SOUND

Sound is a form of energy which produces a sensation in our ears.

. Sound is produced by the vibrating objects or bodies.

eg: 1) When a drum is beaten, then the skin of drum vibrates and sound is produced.

2) Take a tuning fork. Hold it and strike its stem with a rubber pad. We observe that the prongs of tuning fork vibrate and sound is produced.

WAVE -

The movement of the disturbance through a medium due to repeated periodic motion of particles of medium about their mean positions is known as Wave.

Periodic Motion - A motion which repeats itself after regular intervals of time.

Types of Wave

Mechanical Wave

It is a disturbance which requires a medium (Solid, Liquid or gas)

eg: Sound Wave, Water Wave

Transverse

They vibrate about their equilibrium Position at right angles to direction of Propagation.

eg: Water Wave, Wave produced in stretched string.

Longitudinal

They vibrate to and fro about their equilibrium Position along direction of Propagation.

eg: Sound Wave.

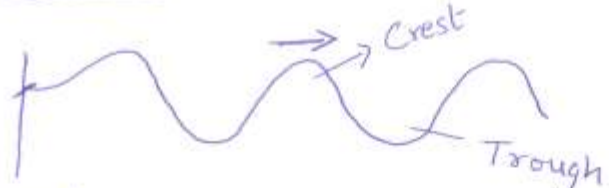
Electromagnetic Wave

eg: Light Wave

Doesnot require material medium

Matter Wave

Transverse Wave -



Up and
down jerk

Longitudinal Wave -

Compression (C)

Compression (C) - The part of a medium where density is ~~medium~~ maximum (where particles are very close).

It is region of high pressure or high density.

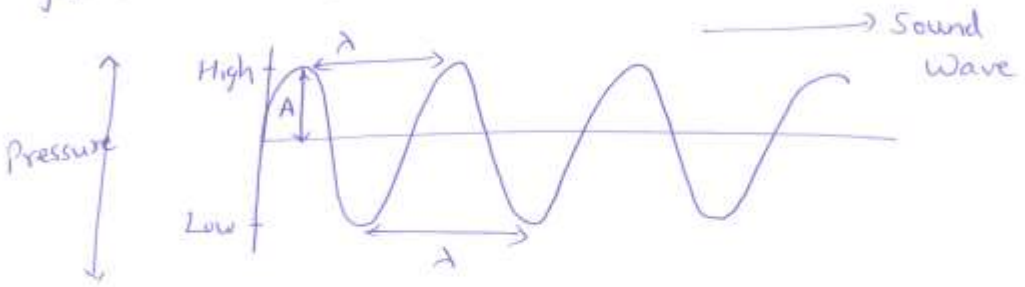
Rarefaction (R) - The part of a medium where density is minimum (where particles are very far apart).

It is region of low pressure or low density.

Sound needs a medium to travel.

Charateristics of a Sound Wave -

When a sound wave travels through medium, then density or pressure of medium changes from maximum to minimum value and viceversa.



(i) **Amplitude** -

Maximum displacement of vibrating body from its mean position.

SI unit ⇒ metre (m)

Denoted by A.

(i) **Wavelength** -

Distance between two consequtive crest or troughs.

Denoted by λ (Lambda).

SI unit ⇒ metre (m)

(iii) Frequency -

Number of oscillations made by vibrating body in one second.

Denoted by - ν (Neu)

SI unit - Hertz (Hz)

(iv) Time period -

Total time taken to complete one oscillation.

Denoted - T

SI unit - second (s)

Frequency = $\frac{1}{\text{Time period}}$

$$\nu = \frac{1}{T}$$

Q. Freq. = 200Hz. Calculate number of times, the source of sound vibrates in 60 sec. Also calculate Time period.

→ $\nu = 200\,Hz$

which means, sound vibrates 200 times in 1 sec.

ii, In 1 second = 200 vibrations

In 60 sec = 200 × 60

= 12000 vibrations

Time period, $T = \frac{1}{\upsilon} = \frac{1}{200}$

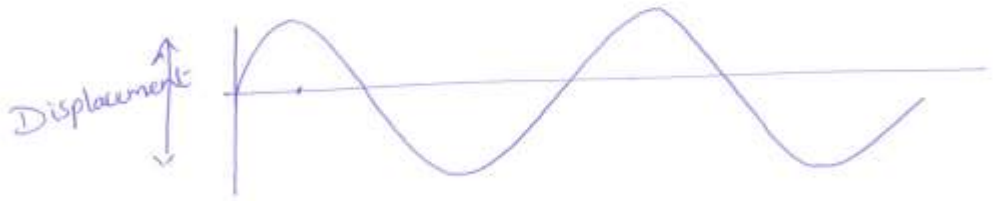
$= 0.005\ s = 5 \times 10^{-3}$ sec

(IV) Pitch or Shrillness -

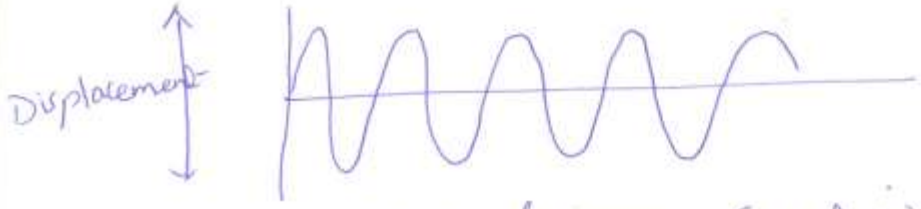
It depends on frequency.

High pitch = High frequency

Low pitch = Low frequency



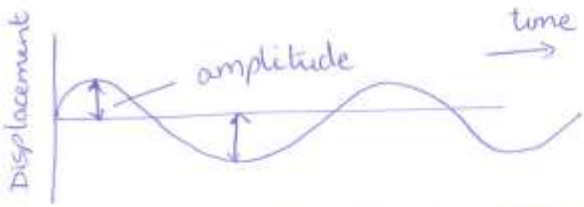
Low frequency sound wave



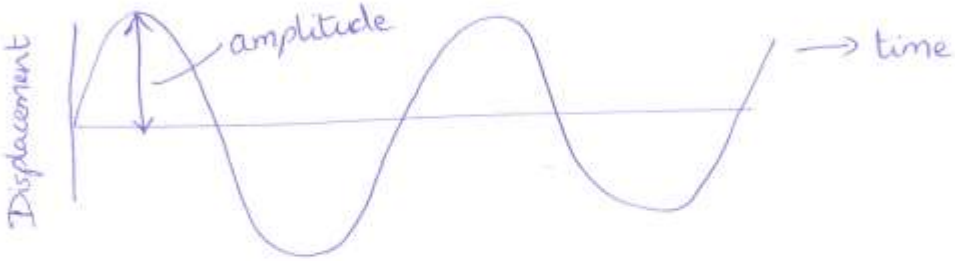
High frequency sound wave

(v) Loudness -

It depends on the amplitude of the vibrating body producing the sound.



Soft Sound (Small amplitude)



Loud Sound (Large amplitude)

(vi) Timbre or Quality -

This enables us to distinguish between the sound of same Loudness and pitch.

(vii) Intensity - It is the sound energy transferred per unit time through a unit area placed perpendicular to the direction of the propagation of sound.

$$\text{Intensity} = \frac{\text{Sound energy}}{\text{Time} \times \text{Area}}$$

SI unit = Joules $s^{-1} m^{-2}$ or Watt m^{-2}

$(1 J s^{-1} = 1 W)$

Relation between Wave Speed, Frequency and Wavelength

$$\text{Wave Speed} = \frac{\text{Distance travelled by Wave}}{\text{Time taken}}$$

Distance travelled = Wavelength (λ)

time taken = T

$$\text{Wave Speed}, c = \frac{\lambda}{T} = \lambda \times \frac{1}{T}$$

$$\frac{1}{T} = \nu$$

$$\boxed{c = \nu \lambda}$$

Units => $c = m/s$

$\nu = Hz$

$\lambda = m$

Q. A bat can hear sound of frequency = 100 KHz. Find wavelength of sound wave. Speed of sound = 344 m/s.

→ Given, ν = 100 KHz

$c = 344$ m/s

$c = \nu\lambda$

$$\lambda = \frac{c}{\nu} = \frac{344 \text{ m/s}}{100 \text{ KHz}} = \frac{344 \text{ m/s}}{10^5 \text{ Hz}}$$

$$= 344 \times 10^{-5} \text{ m}$$

$$= 3.44 \times 10^{-3} \text{ m}$$

Q. Calculate time period of sound wave of frequency 1000 Hz and wavelength 50 cm to travel a distance of 500 m.

$\nu = 1000$ Hz

$\lambda = 50$ cm $= 0.5$ m

$S = 500$ m

$c = \nu\lambda$

$= 1000 \times 0.5 = 500$ m/s

$$\text{Speed, } C = \frac{\text{distance}}{\text{time}} = \frac{S}{T}$$

$$T = \frac{S}{C} = \frac{500\ m}{500\ m/s} = 1\ s$$

Q. A hospital uses an ultrasonic scanner. Speed of sound is 1.7 km/s. Wavelength = ?
Operating Frequency = 4.2 MHz ($1MHz = 10^6 Hz$)

→ $C = 1.7\ km/s = 1700\ m/s$

$\lambda = ?$

$\nu = 4.2 \times 10^6\ Hz$

$C = \nu\lambda$

$$\lambda = \frac{C}{\nu} = \frac{1700}{4.2 \times 10^6}$$

$$= 4 \times 10^{-4}\ m = 0.4\ mm$$

NOTE -

Speed of Sound in Solid is highest.

Solid > Liquid > Gas.

Sound travels fast as temperature of medium increases.

Speed of Sound doesn't depend on pressure if temperature remains constant.

REFLECTION OF SOUND -

When a sound wave travelling in a medium bounces back to same medium after striking the second medium, reflection takes place.

ECHO -

Repetition of Sound due to reflection of original sound by hard obstacle.

Echo can be heard only if minimum distance between Source and obstacle is 17 m.

MULTIPLE ECHO -

when sound is reflected many time by an obstacle, multiple echoes are heard.

eg: 1) Dome shaped whispering gallery.
2) Sound produced between 2 distant hills or buildings.

REVERBERATION -

Multiple reflection of sound produced even when the source stops producing sound.

Quality of sound can be improved by reverberation.

Reverberation Time - It is the time interval for which original sound appears to be prolonged.

How to decrease Reverberation -

1) Sound absorbing materials in auditorium
2) Windows covered by heavy curtains.
3) Padded seats 4) Acoustic tiles.

RANGE OF HEARING

INFRASONIC

↓

Sound below 20Hz.

These waves are produced by vibrations in earth's surface during earthquake.

eg: Elephants, whales, Rhinoceroses

ULTRASONIC

↓

Sound above 20,000Hz.

These waves are not audible by human ear.

eg: Bats produce Ultrasonic by flapping their wings.
They can even detect these sound waves.

Dolphins can produce and detect ultrasound.

Audible range → 20Hz to 20,000Hz

Application of Ultrasound -

1) Used for communication eg: SONAR used to detect depth of a sea.

eg: $S = v\left(\frac{t}{2}\right)$

S = depth of sea

v → speed of ultrasonic sound.

2) Used in Industries -

- Used to detect faults and cracks in metals.
- Used for welding plastic.

3) Medicinal Use -

- Used to kill bacteria in liquids.
- Echocardiography (ECG)
- Used to detect kidney stones.

Hearing Device (HUMAN EAR) -

External Ear

Pinna → Collects the Sound & send it to Ear Canal

Sound in form of Compression & Rarefaction reaches Eardrum.

These Waves when hit eardrum, the eardrum starts vibrating.

Middle Ear

The vibrations transmits to this part.

Hammer, Anvil, Stirrup

Sound waves are amplified here.

Internal Ear

Amplified vibrations are transmitted to Cochlea

It contains fluid. Movement in fluid stimulates the auditory nerves.

These are further send to brain in electrical signals.

NUMERICALS

1) An echo is heard when returns in 3 sec. What is distance of the reflecting surface from source, given speed of sound is 342 m/s.

→ Time taken to travel from source to reflecting surface,

$$t = \frac{3}{2} = 1.5 \text{ sec}$$

Speed, $v = 342 \text{ m/s}$

Distance of reflecting surface from source,

$$S = v \times t$$

$$= 342 \times 1.5$$

$$= 513 \text{ m}$$

2) A Sonar wave takes 1.02 sec to come back. If speed of sound is 1531 m/s. How far is the cliff?

Ans ⇒ 780.81 m

3) Why is speed of sound greater in solids than in gases?

→ Because particles of solids are closer than that of gases.

4) Distinguish between Longitudinal and transverse wave.

5) Explain how human ear works.