SOUND

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

It is produced by vibrating objects. It requires a material medium (solid, liquid or gas) for its propagation.

Sound waves are also called mechanical waves.

Types of waves -

① Longitudinal wave - Individual particles of the medium vibrate in the direction parallel to the direction of propagation of wave.
Sound waves are longitudinal waves.

② Transverse wave - Individual particles of the medium vibrate perpendicular to the direction of wave propagation.
Light is a transverse wave (but not a mechanical wave)

Propagation of sound in Air -

When a vibrating object moves forward, it compresses the air, creating compression (high pressure) and when it moves backward it creates rarefaction (low pressure). Compression (C) is where particles are close together and Rarefaction (R) is where particles are farther apart.

Relationship between speed, frequency and wavelength of sound wave -

Speed = frequency x Wavelength

Range of Hearing -
The average frequency range over which the human ear is sensitive is called audible range (20 Hz to 20000 Hz)

Infrasonic sound - Sound of frequency less than 20 Hz, cannot be heard by humans.

Ultrasonic sound - Sound of frequency higher than 20000 Hz. Bats, dolphins, tortoise and rats can produce as well as hear ultrasound.

REFLECTION OF SOUNDWAVES -
The returning back of sound waves on striking a surface such as wall, metal sheet etc.

Sound does not require a smooth and shining surface like mirror for reflection.

Condition for reflection of sound wave is that the size of reflecting surface must be bigger than the wavelength of sound wave.

ECHO -

The sound heard after reflection from a distant obstacle (such as a cliff, hillside, wall of a building, edge of forest etc) after the original sound has ceased is called echo.

Condition for hearing an echo -

1) The size of obstacle/reflector must be large compared to the wavelength of the incident sound.
2) The distance between the source of sound and the reflector should be atleast 17m.
3) Intensity of sound must be high enough for echo to be heard clearly

NOTE - If there are repeated reflections at the reflecting surface the sound gets prolonged. This effect is known as reverberation.

Determination of speed of sound by method of echo -

$$v = \frac{\text{Total distance travelled}}{\text{time interval}} = \frac{2d}{t} \quad (ms^{-1})$$

v - speed of sound

Uses of echo - Echoes find their application in sound ranging and echo depth sounding by using ultrasonic waves. Reasons for using ultrasonic waves

1) They can travel undeviated through a long distance
2) Can be confined to a narrow beam
3) They are not easily absorbed in a medium.

Uses of echo by -

- Bats, dolphins, fisherman
- SONAR (Sound navigation and ranging)
- Medical field - i.e. ultra sonography

NATURAL, DAMPED AND FORCED VIBRATIONS –

Natural vibrations –

The periodic vibrations of a body in the absence of any external force on it are called the natural (or free) vibrations.

Eg – i) If bob of a simple pendulum is displaced slightly.

$$f = 2\pi\sqrt{\frac{g}{L}}$$

f → frequency
g → acceleration due to gravity
L → length of pendulum.

ii) A load suspended from spring when stretched.

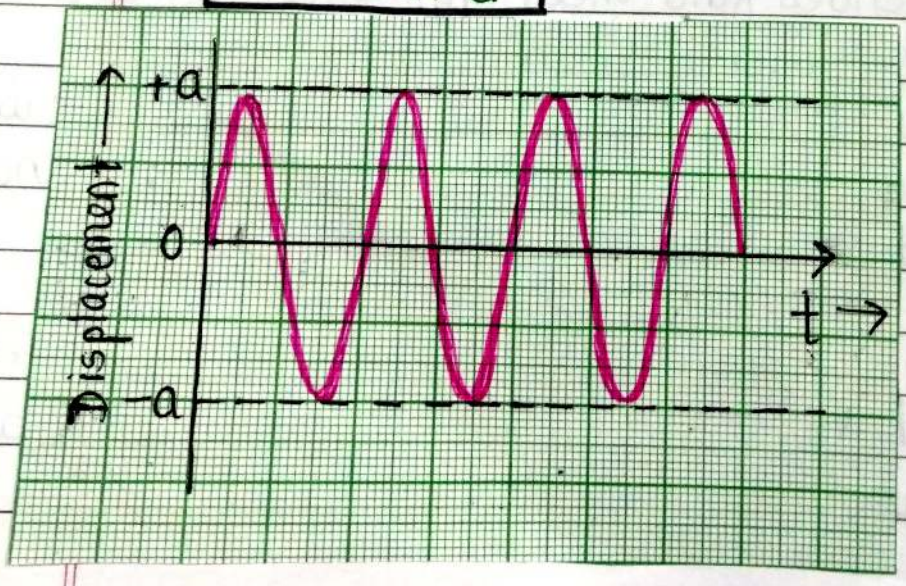
$$f = 2\pi\sqrt{\frac{K}{m}}$$

f → frequency
K → force constant
m → mass of load

iii) Tuning fork struck against rubber pad.
iv) Striking keys of piano
v) When air column in a flute vibrates
vi) When stringed instrument (guitar, sitar, violin) is plucked.

f → frequency, T → Tension,
r → radius of string, d → density of string

$$f = 2\pi\sqrt{\frac{T}{\pi r^2 d}}$$



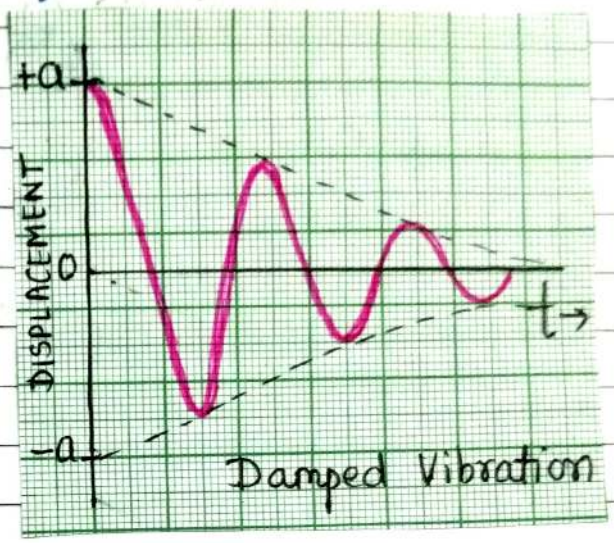
NOTE – In ideal condition once a body starts vibrating it continues to vibrate with same amplitude & frequency forever.

Damped vibrations -

The periodic vibration of a body of decreasing amplitude in presence of resistive force.

In damped vibrations two forces act on the body ① restoring force ② frictional (resistive) force

Eg - i) Branch of tree when pulled and released.
ii) Tuning fork vibrating in air.
iii) Oscillating pendulum in air.
iv) Spring (loaded) vibration in air.



Forced vibrations -

The vibrations of a body which takes place under the influence of an external periodic force acting on it.

The vibrating body is acted upon by 3 forces : ① restoring force ② resistive force ③ external periodic force.

Amplitude of the forced vibrations depends on the frequency of external force.

Eg - i) Swing pushed at a regular interval
ii) While playing a guitar, artist forces the strings of the guitar to execute forced vibrations.

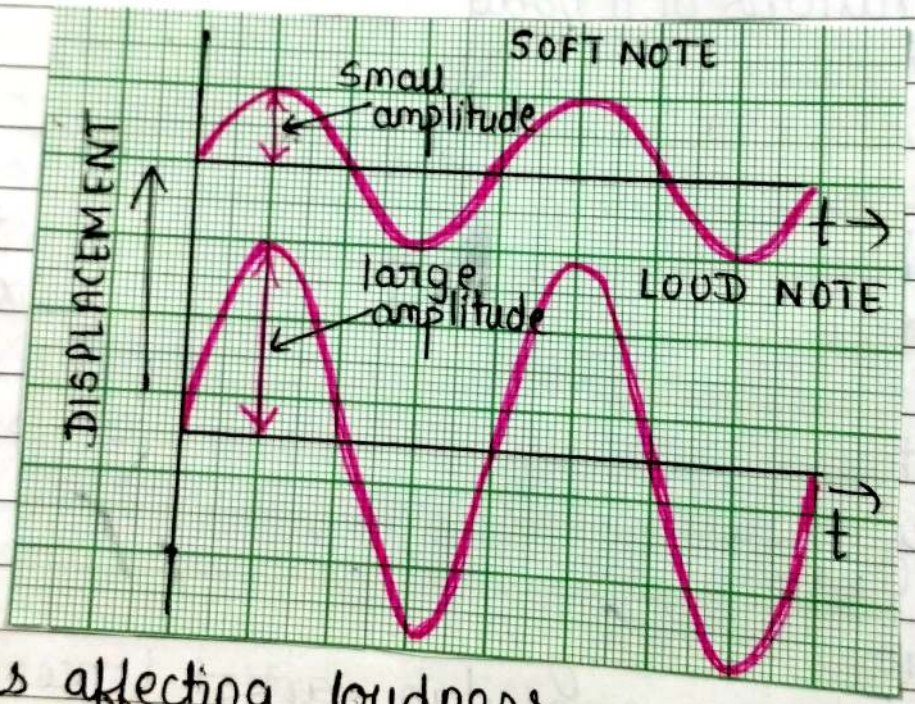
Resonance - It is special case of forced vibration.

When the frequency of an externally applied periodic force on a body is equal to its natural frequency, the body readily begins to vibrate with increased amplitude.

Eg - i) Sympathetic vibrations of pendulums
ii) Resonance in radio and TV receiver.
iii) Resonance in bridge
iv) Resonance in air column and tuning fork.

CHARACTERISTICS OF SOUND -

1) Loudness - It is a characteristic by virtue of which a loud sound can be distinguished from a faint one, both having same pitch and quality. It depends on the amplitude of the wave.

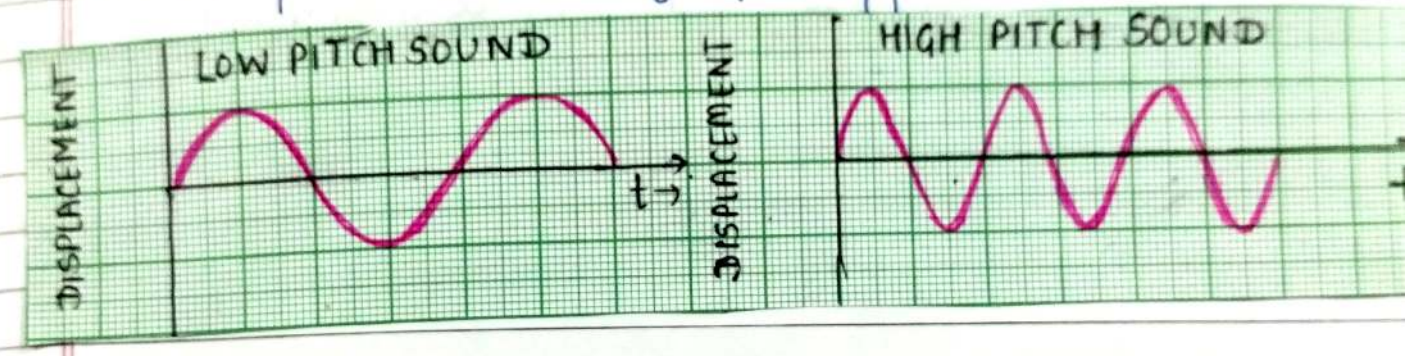


Factors affecting loudness -
i) Proportional to square of amplitude
ii) Inversely proportional to the square of distance from sou
iii) Surface area of vibrating body
iv) Density of medium
v) Presence of resonant bodies.

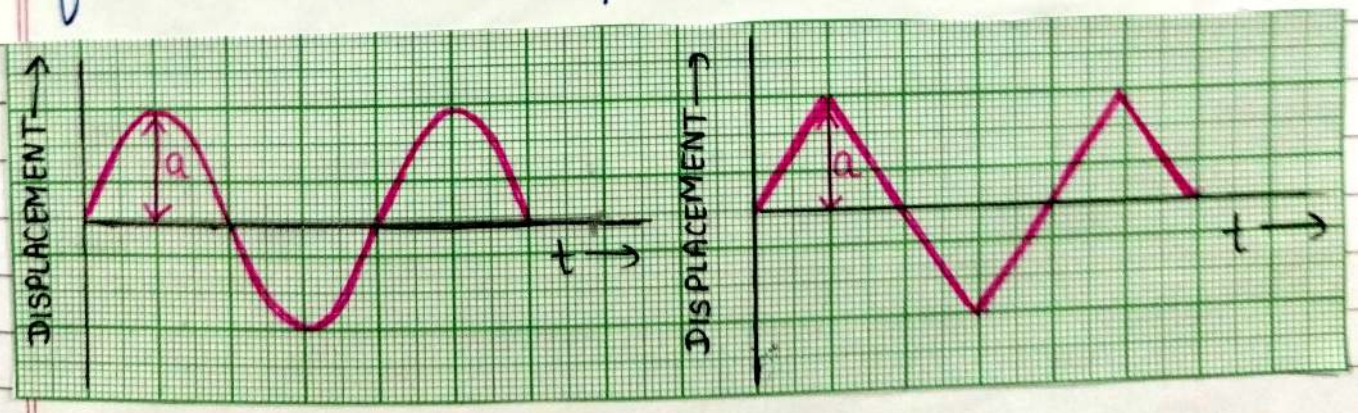
2) Intensity - The amount of sound energy passing each second through unit area.
SI unit ⇒ watt per square metre (W/m^2)

$$L = K \log_{10} I$$

3) Pitch (or shrillness) - Pitch is the characteristic of sound by which an acute (shrill) note can be distinguished from a grave or flat note. Pitch depends on its frequency.



4) Quality (or timbre) and waveform - Quality of a sound is that characteristic which distinguishes the two sounds of the same loudness and same pitch but emitted by two different instruments. The quality of a musical sound depends on the wave form.



MUSIC AND NOISE

Music	Noise
1) It is regular, smooth and pleasant to ears.	1) It is harsh and unpleasant to the ears.
2) Produced by periodic vibrations.	2) Produced by irregular succession of disturbance
3) All the component waves are similar without any sudden change in wavelength & amplitude.	3) Wave changes their character suddenly and they are short duration.
4) Sound level is low (10 dB to 30 dB)	4) Sound level is high (above 120 dB)
5) Wave form is regular	5) Wave form is irregular.

FORMULA SHEET

① $V = f\lambda$

v → velocity
f → frequency
λ → wavelength
T → time period

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

② ECHO

$D = \frac{vt}{2}$

D → distance b/w source and obstacle
v → speed
t → time

③ Frequency of oscillating pendulum

$f = 2\pi\sqrt{\frac{g}{l}}$

Frequency of loaded spring (oscillating)

$f = 2\pi\sqrt{\frac{k}{m}}$

Frequency of oscillating string

$f = 2\pi\sqrt{\frac{T}{\pi r^2 d}}$

④ Intensity & Loudness

$L = K \log_{10} I$

$L = 10 \log_{10}\left[\frac{I_1}{I_0}\right]$ decibel

$I_0 = 10^{-12}\ W/m^2$
I_1 = intensity of sound