# *Chapter 11: Sound — Detailed Premium Notes*

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## *1. What is Sound?*

**Sound is a form of energy that we can hear. It is produced when an object vibrates. These vibrations travel through a medium such as air, water, or solid, and reach our ears.**

**For example, when you pluck a guitar string, it vibrates and sets the surrounding air particles in motion. These moving particles carry the sound to your ear — and you hear it.**

**So, in simple words:**

**Sound is the energy produced by vibrating objects and heard when it travels through a medium to our ears.**

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## *2. Production of Sound*

***Sound is produced when an object vibrates.***
***These vibrations cause the particles of the surrounding medium (like air, water, or solids) to vibrate as well, and this vibration travels as sound waves to our ears.***

*For example:*

- ***When you pluck a guitar string, it vibrates and produces sound.***
- ***When you strike a drum, its stretched membrane vibrates to produce sound.***
- ***Even in humans, vocal cords vibrate when we speak.***

***In short:***

***Sound is produced by the vibrations of objects and reaches our ears through a medium.***


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## *3. Propagation of Sound*

***The process by which sound travels from its source to our ears is called propagation of sound.***
***When an object vibrates, it disturbs the nearby particles of the medium (like air). These particles then vibrate back and forth, passing the energy to the next particles.***
***This continuous transfer of vibration forms a wave that moves through the medium — known as a sound wave.***

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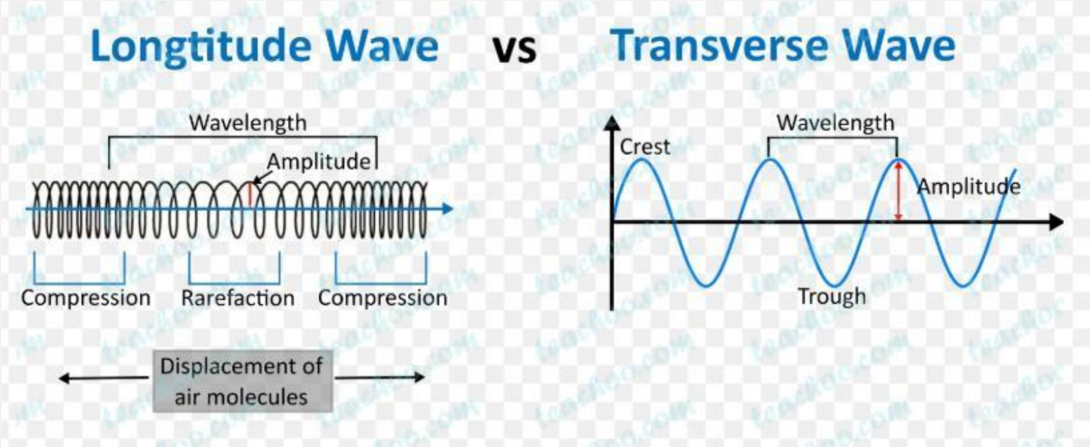
***Types of Waves:***
***There are two main types of mechanical waves that transfer sound energy:***

1. *Longitudinal Waves* ○ ***The particles of the medium vibrate in the same direction as the wave travels.***
    - ***Sound in air, liquids, and solids travels as longitudinal waves.***
    - ***These waves consist of:***
        - ***Compressions → regions where particles are close together***
        - ***Rarefactions → regions where particles are far apart***

2. ***Transverse Waves***
   - ***The particles of the medium vibrate at right angles (90°) to the direction of wave travel.***
   - ***Though sound usually travels as longitudinal waves, transverse waves can form on the surface of solids or on strings (like in guitars or tuning forks).***

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***In Short***

***Sound propagates through a medium as a mechanical wave, mostly longitudinal in nature, by the vibration of particles that carry the sound energy forward.***

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## *4. Characteristics of Sound*

***Every sound we hear is different. Some are loud, some are soft, some high-pitched, and some deep.***
***These differences are due to the characteristics of sound.***

***The main characteristics of sound are:***

1. ***Amplitude***
2. ***Frequency (Pitch)***
3. ***Time Period***
4. ***Wavelength***
5. ***Speed***
6. ***Quality (Timbre)***

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***1. Amplitude – Loudness of Sound***

***Amplitude is the maximum displacement of vibrating particles from their rest position.***

***Greater the amplitude → louder the sound.***

***Smaller the amplitude → softer the sound.***

***Example: Shouting produces a sound wave with greater amplitude than whispering.***

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***2. Frequency – Pitch of Sound***

***Frequency is the number of vibrations or waves produced per second.***

***It is measured in Hertz (Hz).***

***Higher frequency → higher pitch (shrill sound).***

***Lower frequency → lower pitch (deep sound).***

***Example: A girl's voice usually has a higher pitch than a boy's voice.***

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***3. Time Period***

***Time period is the time taken for one complete vibration.***

***It is related to frequency by the formula: Frequency = 1 / Time Period***

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***4. Wavelength***

***Wavelength is the distance between two consecutive compressions or rarefactions in a sound wave. It is represented by the Greek letter lambda (λ).***

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***5. Speed of Sound***

***Speed of sound is the distance travelled by sound per unit time. It depends on the medium – sound travels fastest in solids, slower in liquids, and slowest in gases.***

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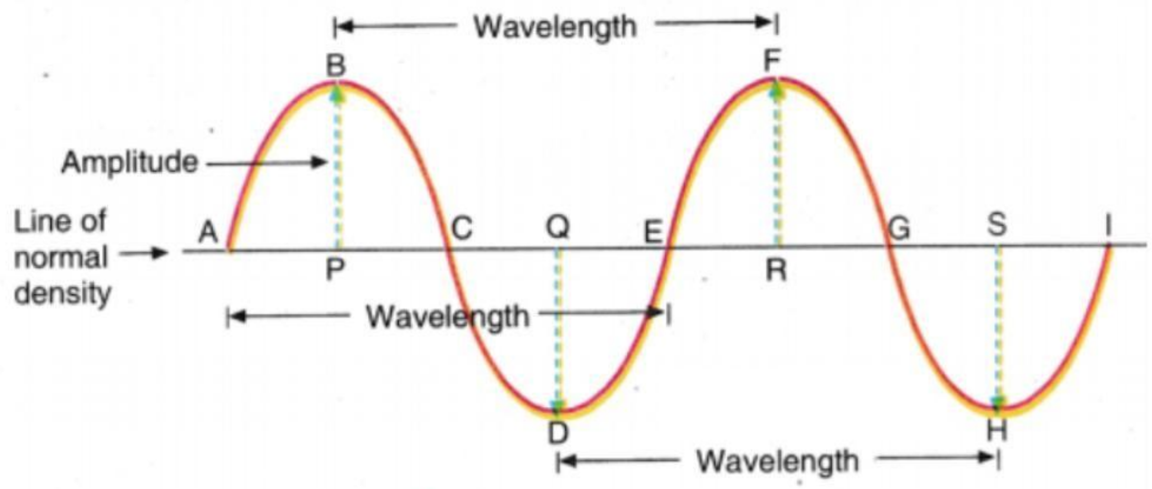
***6. Quality or Timbre***
***Quality is the property that helps us distinguish between sounds even if they have the same loudness and pitch.***
***Example: A guitar and a piano playing the same note sound different because of their different wave patterns.***




Characteristics of a sound wave.

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## *5. Speed of Sound*

***The speed of sound is the distance travelled by a sound wave in one second.***
***It tells us how fast sound energy moves through a medium. It is given by the formula:***
***Speed = Distance / Time***

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***Dependence on Medium***
***The speed of sound depends on the nature of the medium through which it travels.***
***Sound needs a material medium like air, water, or solids, and its speed changes in each.***

- ***Fastest in solids → because particles are very close together.***
- ***Slower in liquids → particles are less tightly packed.***
- ***Slowest in gases → particles are far apart.***

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**Approximate Speed of Sound at 25°C**

| Medium | Speed (m/s) |
| --- | --- |
| Air | 343 |
| Water | 1498 |
| Iron | 5130 |

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**Dependence on Temperature**

*The speed of sound increases with temperature.*
*At higher temperatures, particles move faster and transfer vibrations more quickly.*
*Example:*
*Sound travels faster in warm air than in cold air.*

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**Dependence on Humidity**

*When the humidity (moisture) in air increases, the speed of sound also increases.*
*This happens because water vapour is lighter than dry air, making it easier for sound to travel.*

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**In Short**

*Speed of sound depends on the medium, temperature, and humidity, and is fastest in solids and slowest in gases.*

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## 6. Range of Human Hearing

*The range of human hearing is the range of sound frequencies that a human ear can hear.*

- *Humans can typically hear sounds with frequencies between 20 Hz and 20,000 Hz (20 kHz).*
- *Sounds below 20 Hz are called infrasound (too low to hear).*
- *Sounds above 20,000 Hz are called ultrasound (too high to hear).*

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***Key Points***

1. ***Audible Range: 20 Hz – 20,000 Hz***
2. ***Infrasound: < 20 Hz → cannot be heard by humans***
3. ***Ultrasound: > 20,000 Hz → cannot be heard by humans***

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***Examples***

- ***Normal speech: 200 Hz – 4000 Hz***
- ***Dog whistle: Above 20 kHz (ultrasound)***
- ***Earthquake vibrations: Below 20 Hz (infrasound)***

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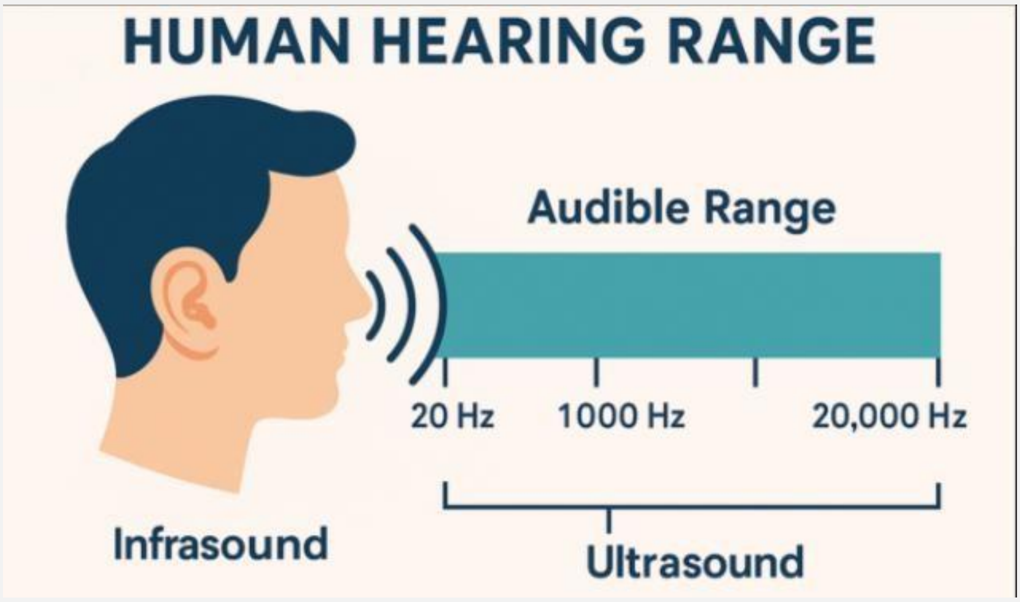
***In Short***

***Humans can hear sounds in the frequency range of 20 Hz to 20,000 Hz.***
***Frequencies below or above this range cannot be heard.***

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## *7. Reflection of Sound*

***Reflection of sound is the bouncing back of sound waves when they hit a hard, smooth surface.***

- ***Just like light, sound also reflects from surfaces.***
- ***The angle of incidence (angle at which sound strikes) is equal to the angle of reflection (angle at which it bounces back).***

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*Key Points*

1. ***For reflection, the surface should be hard and smooth.***
2. ***Soft or irregular surfaces absorb sound and reduce reflection.***
3. ***Reflected sound can be heard after a short delay, depending on the distance of the reflecting surface.***

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*Examples*

- ***Sound echoing in a mountain valley***
- ***Shouting in a hall with hard walls***
- ***Sound reflection in concert halls to enhance acoustics***

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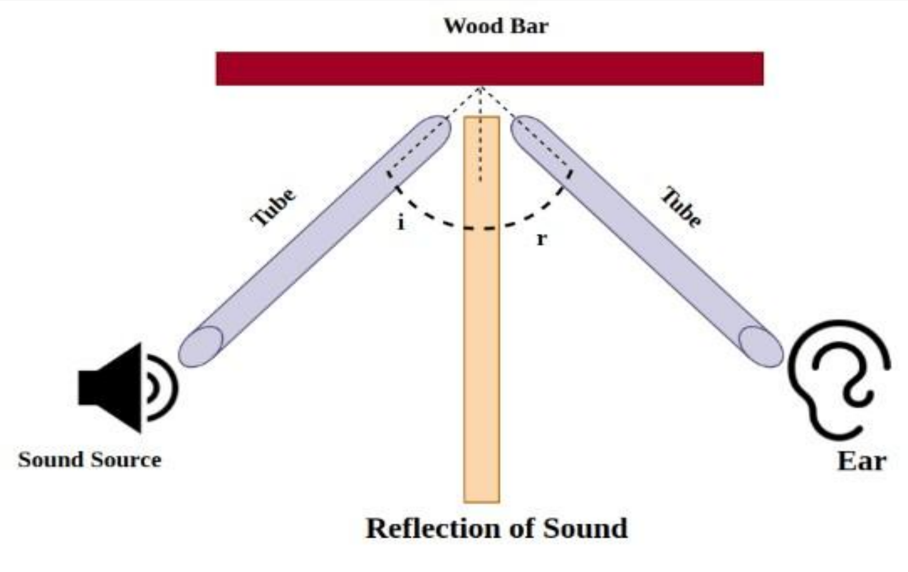
*In Short*

***Reflection of sound is the bouncing back of sound waves from a hard surface, following the law of reflection.***

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## *8. Applications of Reflection of Sound*

***The reflection of sound has many practical uses in daily life and technology.***

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*1. Echo*

- ***An echo is the reflected sound heard clearly after a short delay.***
- ***Used in distance measurement and for entertainment in auditoriums.***

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***2. SONAR (Sound Navigation and Ranging)***

- ***SONAR works on the principle of reflection of sound under water.***
- ***It helps in detecting underwater objects, measuring water depth, and locating submarines.***

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***3. Architectural Acoustics***

- ***Reflection of sound is used to design auditoriums, halls, and theaters.***
- ***Proper reflection ensures clear sound reaches every corner.***

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***4. Ultrasound in Medicine***

- ***Medical ultrasound uses reflected sound waves to create images of internal organs.***
- ***Example: Detecting baby in womb or tumors.***

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***5. Megaphones and Musical Instruments***

- ***Certain instruments and devices use reflection to amplify sound.***
- ***Example: Megaphones, guitar bodies, and pianos.***


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## *9. Structure of Human Ear*

***The human ear is the organ responsible for hearing and maintaining balance. It is divided into three main parts:***

1. *Outer Ear*
2. *Middle Ear*
3. *Inner Ear*

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***1. Outer Ear***

- ***Consists of the pinna (the visible part) and the ear canal.***
- ***Pinna collects sound waves and directs them into the ear canal.***
- ***Ear canal ends at the eardrum (tympanic membrane), which vibrates when struck by sound waves.***

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***2. Middle Ear***

- ***An air-filled chamber containing three tiny bones (ossicles):***
    1. ***Malleus (hammer)***
    2. ***Incus (anvil)***
    3. ***Stapes (stirrup)***
- ***These bones amplify vibrations from the eardrum and transmit them to the inner ear.***
- ***The Eustachian tube connects the middle ear to the throat and maintains air pressure.***

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***3. Inner Ear***

- ***Contains the cochlea (for hearing) and semicircular canals (for balance).***
- ***Cochlea converts vibrations into electrical signals that are sent to the brain via the auditory nerve.***
- ***Semicircular canals help in maintaining balance and body orientation.***


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## *10. Noise and Music*

- ***Noise: Unpleasant, irregular, and unwanted sound. It causes irritation and disturbance.***
- ***Music: Pleasant, organized sound with definite pitch and rhythm.***

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## *11. Noise Pollution*

- ***Excessive or unwanted noise in the environment.***
- ***Sources include vehicles, industries, loudspeakers, construction sites.***
- ***Causes health problems such as hearing loss, stress, and sleep disturbances.***
- ***Noise control measures include sound barriers, proper urban planning, and use of ear protection.***

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## *12. Sample Problems*

***Q: A sound wave has frequency 500 Hz and wavelength 0.68 m. Calculate speed of sound in the medium.***

***A: Speed, v = frequency × wavelength = 500 × 0.68 = 340 m/s***

***Q: A person claps his hands near a cliff and hears the echo after 4 seconds. If the speed of sound in air is 340 m/s, calculate the distance of the cliff from the person.***
***A:***

- ***Time for echo = 4 s (time for sound to go to cliff and come back)***
- ***Distance travelled by sound = Speed × Time = 340 × 4 = 1360 m***
- ***Distance to cliff = 1360 ÷ 2 = 680 m***

***=680 m***

***Q: The highest frequency that a human can hear is 20,000 Hz. If the speed of sound in air is 340 m/s, calculate the wavelength of this sound.***
***A:***

- ***Wavelength (λ) = Speed / Frequency***
- ***λ = 340 ÷ 20,000 = 0.017 m = 1.7 cm***

***=1.7 cm***