

ICSE Class 9 –

Chapter 7: Sound – Page 1

1. Introduction to Sound

- Sound is a form of energy that produces the sensation of hearing in our ears.
- It is produced by the vibration of an object.
- We perceive sound through our ears as hearing.
- Sound is a mechanical wave and requires a material medium to travel; it cannot travel in vacuum.

2. Production of Sound

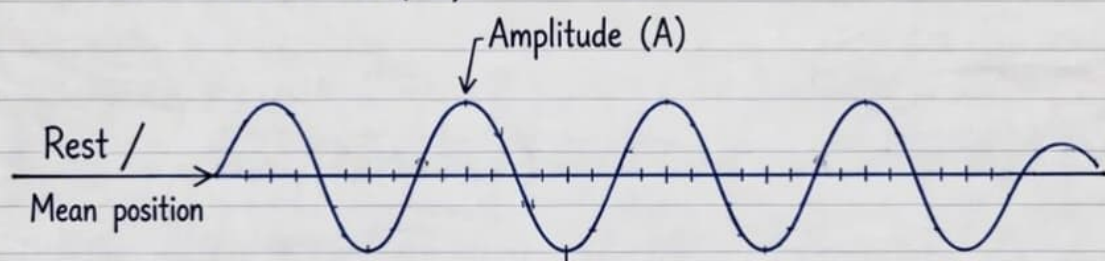
- Sound is produced when an object vibrates.
- Examples:
 - Striking a tuning fork causes its prongs to vibrate, producing sound.
 - Plucked guitar string vibrates to produce musical sound.
 - Human voice is produced by the vibration of vocal cords.

3. Propagation of Sound

- Sound travels in the form of waves through a medium.
- The medium may be solid, liquid, or gas – for example air, water, or steel.
- Sound needs particles of the medium to transfer energy from one particle to the next.
- In vacuum, there are no particles, hence sound cannot propagate.

4. Wave Terms

- Wavelength (λ): Distance between two consecutive crests or two consecutive troughs of the wave.
- Amplitude (A): Maximum displacement of vibrating particles from their mean/rest position.
- Frequency: Number of oscillations/waves passing a point per second, measured in Hertz (Hz).



1. Speed of Sound

- Defined as the distance travelled by sound wave per second in a medium.
- Measured in metres per second (m/s).
- Speed in air at 20°C is approximately 343 m/s.
- Fastest in solids, slower in liquids, slowest in gases : Solids > Gases.
- Example : Speed in steel ≈ 5100 m/s, in water ≈ 1480 m/s, in air ≈ 343 m/s.

2. Factors affecting the Speed of Sound

- Temperature : Speed of sound increases with rise in temperature. (At higher temp, particles vibrate faster $\rightarrow$ sound travels faster)
- Nature of Medium : Sound travels fastest in solids, then liquids, then gases, due to closeness of particles.
- Humidity (for air) : Higher humidity $\rightarrow$ slightly higher speed of sound in air.
- Density & Elasticity : More elastic medium leads to higher speed of sound.

3. Reflection of Sound

- When a sound wave strikes a hard, smooth surface, it is reflected back, known as reflection of sound.
- It obeys the same laws as reflection of light : Angle of incidence = Angle of reflection.
- This property is useful in design of auditoriums, megaphones, etc.

4. Echo

- Echo is the distinct repetition of sound heard after reflection from a distant obstacle.
- Condition for hearing an echo : The reflecting surface must be at least 17 m away in air, so that time gap between original and reflected sound is ≥ 0.1 second.
- Human ear can distinguish echo only if time interval is at least 0.1 s.
- Applications : Used to measure depth of sea, in caves and mountains.

5. SONAR

- SONAR stands for Sound Navigation And Ranging.
- It is a device used to find the distance, direction and speed of underwater objects using sound waves.
- Working : SONAR sends ultrasonic sound waves underwater : these reflect from objects and are received back.
- Uses : Measuring depth of ocean, locating submarines, shoals of fish, detecting icebergs.

Numerical Formula

$$v = \frac{2d}{t}$$

where,

= $v \rightarrow$ Speed of sound (m/s)

= $d \rightarrow$ Distance between source and the reflecting surface (m)

= $t \rightarrow$ Total time for sound to travel to the surface and back (s)

- Formula is used to calculate distance or depth using echo.

- Example : If echo is heard after 2 s, then distance $d = (v \times t) / 2$

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Characteristics of Sound :

1. **Loudness** : It is the sensation of how loud or soft a sound is perceived by the ear.
 - Depends on the amplitude of the sound wave.
 - Greater the amplitude → Louder the sound.
 - Example : Striking a drum with more force produces a louder sound compared to striking it gently.
2. **Pitch** : It is the highness or lowness of a sound, i.e., how shrill or dull the sound is.
 - Depends on the frequency of the sound wave.
 - Higher frequency → Higher pitch (shriller sound).
 - Lower frequency → Lower pitch (deeper/flat sound).
 - Example : The sound of a whistle has a higher pitch than the sound of a drum.
3. **Quality (Timbre)** : It is the characteristic that distinguishes two sounds of the same pitch and loudness.
 - Depends on the waveform and the number of harmonics/overtones present.
 - Allows us to tell apart sounds from different sources, e.g. a piano and a guitar playing the same note.

Factors affecting Loudness and Pitch :

A. Factors affecting Loudness :

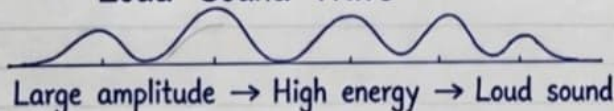
- Amplitude of vibration : Larger amplitude → Greater loudness.
- Surface area of the vibrating body : Larger surface area → Louder sound.
- Distance from the source : Loudness decreases as the distance from the source increases.

B. Factors affecting Pitch :

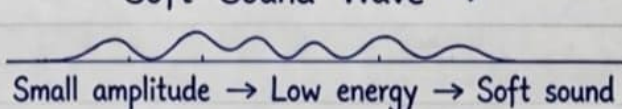
- Frequency of vibration : Higher frequency → Higher pitch.
- Length of vibrating string/air column : Shorter length → Higher pitch; Longer length → Lower pitch.
- Tension in the string : More tension → Higher pitch.
- Thickness of the string : Thinner string → Higher pitch; Thicker string → Lower pitch.

Diagram : Loud Sound vs Soft Sound Waves

Loud Sound Wave →



Soft Sound Wave →



- * Both waves are shown with the same wavelength, so their frequency (pitch) is the same. Only the amplitude differs, hence the loudness differs.

Summary :

- Loudness is determined by the amplitude of the sound wave.
- Pitch is determined by the frequency of the sound wave.

Key : Amplitude → Loudness | Frequency → Pitch | Waveform → Quality (Timbre)