high pitch sound has faster vibrations and higher wave frequency.
- A low pitch has slower vibrations and a lower wave frequency of the sound.

$$f(\mu) \propto \frac{1}{\lambda}$$

Amplitude



- Amplitude is the maximum displacement of vibrating particles from their mean (equilibrium) position.
- It represents the loudness (intensity) of a sound wave.
- Greater amplitude = louder sound.
- **Unit:** Metre (m) in the S.I. system
- **Decibel (dB):** Unit of sound intensity level.
- The range of sound intensities a human ear can generally perceive is from 0 to 130 decibels (dB). Sound above this is considered as noise.
- The amplitude of the sound wave depends upon the force with which an object is made to vibrate. If we strike a table lightly, we hear a soft sound because we produce a sound wave of less energy (amplitude). Conversely, a loud sound has a large amplitude.

Timbre (Tone Quality/Tone Color)

- Timbre is the quality of a sound that distinguishes it from other sounds having the same pitch and loudness.
- **Note:** Note is produced due to a mixture of several frequencies (fundamental + overtones), not just a single frequency.

Audible Range

- The audible range is the range of sound frequencies that humans can hear, which is from 20 Hz to 20,000 Hz (20 kHz).
- **Infrasonic:** Sounds below 20 Hz that humans can't hear.
- Many animals can hear infrasonic sounds. E.g. sounds produced by earthquakes.
- **Ultrasonic:** Sounds above 20,000 Hz that humans can't hear.

Applications of Ultrasonic Sounds

- It is produced by bats and dolphins.
- Ultrasound is banned in gender determination.
- It is used to monitor growth and development of foetus.
- It is used to identify kidney stones and to break kidney stones.
- It is used to identify the conditions of our internal organs.

Mach Number

- Mach number is the ratio of the speed of an object to the speed of sound in the surrounding medium.

$$\text{Mach No.} = \frac{\text{Speed of a Body}}{\text{Speed of Sound in that Medium}}$$

Speed of Objects Based on Mach Number

- Subsonic <1
- Supersonic: 1 to 5
- Hypersonic >5
- Transonic: ≈1

Reflection of Sound

- Reflection of sound can be defined as the bouncing back of sound waves after striking the surface and within the same media.
- This medium can be either solid or liquid. Similar to light, sound also follows the same laws of reflection.
- It gives rise to phenomena like Echo, Reverberations, and Diffraction.

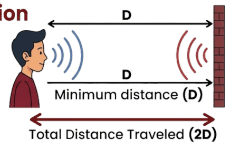
Echo

- An echo is the reflected repetition of a sound that occurs when sound waves bounce off a surface and return to the listener, allowing the sound to be heard again after the original has faded.

Minimum Echo Distance Determination

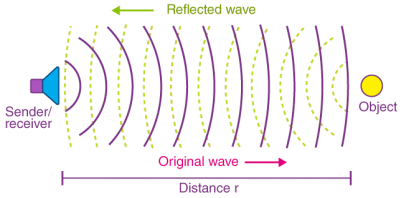
Formula: $= \frac{2D}{t}$

1. **Given Values**
   v (Speed of Sound in Air) = ~344 m/s
   t (Minimum Echo Time) = 0.1 s
2. **Calculation**
   2D = v × t
   2D = 344 m/s × 0.1 s
   D = 34.4 / 2
   D = 17.2 m



Result (D) = 17.2 meters

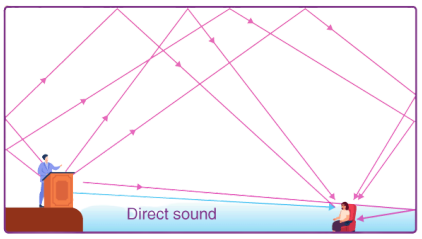
Result may vary with changes in air temperature and humidity



For hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be at least 17.2 m.

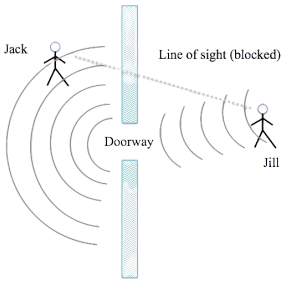
Reverberation

- It is the continued presence of sound in an enclosed space even after the original sound source has stopped.
- This occurs due to repeated reflections of sound waves from surfaces like walls, ceilings, and furniture, causing the sound to linger before gradually fading away as it gets absorbed.



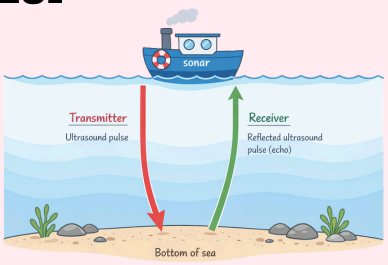
Diffraction

- Diffraction is the bending of sound waves as they move around obstacles or through small openings.
- This allows us to hear sounds even when the source is hidden from view.



SONAR (Sound Navigation and Ranging)

- It is a technology that uses sound waves to detect and locate objects underwater.
- It is used for a variety of purposes, including navigation, communication, and mapping.
- It emits sound waves and analyses the echoes that bounces back.



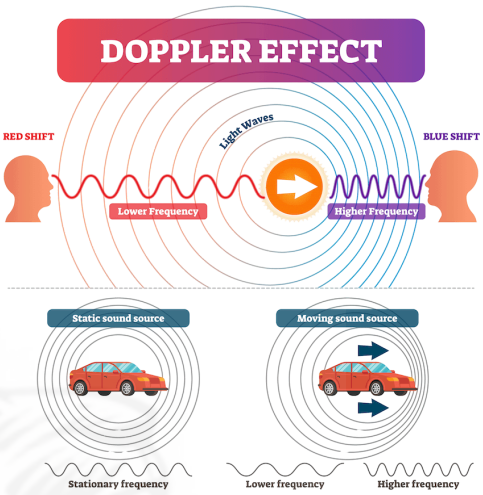
Velocity of Sound in moist air is greater than the velocity of sound in dry air. Sound cannot travel through a vacuum because it requires a medium like air, water, or solids, to propagate.

Doppler Effect

- The Doppler effect is the change in frequency or wavelength of a wave as perceived by an observer who is moving relative to the source of the wave.

$$f_o = \frac{v + v_o}{v + v_s} f_s$$

- f_o = Observer frequency of sound
- v = Speed of sound wave
- Vo = Observer velocity
- Vs = Velocity of source
- fs = Source frequency (actual frequency)





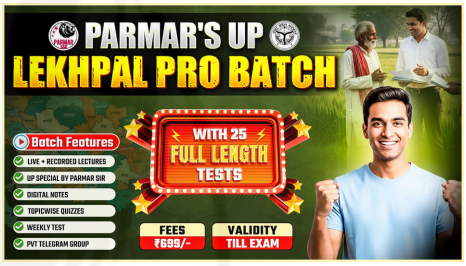
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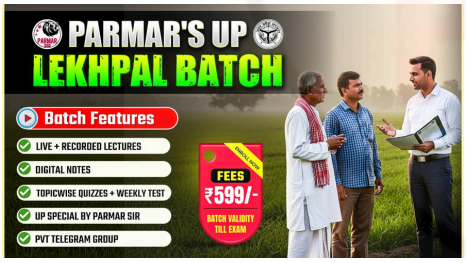
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