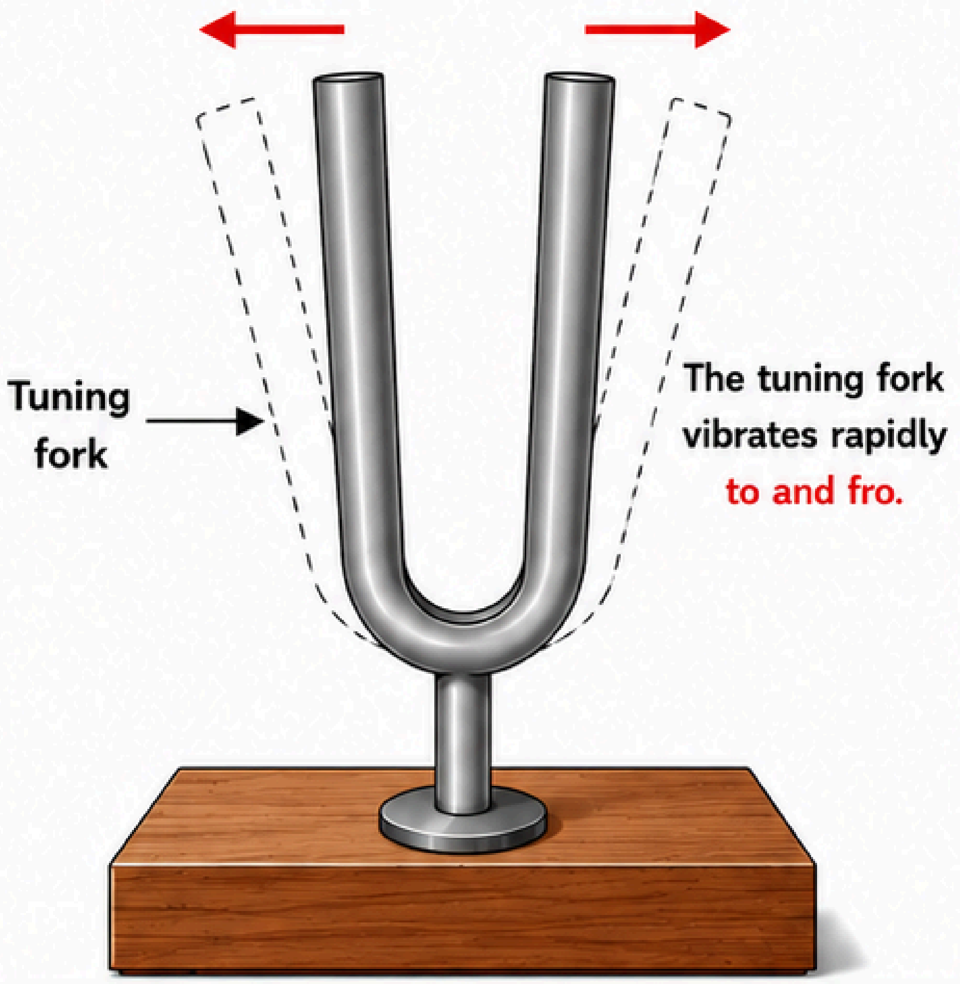
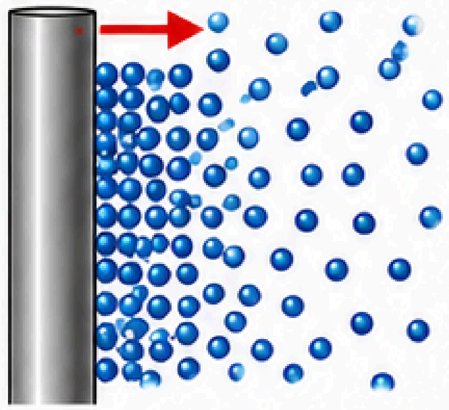
PRODUCTION OF SOUND BY VIBRATING OBJECT

Sound is produced when an object **vibrates**.
The vibrations set the surrounding **particles of air** into vibration.



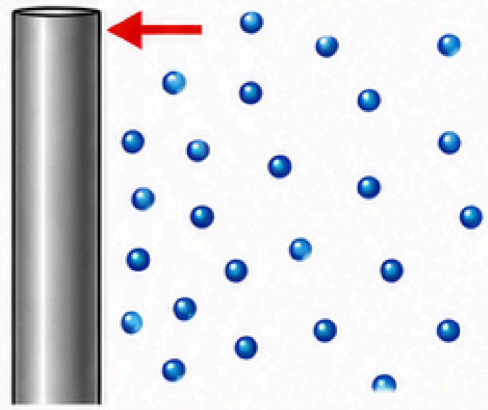
ZOOMED VIEW

When prong moves outward (Compression)



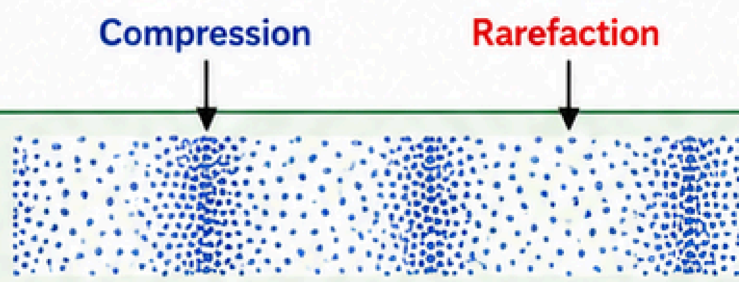
Air particles are pushed closer together.

When prong moves inward (Rarefaction)



Air particles are spread farther apart.

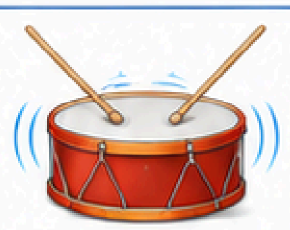
These vibrations are passed on to the surrounding air particles in the form of compressions and rarefactions, producing a sound.



KEY POINTS

- An object must vibrate to produce sound.
- Vibrations produce successive compressions and rarefactions in the surrounding air.
- These compressions and rarefactions travel through the air as sound waves.
- Without a material medium (like air), sound cannot travel.

EXAMPLES



Vibrating drumhead

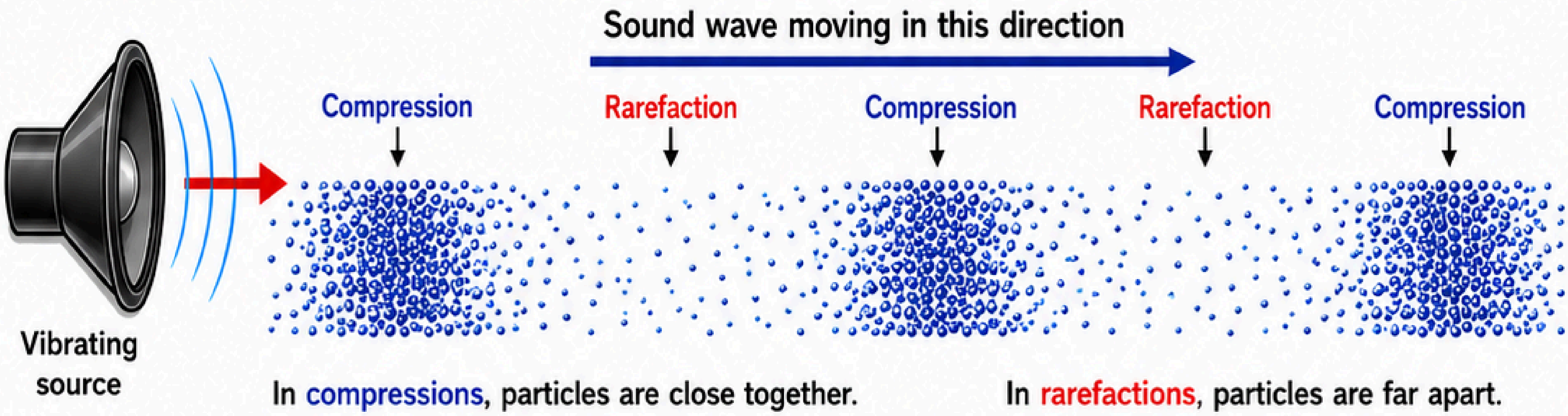
Vibrating guitar string

Vibrating speaker cone

Vibrating air column in flute

PROPAGATION OF SOUND – COMPRESSIONS & RAREFACTIONS

Sound waves travel through a medium (like air) in the form of compressions and rarefactions.

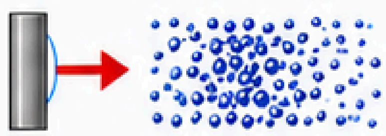


In compressions, particles are close together.

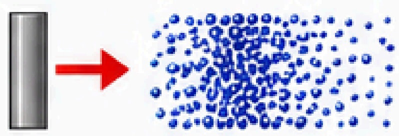
In rarefactions, particles are far apart.

HOW IT WORKS

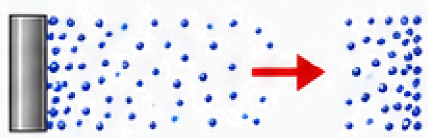
1. The vibrating source pushes the nearby air particles together. This region is called a **COMPRESSION**.



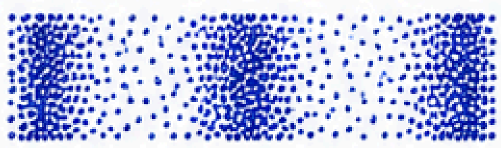
2. These particles then move to the next position and push other particles, creating another compression.



3. After the compression, particles move apart, creating a region of low pressure called a **RAREFACTION**.



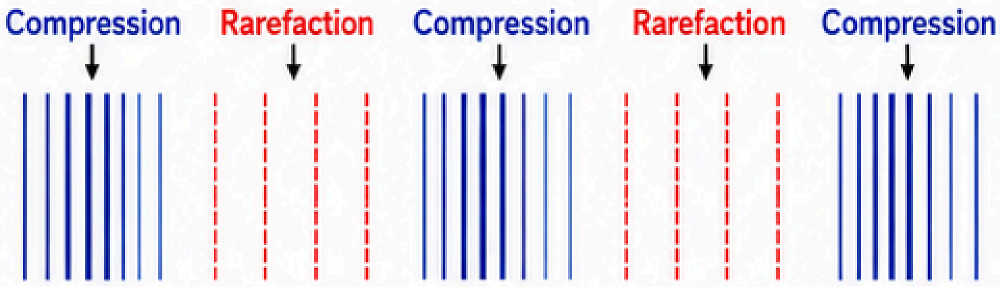
4. These compressions and rarefactions continue to travel through the medium as a **SOUND WAVE**.



KEY POINTS

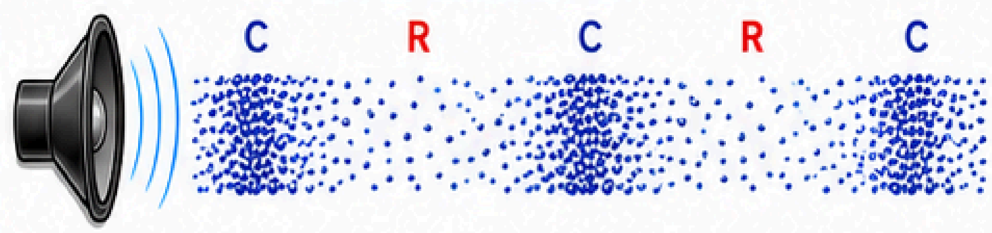
- Sound is a **LONGITUDINAL WAVE**.
- It consists of alternate compressions (high pressure) and rarefactions (low pressure).
- Sound needs a material medium to travel.
- The distance between two successive compressions (or rarefactions) is called the **WAVELENGTH (λ)**.

SYMBOLIC REPRESENTATION



= Compression (high pressure) = Rarefaction (low pressure)

EXAMPLE



C – Compression (high pressure)

R – Rarefaction (low pressure)

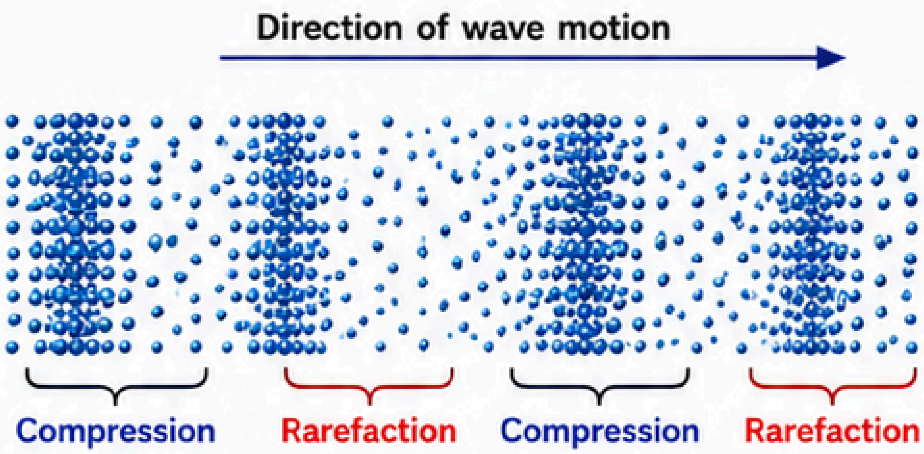
Sound waves are produced by vibrations and travel through a medium as successive compressions and rarefactions.

LONGITUDINAL VS TRANSVERSE WAVES

Waves are disturbances that transfer energy from one place to another without transfer of matter.

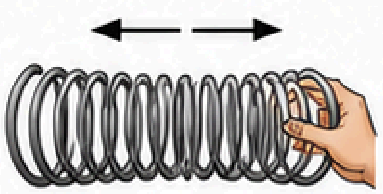
LONGITUDINAL WAVES

In longitudinal waves, the particles of the medium vibrate parallel to the direction of wave motion.



Example :

Sound waves in air

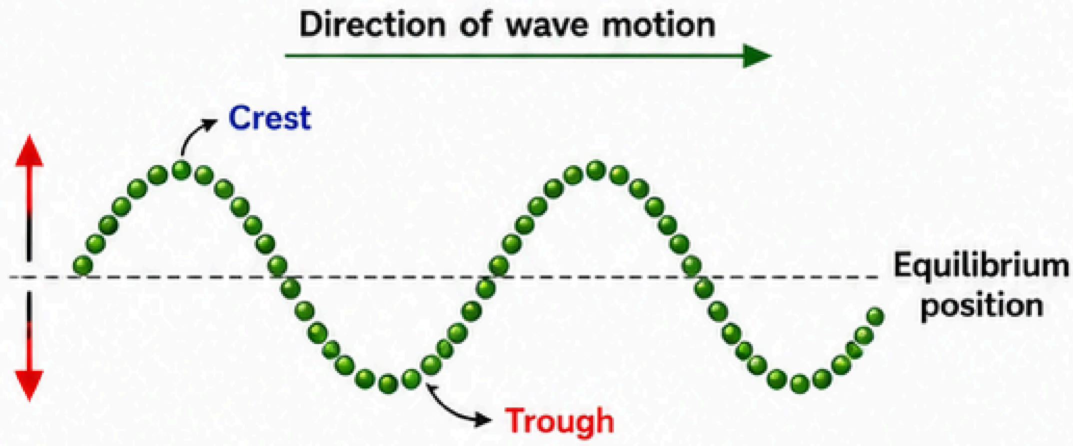


Compression in a slinky spring

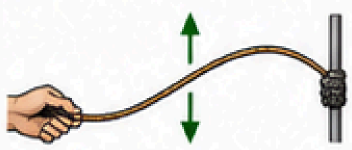
Vibrations of a tuning fork

TRANSVERSE WAVES

In transverse waves, the particles of the medium vibrate perpendicular to the direction of wave motion.

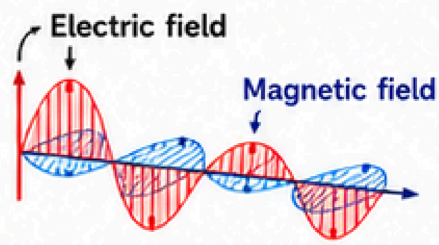


Example :



Wave in a rope

Ripples on the surface of water



Electromagnetic waves (light, radio waves)

KEY DIFFERENCES

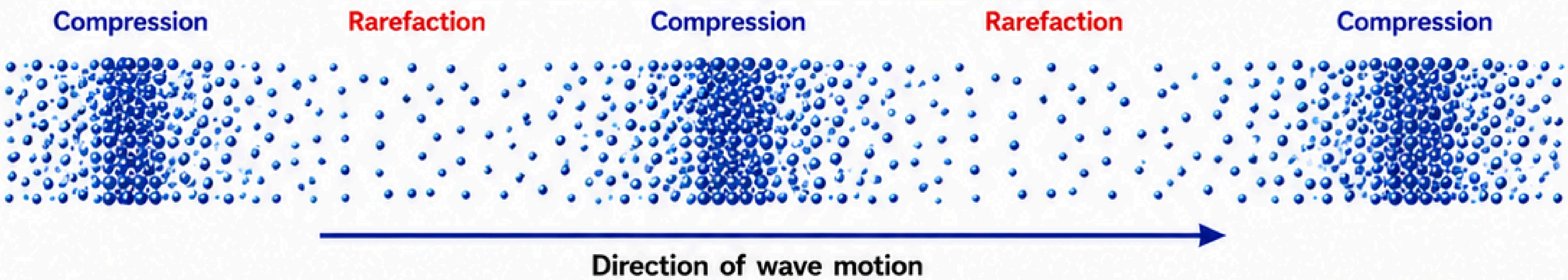
FEATURE	LONGITUDINAL WAVES	TRANSVERSE WAVES
1. Direction of particle vibration	Parallel to the direction of wave motion.	Perpendicular to the direction of wave motion.
2. Nature	Have compressions and rarefactions.	Have crests and troughs.
3. Medium of propagation	Can travel in solids, liquids and gases.	Generally travel in solids and on the surface of liquids. Not in gases.
4. Examples	Sound waves, compression in a spring, waves in a slinky, seismic P-waves.	Waves in a rope, water waves, light waves, seismic S-waves.
5. Energy transfer	Transfer energy through compressions and rarefactions.	Transfer energy through crests and troughs.
6. Particle motion	Back and forth in the same line.	Up and down (or perpendicular) to the direction of motion.

Longitudinal waves have particle vibration parallel to the direction of motion with compressions and rarefactions, whereas transverse waves have particle vibration perpendicular to the direction of motion with crests and troughs.

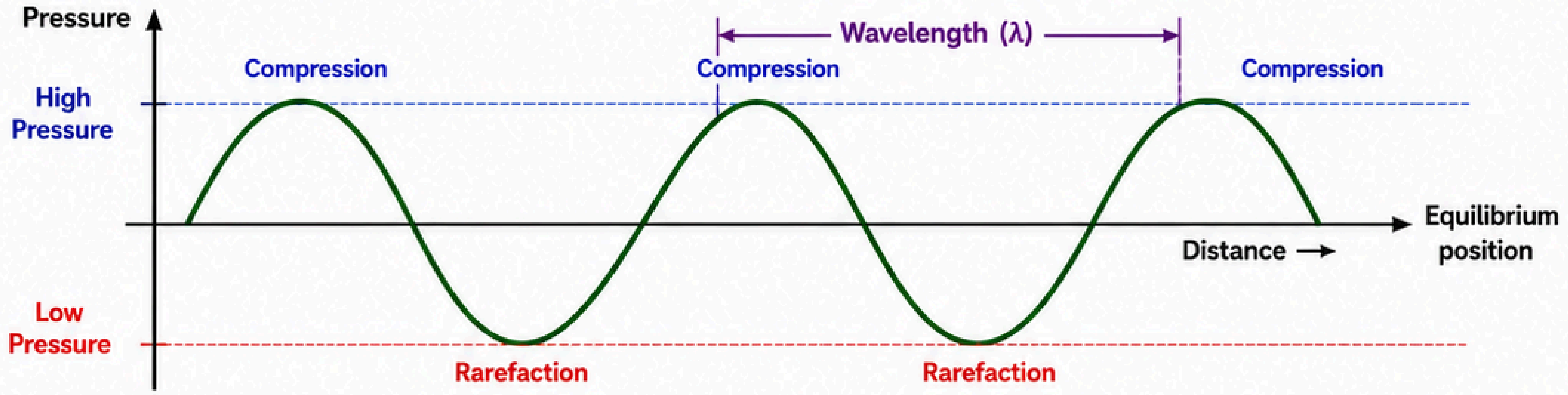
GRAPHICAL REPRESENTATION OF A SOUND WAVE – WAVELENGTH & FREQUENCY

Sound waves are longitudinal waves. They consist of successive **compressions** (high pressure) and **rarefactions** (low pressure).

LONGITUDINAL SOUND WAVE (PARTICLE VIEW)

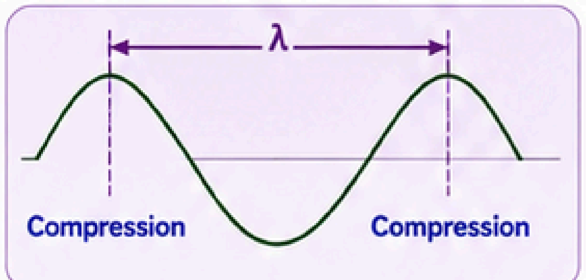


LONGITUDINAL SOUND WAVE (GRAPH VIEW)



WAVELENGTH (λ)

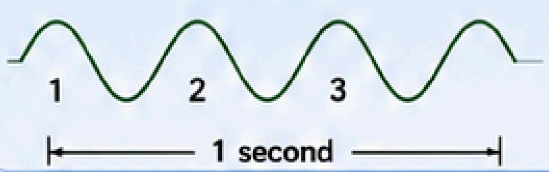
- Wavelength (λ) is the distance between two successive **compressions** or two successive **rarefactions**.
- It is measured in metres (m).



FREQUENCY (ν)

- Frequency (ν) is the number of complete waves passing a point in **one second**.
- It is measured in **hertz (Hz)**.
- Unit: 1 Hz = 1 wave per second.

If 3 complete waves pass in 1 second,
Frequency (ν) = 3 Hz



SPEED, WAVELENGTH & FREQUENCY

The speed (v) of sound is related to wavelength and frequency by:

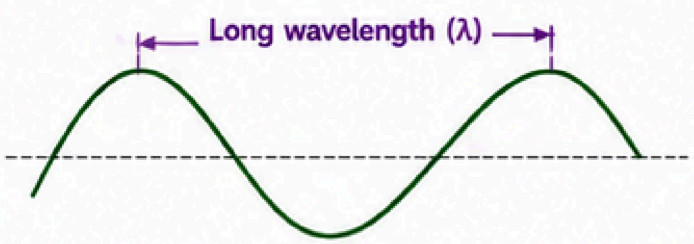
$$v = f\lambda$$

Where,

v = Speed of sound (m/s)
f = Frequency (Hz)
λ = Wavelength (m)

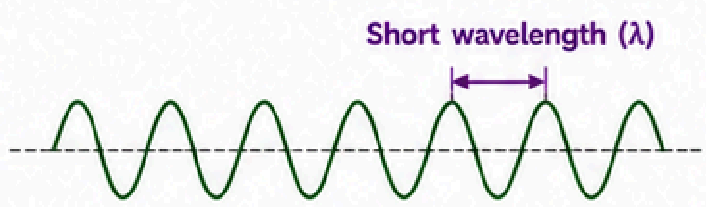
EXAMPLES

- Low frequency (less number of waves in 1 second) ⇒ Long wavelength



Deep sound (e.g., bass note in music)

- High frequency (more number of waves in 1 second) ⇒ Short wavelength



Shrill sound (e.g., whistle sound)

KEY POINTS

- Sound wave is a longitudinal wave.
- It has **compressions** and **rarefactions**.
- Wavelength is the distance between two successive **compressions** or two successive **rarefactions**.
- Frequency is the number of waves passing a point in one second.
- $v = f\lambda$

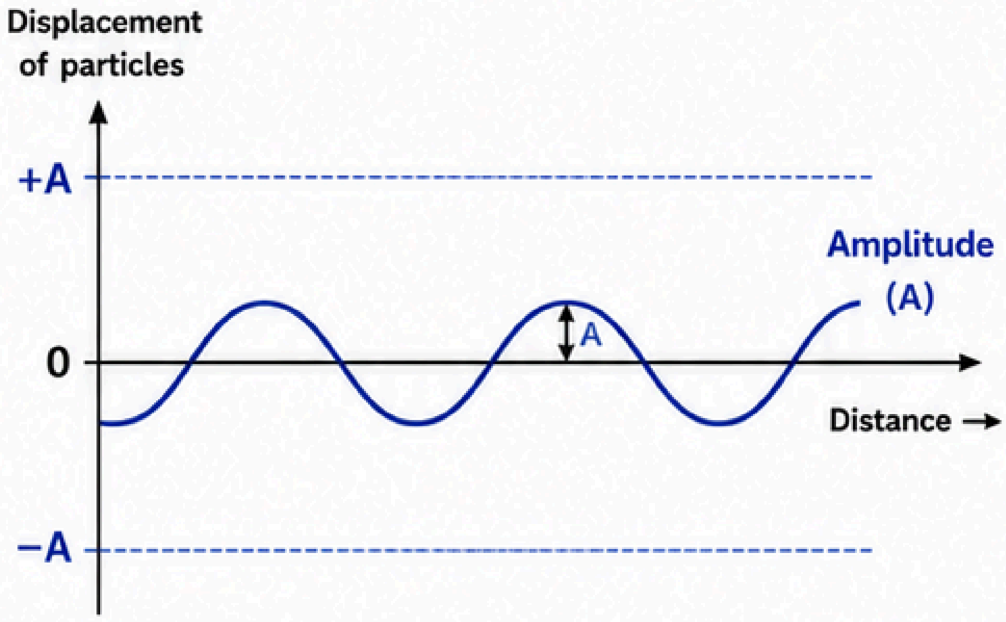
LOW vs HIGH AMPLITUDE SOUND WAVES

Amplitude is the maximum displacement of the particles of the medium from their **mean (equilibrium)** position.

LOW AMPLITUDE SOUND WAVE

Particles vibrate with small amplitude.

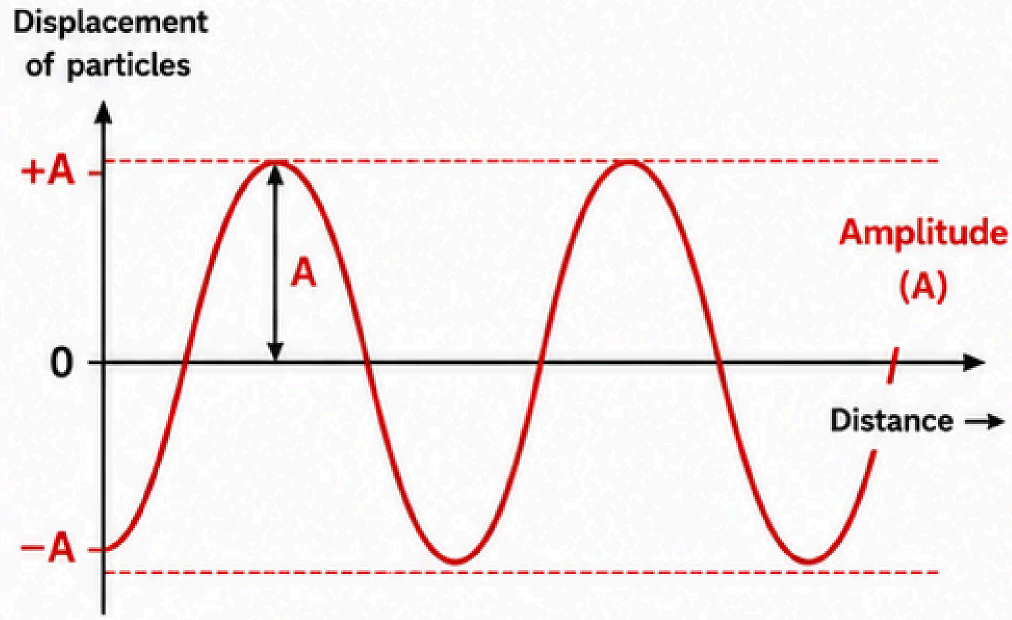
It produces a **soft (faint)** sound.



HIGH AMPLITUDE SOUND WAVE

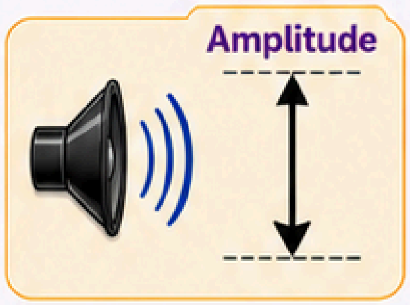
Particles vibrate with large amplitude.

It produces a **loud** sound.



COMPARISON

- **Small** amplitude (A)
- Particles move a **short** distance from the mean position.
- **Low energy**
- **Soft (faint)** sound
- **Less** intensity

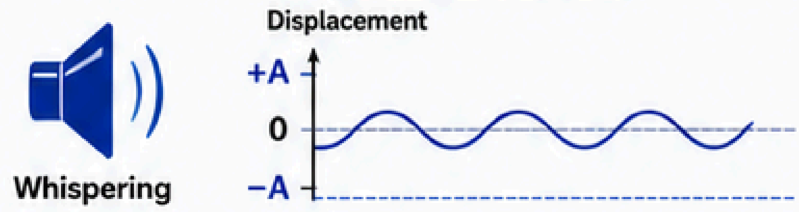


- **Large** amplitude (A)
- Particles move a **long** distance from the mean position.
- **High** energy
- **Loud** sound
- **More** intensity

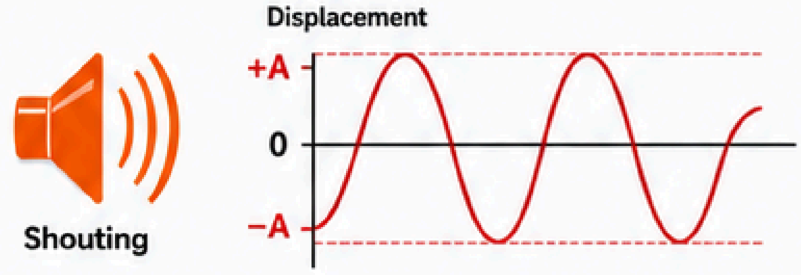
KEY POINTS

- The amplitude of a sound wave determines its **loudness**.
- **Greater** the amplitude, greater is the energy and intensity, and the **louder** is the sound.
- Amplitude does not affect the **pitch** (pitch depends on frequency).
- Both low and high amplitude waves travel with the **same speed** in a particular medium.

EXAMPLES



Low amplitude
Soft sound

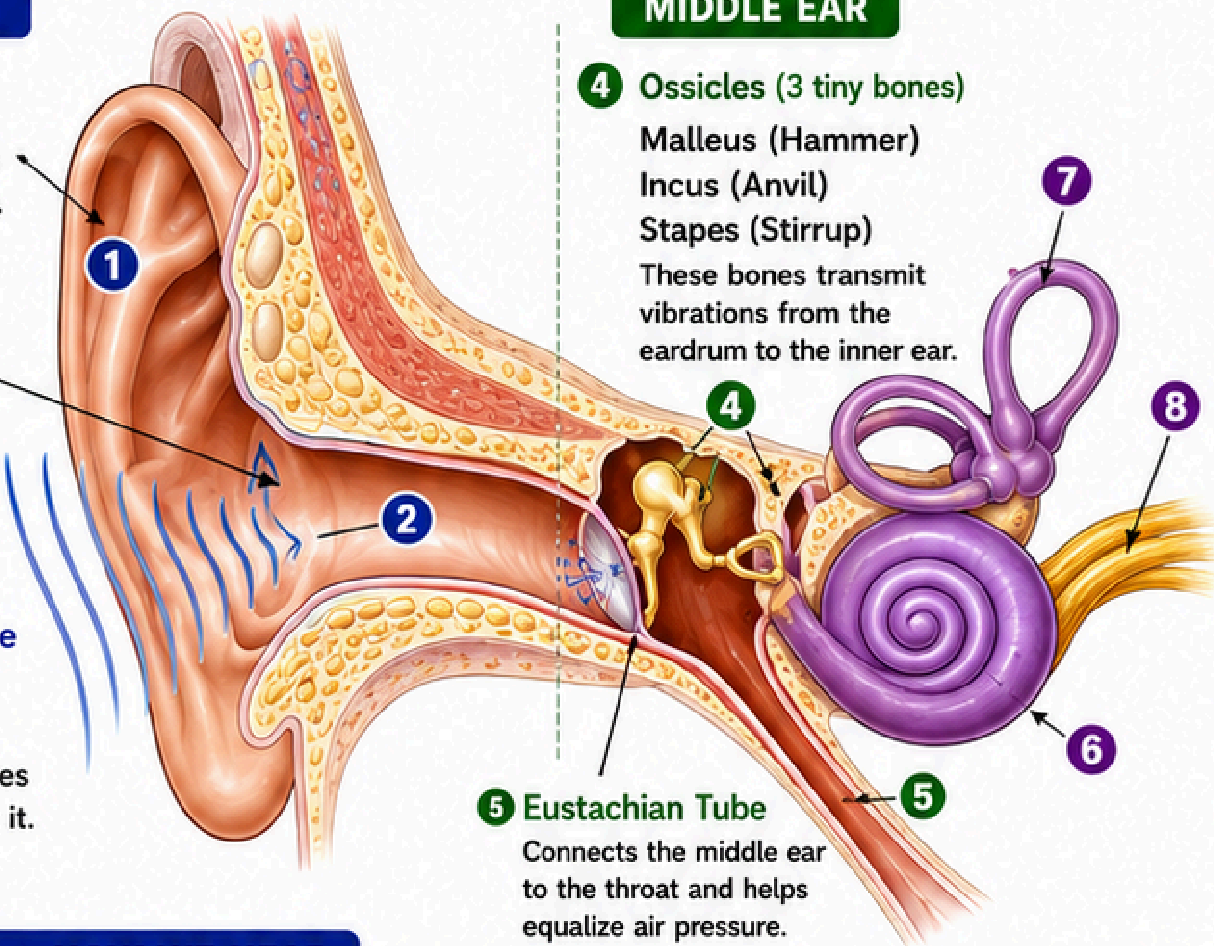


High amplitude
Loud sound

Amplitude decides how **LOUD** or **SOFT** a sound is.

HUMAN EAR – STRUCTURE & HEARING PROCESS

The human ear is a complex organ that helps us hear sounds.
It consists of three main parts: Outer Ear, Middle Ear and Inner Ear.



OUTER EAR

1. **Pinna (ear flap)**
Collects sound waves from the surroundings.

2. **External Auditory Canal**
A passage that carries sound waves to the eardrum.

3. **Tympanic Membrane (Eardrum)**
A thin, stretched membrane that vibrates when sound waves hit it.

MIDDLE EAR

4. **Ossicles** (3 tiny bones)
Malleus (Hammer)
Incus (Anvil)
Stapes (Stirrup)
These bones transmit vibrations from the eardrum to the inner ear.

5. **Eustachian Tube**
Connects the middle ear to the throat and helps equalize air pressure.

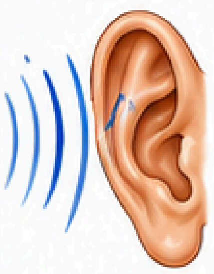
INNER EAR

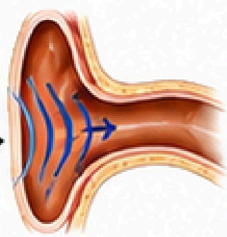
6. **Cochlea**
A spiral-shaped structure filled with fluid. It contains hair cells that convert vibrations into electrical signals.

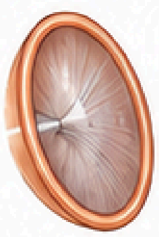
7. **Semicircular Canals**
Help in maintaining balance and detecting head movement.

8. **Auditory Nerve**
Carries electrical signals from the cochlea to the brain.

HEARING PROCESS – HOW WE HEAR

1. **Sound waves enter the ear.**

The pinna collects sound waves and directs them into the ear canal.

2. **Waves travel through the ear canal.**

Sound waves travel through the external auditory canal and reach the eardrum.

3. **Eardrum vibrates.**

The eardrum (Tympanic membrane) vibrates back and forth.

4. **Vibrations pass through the ossicles.**

The three tiny bones (malleus, incus, stapes) transmit and amplify the vibrations.

5. **Vibrations reach the cochlea.**

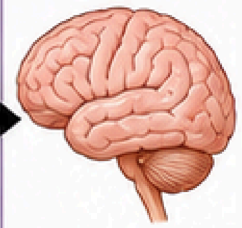
The stapes pushes on the oval window and vibrations enter the cochlea.

6. **Hair cells detect vibrations.**

Fluid inside the cochlea moves and stimulates hair cells.

7. **Signals travel via auditory nerve.**

Hair cells convert vibrations into electrical signals. These signals travel through the auditory nerve to the brain.

8. **Brain interprets the signals as sound.**

The brain understands these signals and we perceive sound.

KEY POINTS

- The ear converts sound energy into electrical signals.
- Outer ear collects sound, middle ear amplifies it, and inner ear converts it into signals.
- The auditory nerve sends signals to the brain, where we recognize and understand sounds.

FUN FACT

The human ear can detect sounds in the frequency range of 20 Hz to 20,000 Hz.

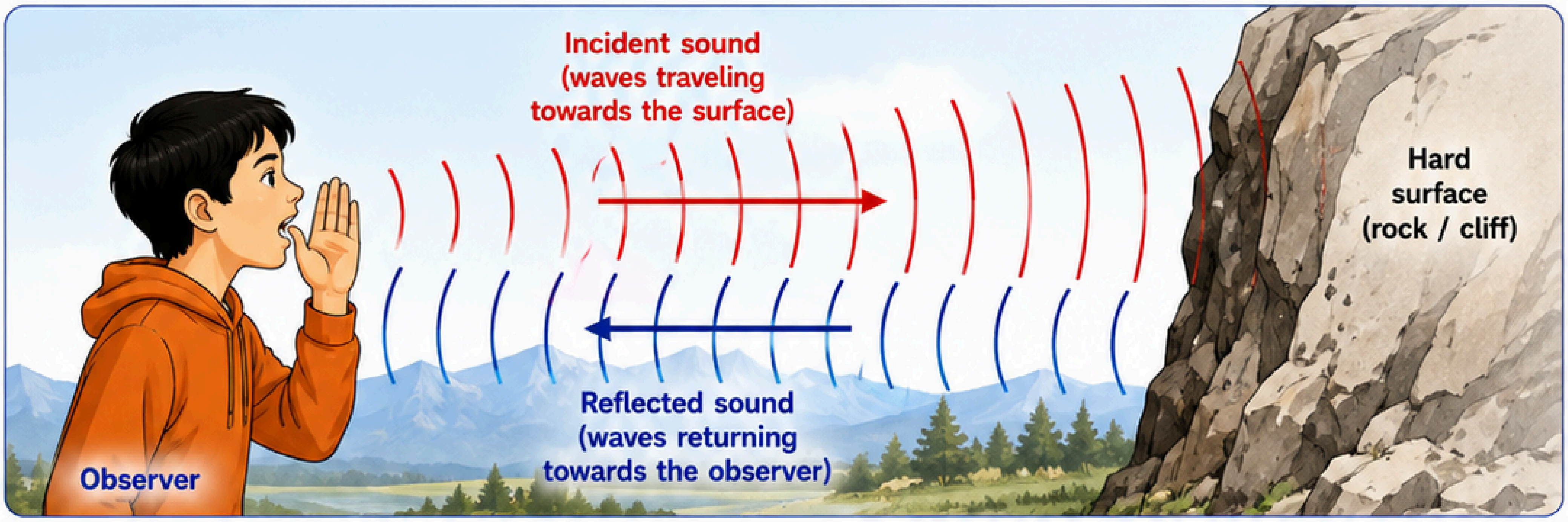
CARE TIP

Keep your ears clean and avoid loud noises to protect your hearing.

Our ears are incredible! They help us enjoy music, talk with others, learn, and stay safe by hearing important sounds.

ECHO – REFLECTION OF SOUND

When sound waves strike a large, hard surface, they are reflected back in the same medium. This reflected sound is heard again as an ECHO.



HOW ECHO IS HEARD

- The reflected sound reaches the observer after a short time delay.
- If the time gap between the original sound and the reflected sound is 0.1 second or more, we hear it as a separate ECHO.

Time gap (Δt) ≥ 0.1 s $\Rightarrow$ Echo is heard
Time gap (Δt) < 0.1 s $\Rightarrow$ Echo is not heard

DISTANCE OF THE OBSTACLE

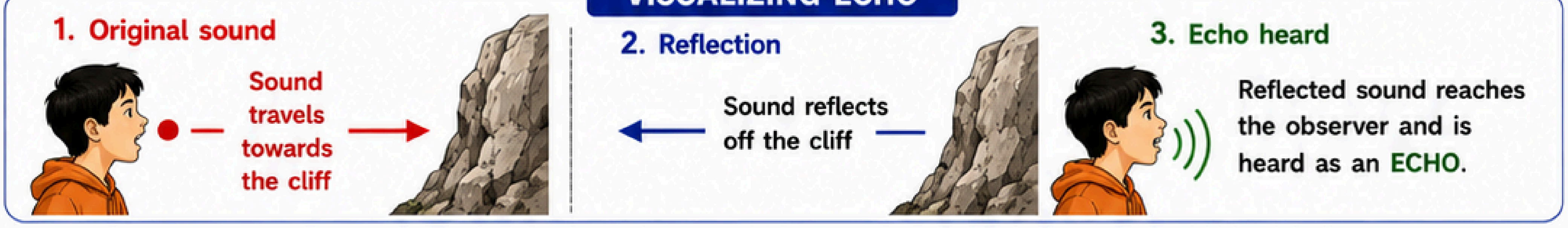
If the time gap between the original sound and the echo is Δt, then the distance (d) of the reflecting surface is:

$$\boxed{d = \frac{v \times \Delta t}{2}}$$

Where,

v = Speed of sound in air (≈ 340 m/s at 15°C)
Δt = Time gap between original sound and echo (in seconds)
d = Distance of the obstacle (in metres)

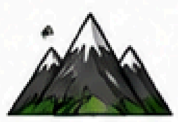
VISUALIZING ECHO



KEY POINTS

- Echo is the reflection of sound.
- It is heard when the time gap is 0.1 s or more.
- It requires a large, smooth and hard surface.
- The minimum distance to hear an echo in air is about 17 metres.

APPLICATIONS OF ECHO


Used in mountains and valleys to measure distances.


Bats use echo to find their prey and avoid obstacles (echolocation).


Ships use SONAR (echo) to detect the depth of the sea and locate underwater objects.

ECHO helps us in navigation, distance measurement, and in the working of SONAR and other modern technologies.

SONAR – WORKING PRINCIPLE

Sound Navigation And Ranging

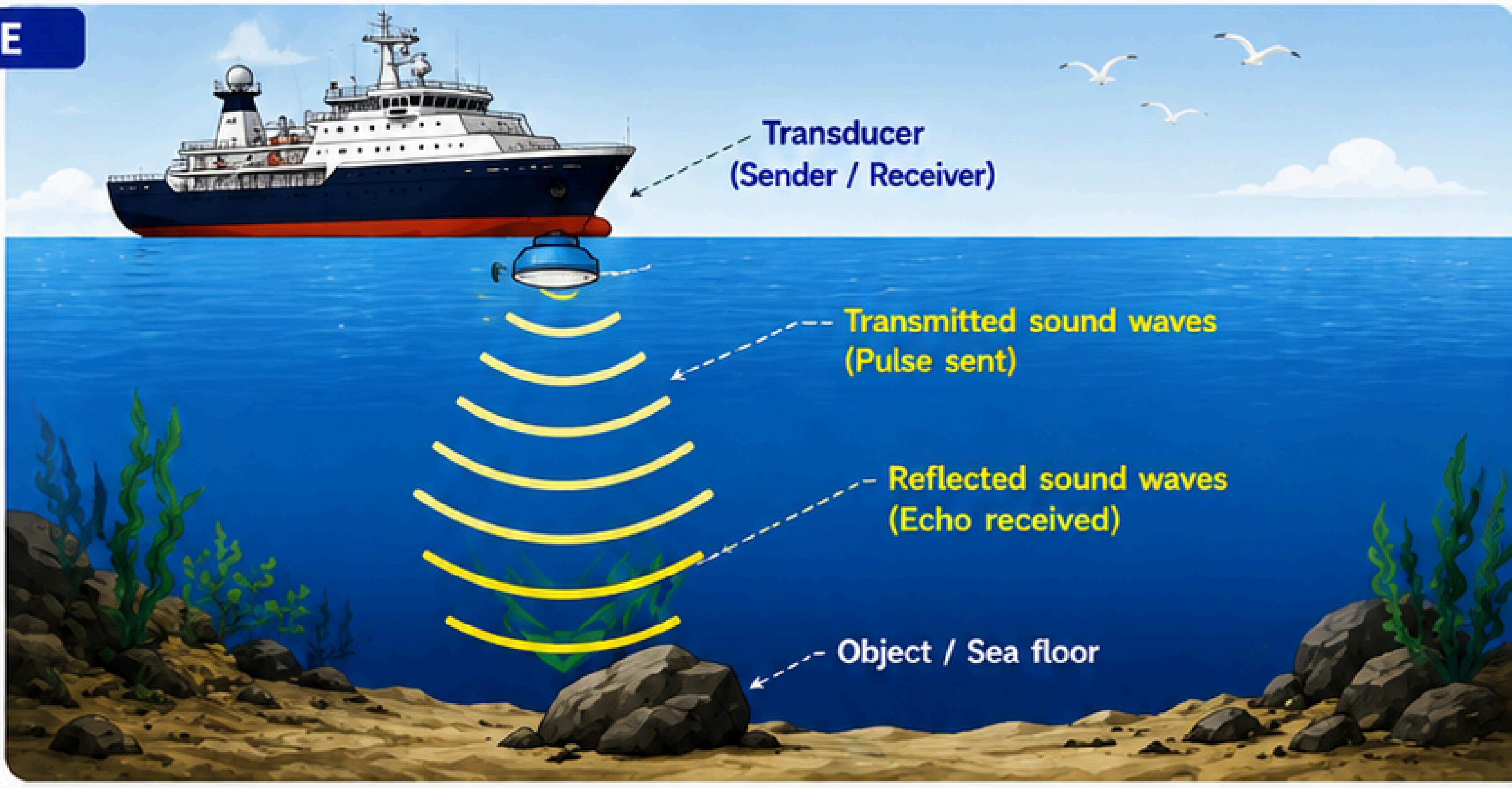
SONAR uses sound waves to detect objects, measure distance and determine the depth of the sea.

WORKING PRINCIPLE

SONAR works on the principle of reflection of sound waves.

It sends high-frequency sound waves into the water. These waves travel through water, strike an object or the sea floor, and get reflected back.

The system receives the reflected waves and calculates the distance based on the time taken for the echo to return.



HOW SONAR WORKS – STEP BY STEP

1. Transducer emits a short pulse of ultrasonic sound into the water.
2. Sound waves travel through water towards an object or the sea floor.
3. Waves hit the object or sea floor and get reflected back.
4. Reflected waves travel back to the transducer.
5. Transducer receives the echo and sends the data to the system.
6. System calculates the distance or depth using the time taken.

Depth = 120 m

DISTANCE / DEPTH FORMULA

The distance (d) of the object from the SONAR is calculated by:

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

Where,

d = Distance of the object (m)

v = Speed of sound in water (≈ 1500 m/s)

t = Time taken for the echo to return (s)

(Divide by 2 because the sound travels to the object and back.)

KEY POINTS

- SONAR uses high-frequency sound waves (ultrasound).
- It works on the principle of reflection of sound.
- Water is an excellent medium for transmitting sound.
- SONAR helps in measuring distance, depth and detecting underwater objects.
- It is widely used in navigation, fishing, ocean exploration and military operations.

APPLICATIONS OF SONAR

- Measuring the depth of oceans and seas.
- Detecting underwater mountains, valleys and objects.
- Navigation and safe movement of ships and submarines.
- Locating schools of fish (echo sounders).
- Used in submarines, naval defense and mine detection.

SONAR is the "EYES and EARS" of ships and submarines under water.
It helps us explore, navigate and protect our oceans!