SHORT NOTES: CLASS 9

CHAPTER 11: SOUND

PERIODIC MOTION: The motion of a body that repeats itself regularly after a fixed interval of time is called a periodic motion.

Examples of periodic motion:

a) motion of a planet around the sun
b) motion of the hands of a clock
c) motion of a ball bearing rotated in a circle at the end of a string

OSCILLATORY OR VIBRATORY MOTION: If a body moves to and fro repeatedly about a fixed position called a mean position, its motion is said to be oscillatory or vibratory motion.

Examples of oscillatory motion:

a) motion of a pendulum of a wall clock
b) motion of a mass attached to a spring
c) motion of a swing

Note: A motion can be periodic but not oscillatory. For example, **uniform circular motion** is periodic but not oscillatory.

WAVES AND WAVE MOTION: A wave is a pattern of disturbance that travels through a medium due to repeated vibrations of the particle of the medium.

Note:

a) It is the disturbance that travels forward through the medium and not the particles of the medium.
b) The particles of the medium merely vibrate about their mean position.
c) What is transferred by wave motion from one place to another is energy not matter.

TRANSVERSE AND LONGITUDINAL WAVES:

a) Transverse waves:

i) These are the waves in which particles of the medium vibrate in a direction perpendicular to the direction of wave motion.
ii) In transverse waves, the particles of the medium that have maximum displacement in the upward direction (positive Y direction) are called crest while those that have maximum displacement in the downward direction (negative Y direction) are called troughs.
iii) These waves can be transmitted through solids or over liquid surfaces.
iv) Examples: light waves, waves formed over the water surface, waves in stretched strings.

b) Longitudinal waves:

i) These are the waves in which particles of the medium vibrate along the direction of wave motion.
ii) A longitudinal wave passes through a medium, these cause pressure variations in different parts of the medium. The regions of increased pressure are called compressions and the regions of decreased pressure are called rarefactions.
iii) These waves can be transmitted through all three types of media viz solids, liquids, and gases.
iv) Examples: sound waves in air, waves formed along a compressed spring.

ELECTROMAGNETIC AND MECHANICAL WAVES:

a) Electromagnetic waves or non-mechanical waves:

i) The waves which do not require a material medium for their propagation are called electromagnetic waves. Such waves can travel through a vacuum.
ii) These are only transverse waves.
iii) For example, light waves, radio waves, X-rays, microwaves.

b) Mechanical or Elastic waves:

i) The waves which require a material medium for propagation are called mechanical waves. They are also called elastic waves because the propagation depends on the elastic properties of the

medium.

ii) These are caused due to vibrations of the particles of the medium.

iii) These can be transverse or longitudinal.

iv) For example, sound waves in air, waves over water surface, and waves produced during earthquakes.

SOUND: A sound is a form of energy that produces a sensation of hearing in our ears.

How is the sound produced? Sound is produced by vibrating bodies.

For Example:

a) Sound is produced by humans due to the vibration of their vocal cords.

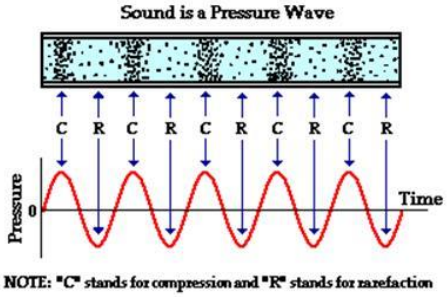
b) Bees produce a buzzing sound by vibrating their wings

When the object vibrates; it sets the neighbouring particles to vibrate. These particles exert force on other particles and pass on the energy to other parts of the medium. The particles do not get transported but only the disturbance or energy is transferred. In this way, sound reaches our ears.

What is vibration? Vibration is a rapid to and fro kind of motion of an object about its mean position.

Sound waves are mechanical waves: Sound waves are produced by mechanical disturbances in the medium and cannot travel through a vacuum therefore they are called mechanical waves.

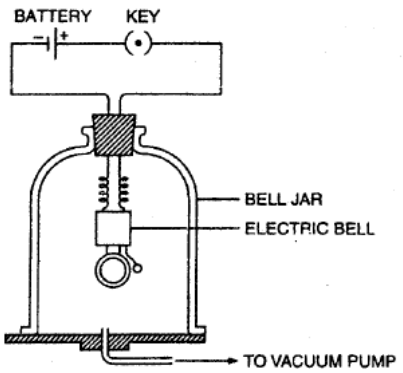
Sound needs a medium to propagate. A substance through which sound is transmitted is called a medium. It can be solid liquid or gas.



Sound waves are longitudinal waves: When a sound wave passes through a medium, such as air, the layers of air are alternatively pushed and pulled. The particles of the medium do move to and fro along the direction of propagation of the sound waves. Hence, sound waves are longitudinal waves.

Pictorial representation of sound waves has compression and rarefaction

Experiment to demonstrate that sound waves are mechanical waves (i.e., they require material medium to propagate:



a) An electric bell is suspended inside an airtight bell jar. The sound of the bell can be heard on pressing the switch.

b) When the vacuum pump attached to the bell jar is started, the air in the bell jar is pumped out gradually and the sound becomes fainter

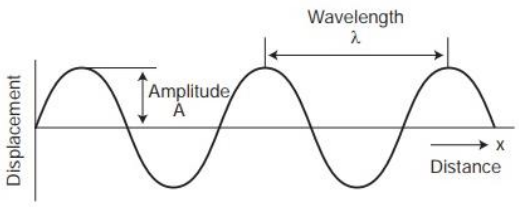
c) If the bell jar was completely emptied of air, no sound can be heard.

SOUND WAVES ARE CHARACTERIZED BY THE FOLLOWING PHYSICAL QUANTITIES:

a) Amplitude (A): The maximum displacement of an oscillating particle from the mean position is called amplitude. Its SI unit is m.

b) Wavelength (λ): It is the distance travelled by the wave during the time a particle of a medium completes one vibration (i.e., time interval equal to its time period of vibration). Its SI unit is m.

Note: It is equal to the distance between two successive crests or troughs or between two successive compressions and rarefactions



c) Time Period (T): The time taken by an oscillating body to complete one oscillation is called its time period. Its SI

unit is second.

$$\text{Time Period} = \frac{Total\ time\ taken}{Number\ of\ Oscillations}$$

d) Frequency (v): The number of oscillations or vibrations completed by an oscillating body in one second is called its frequency. SI unit of frequency is Hertz (Hz). Other units: per second, s^{-1}, cycles per second.

$$\text{Frequency} = \frac{Number\ of\ Oscillations}{Total\ time\ taken}$$

Relation between time period and frequency: $v = \frac{1}{T}$

e) Wave velocity (v): It is the distance traveled by a wave per unit time. It is the speed with which a disturbance propagates through a medium. Its SI unit is m/s.

Note:

a) Sound propagates through a medium at a finite speed. The speed of sound remains almost the same for all frequencies in a given medium under the same physical conditions.
b) The speed of sound increases when the temperature of the medium increases.
c) It is maximum in solids and minimum in gaseous medium (nature of medium).
d) The sound of thunder is heard much later than the flash of lightning is seen. $v_{sound} < v_{light}$

RELATION BETWEEN WAVELENGTH, FREQUENCY AND WAVE VELOCITY:

Velocity = $\frac{Distance}{Time}$

⇨ **v = λ/T**
⇨ v =(1/T) λ
⇨ **v = vλ**

⇨ Wave velocity = Frequency x Wavelength

WAVE NUMBER: The number of waves contained in the unit length of the medium is called wave number.

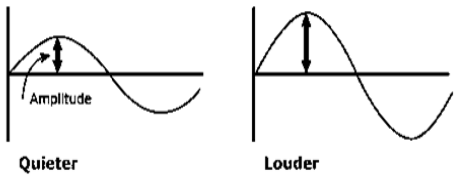
N = 1/λ

Characteristics of sound

a) Loudness: loudness is the physiological response of the ear to the intensity of sound which is directly proportional to the square of the amplitude of the sound wave.

The loudness or softness of sound is determined by its amplitude. The amplitude of sound depends on the force with which the object is set to vibrate. Large amplitude means loud sound whereas small amplitude means soft/feeble sound.

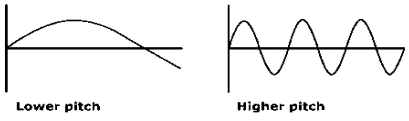
Loudness α (Amplitude)²



LOUDNESS Vs INTENSITY OF SOUND:

LOUDNESS	INTENSITY
1. Loudness is a subjective quantity. It depends upon the sensitivity of the ear.	1. The intensity of sound is an objective physical quantity. It does not depend upon the sensitivity of the human ear.
2. Loudness cannot be measured as a physical quantity because it is just a sensation that can be felt only.	2. The intensity of sound can be measured as a physical quantity. It is defined as the sound energy transferred per unit of time through a unit area placed perpendicular to the direction of propagation of a sound wave.

b) Pitch: Pitch is the sensation that helps the listener to distinguish between a high and a grave note. Low pitch sound has low frequency while high pitch sound has higher frequency.



c) Quality or timbre: It is that characteristic which enables us to distinguish one sound from another

having the same pitch and loudness.

i) Sound which is more pleasant to hear is said to have rich quality

ii) Quality of sound depends on the nature of the vibrating object.

TONE AND NOTE: Tone is the sound of single frequency while note is produced by mixing several frequencies. The quality of a musical note depends on the wave form.

MUSIC AND NOISE: Music: It is produced due to regular vibrations. It is pleasant to hear.

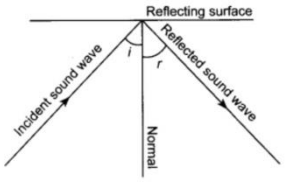
Noise: It is produced due to irregular vibrations. It is unpleasant to hear.

PULSE AND PERIODIC WAVE: A **pulse** is a wave produced by a certain disturbance of short duration. **Periodic wave** is produced by continuous and regular vibrations of the particle of the medium.

REFLECTION OF SOUND:

a) When a sound wave travelling in a medium, bounces back to the same medium after striking a second medium, reflection of sound is said to take place.

b) The **two laws of reflection of sound** are:



i) Incident wave, reflected wave and normal at the point of incidence, all lie on the same plane.

ii) Angle of incidence = Angle of reflection

c) An obstacle of large size which may be polished or rough is required for reflection of sound waves.

PRACTICAL APPLICATIONS OF MULTIPLE REFLECTION OF SOUND:

a) **Megaphone (speaking tube) and musical instruments:** A megaphone loud hailers horns musical instruments such as trumpets and shehnai are all designed to send sound in a particular direction without spreading it in all directions.

b) **Stethoscope:** it is used to hear sound produced by the body, especially in the heart and lungs.

c) **Curved ceilings concert hall:** The **ceiling of concert halls**, conference halls, and cinema halls is curved so that the reflected sound reaches all the corners of the hall and the audience can hear the sound clearly.

d) **Soundboards:** A **large concave wooden board** is placed behind the stage so that the sound reflected by the board spreads evenly across the hall. It is used to direct the sound waves towards the people sitting in a hall.

e) **Hearing aid:** The sound waves falling on a hearing aid are concentrated into a narrow beam by reflection.

f) **ECHO:** Echo is the phenomenon of repetition of a sound due to its reflection from the surface of a large obstacle when a loud sound is produced in an empty hall. The same sound is heard again after some time. When the original sound and reflected sound are heard separately, the reflected sound is called an echo. You can distinguish between two sounds if there is a difference of 0.1 seconds between them.

CONDITIONS FOR THE PRODUCTION OF ECHOES:

a) **Sufficient time gap between the original and reflected sounds:** The sensation of sound persists in our brain for about 0.1 s therefore to hear a distant echo the time interval between the original sound and the reflected sound must be at least 0.1 s.

b) **Sufficient distance between the source of sound and the obstacle:** The minimum distance between the source of sound and the reflector should be at least 17.2m in air.

Speed = $\frac{Distance\ travelled}{Time\ taken}$

Speed of sound = 344 m/s, time = 0.1 s

Distance travelled by sound = 344 x 0.1 = 34.4 m

Therefore, the minimum distance between the source and the obstacle = 34.4/2 = 17.2 m

c) The size of the reflector must be large.

d) For the formation of echo the reflecting surface must be rigid such as a building hill or a cliff.
e) The intensity or loudness of the sound should be sufficient.

REVERBERATION:

a) The repeated reflection of sound that results in the persistence of sound is called reverberation. A certain amount of reverberation may improve the quality of sound; however excessive reverberation is sometimes undesirable as it interferes with the original sound.

b) The Reverberation time is defined as the time interval during which the original sound appears to be prolonged.
c) In big halls or auditoriums, excessive reverberation is undesirable. The reverberation time of a hall should be very short otherwise multiple echoes will interfere due to multiple reflections of sound and nothing will be heard distinctly.

Methods of reducing reverberation:

a) By covering the walls and roof of the auditorium with sound-absorbent materials.
b) Providing open windows in the space.
c) Windows of the auditorium are covered with heavy curtains.
d) The ceiling of the auditorium is made by soft and textured material.
e) The special tiles, known as acoustic tiles are used for the flooring of the auditorium.
f) Some plants in pots can also be arranged in the hall to reduce reverberation time.

RANGE OF HEARING

a) The Audible range of the human ear is 20 Hz to 20,000 Hz.
b) Children below five years and some animals can hear up to 25 kHz.
c) As people grow older the ears become less sensitive to higher frequencies.

Infra sounds: Sounds of frequencies less than 20 Hz are called infrasound.

a) Rhinoceros communicate using infrasound of 5 Hz.
b) Earthquakes produce vibrations of low-frequency infrasound which some animals can hear so they get disturbed and restless before the earthquakes.
c) Whales and elephants can also produce infrasound.

Ultrasounds: Sounds of frequencies greater than 20 kHz are called on ultrasound

a) Ultrasound is produced by bats dolphins and porpoises. Bats use ultrasound to catch prey. Bats search out their prey by emitting and detecting the reflection of sound waves.
b) Certain moths can hear higher frequencies.
c) Rats also play games by producing ultrasound.

Special characteristics of ultrasound: They are high-frequency sound waves so they have very small wavelengths.

APPLICATIONS OF ULTRASOUND:

a) **SONAR:** Ship-to-ship communication, to determine the depth of a sea.
b) To kill bacteria in liquids.

Industrial purpose

c) **For cleaning the hidden parts of an instrument:** It can be used to clean parts that are hard to reach or not easily accessible. For example spiral tubes, odd-shaped parts, and electric components. Objects are placed in cleaning solutions and ultrasound waves are sent into it which forces the dirt particles out from the parts of the instrument. These high-frequency ultrasound waves detach dust or grease from the objects.

d) **For detecting flaws and cracks in metals:** Ultrasound can be used to detect cracks and flaws in prefabricated blocks. Ultrasound waves are allowed to pass through a block and detectors are used to detect transverse waves. If there is a defect the ultrasound waves are deflected.

e) **For welding plastic:** two plastic surfaces are pressed against each other and ultrasonic waves are passed at the point of contact. These waves produce heat energy which binds two plastic surfaces together.

Note: ordinary sound waves have long wavelengths therefore they cannot be used for such purpose as they would bend along the corners of the bend and enter the detector.

Medicinal purpose

f) **Electrocardiography:** Ultrasound waves get reflected from various parts of the heart to form its image on the screen.

g) **Ultrasonography:** ultrasound scanners are used to get an image of the internal organs of the patients. This helps us to detect stones in the kidney or gallbladder tumors etc. It is also used to examine a fetus during pregnancy.

h) Ultrasound waves are used to break stones in the kidney into small grains which get flushed out of urine.

SONAR: Sound Navigation And Ranging

Sonar uses ultrasound waves to measure the distances, directions, and speeds of underwater objects

Principle: It is based on the principle of reflection of sound wave/echo.

Working: It consists of transmitters and detectors installed in boats, ships, submarines, etc. The transmitter sends ultrasonic waves which are reflected by obstacles and received by detectors. Detectors are able to know the time taken and therefore the distance of the obstacle can be determined.

The above method is known as **echo ranging** and is used to determine the depth of the sea to locate underwater hills valleys, icebergs, submarines, sunken ships etc.

The time taken by the ultrasonic waves to go from the ship to the bottom and then back to the ship is noted. Let it be 't' seconds. Therefore, the time taken by the ultrasonic waves to go from the ship to the bottom of the sea is t/2 seconds.

Let S be the depth of the sea and v be the velocity of the ultrasonic wave in water.

Therefore, **S = v x t/2**

SHOCK WAVES/ SONIC BOOM:

Supersonic speed: The speed of any object moving faster than the speed of sound is called supersonic speed.

Shock waves: When an object attains a supersonic speed, it causes shock waves in the air. Shock waves produced by it are piled up in the form of cone-shaped waves known as shock waves of highly compressed air. Ex: shock waves produced by a supersonic jet craft, shock waves produced by a bullet.

Sonic Boom:

The shock wave carries a huge amount of energy. The shock waves are produced by a large sound called a sonic boom as it travels through the air.

HUMAN EAR: Human Ear is divided into three parts: The outer ear, middle ear, and inner ear.

The outer ear is called the **pinna.** It collects the sound from the surroundings. The collected sound passes through the **auditory canal**. At the end of the auditory canal, there is a thin membrane called the **ear drum or tympanum**. The eardrum vibrates due to incident sound waves' compressions and rarefactions. The vibrations are amplified several times by three bones: **hammer, Anvil, and Stirrup** in the middle ear. The middle ear transmits the amplified sound to the inner ear. In the inner ear, the pressure variations are turned into electrical signals by the **cochlea.** These electrical signals are sent to the brain via the **auditory nerve**. And, the brain interprets the sound.