1. Which part of human ear converts sound vibrations into electrical signals

a. Hammer
b. Stirrup
c. Tympanic membrane
d. Cochlea

2. What do dolphins, bats and porpoise use

a. Ultrasound
b. Infrasound
c. Both a and b
d. None of them

3. Children under the age of 5 can hear upto

a. 25 Hz
b. 25k Hz
c. 20 Hz
d. 25 kHz

4. Reverberation of sound is used in

a. Stethoscope
b. Trumpets
c. Megaphone
d. All of these

5. To hear a distinct echo each time interval between the original sound and the reflected sound must be:

a. 0.2 s
b. 1s
c. 2s
d. 0.1 s

6. Speed (v) abs wavelength (�) and the frequency (v) of sound are related as

a. λ= v X v
b. v= λ X v
c. v= λ X v
d. v= λ / v

7. Speed of sound depends upon

a. Temperature of the medium
b. Pressure of the medium
c. Temperature of source producing sound
d. Temperature and pressure of medium

8. Which characteristic is this? We can distinguish between sound having same pitch and loudness.

a. Tone
b. Note
c. Pitch
d. Timber

9. Loud sound can travel a larger distance, due to

a. Higher amplitude
b. Higher energy
c. High frequency
d. High speed

10. A wave in slinky travelled two and fro in 5 sec the length of the slinky is 5m. What is the velocity of wave?

a. 10m.s
b. 5m/s
c. 2m/s
d. 25m/s

Answers

1. D
2. A
3. B
4. D
5. D
6. C
7. A
8. D
9. B
10. C

Introduction - Sound

Sound is a type of energy. Sound travels in the form of wave from one place to another.

Production of sound:

Sound is produced because of the vibration of any object. In other words, when an object is vibrated it produces sound.

Example:

Sound can be produced by clapping of palms.

Sound can be produced by vibrating a string.

Sound can be produced by beating a table or diaphragm of a drum.

Sound is produced by a flute because of vibration of air column.

Sound is produced by a guitar because of vibration of its string.

Thus, an object is needed which could be vibrated to produce sound.

Propagation of sound:

When a stone is dropped in pond water, it produces many circular wrinkles and water appears to be travelling outwards from centre. These circular wrinkles are called ripples. This happens because of formation of waves in water.

When a stone is dropped in water, it creates a disturbance in water particles. The water particles pass the disturbance to the adjacent particles and the adjacent particles pass the disturbance to the next adjacent particles and so on. This phenomenon continues and the disturbance moves outward from the centre of disturbance. This makes water appear to be moving. In fact, water molecules do not travel in this case, rather only the disturbance is passed through particles of water. This creates wave in the form of ripples in water.

Sound travels from one place to another in similar manner i.e. through wave formation. In this case, the particles of medium do not travel rather only the disturbance; caused by sound energy; passes to the adjacent particles of the medium. So, the traveling of sound is called propagation of sound.

Thus, sound propagates from one place to another in the form of waves, i.e. because of the disturbance of particles of the medium.

Wave – Sound Wave

The disturbance or oscillation from one location to another location; accompanied by transfer of energy is called wave.

There are two types of wave, viz. Electromagnetic Wave and Mechanical Wave.

ELECTROMAGNETIC WAVE – Wave that requires no medium to propagate is called Electromagnetic wave. For example – light wave. Light can also travel through vacuum.

MECHANICAL WAVE – Wave that requires medium to propagate is called Mechanical Wave. For example - sound wave. Sound cannot travel in the absence of a medium.

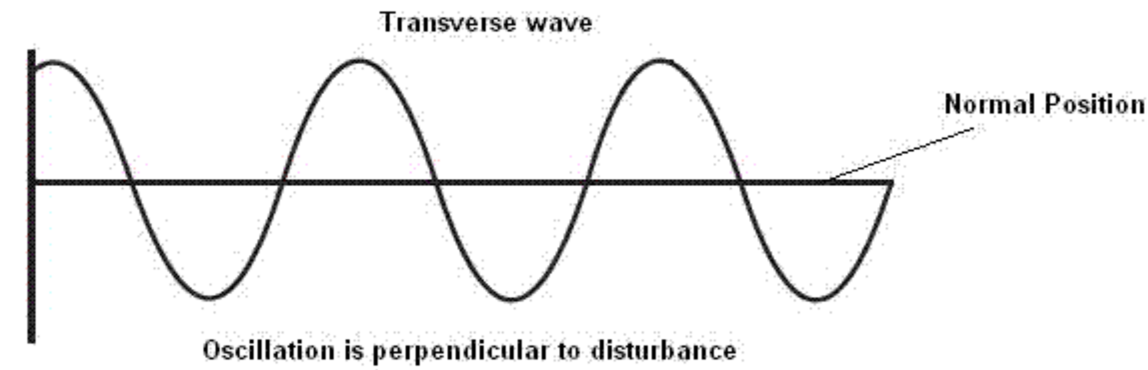
TYPES OF WAVE - ON THE BASIS OF DIRECTION:

On the basis of direction of propagation, waves can be divided into two types –

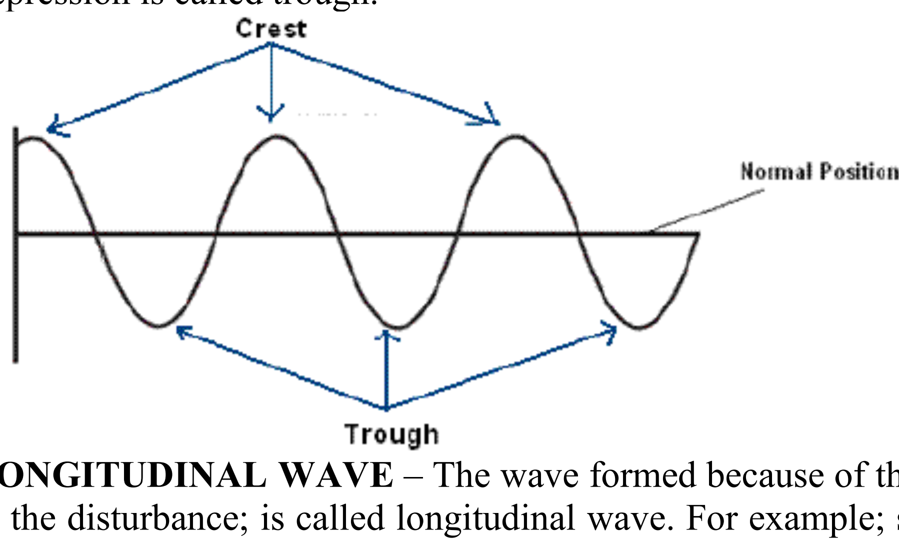
Transverse Wave

Longitudinal Wave

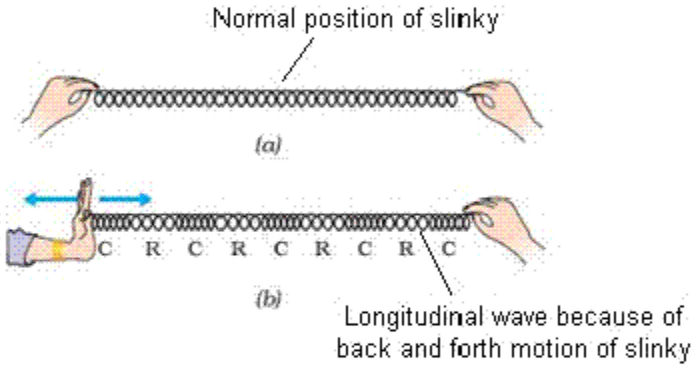
TRANSVERSE WAVE – The wave formed because of the oscillation perpendicular to the disturbance is called transverse wave. For example light wave, water wave, etc.



In transverse wave, particles oscillate in up and down directions; relative their normal position of rest. Particles of medium create elevation above the normal position or line of zero to the surface of medium and depression below the normal position in the course of oscillation. The elevation is called crest and the depression is called trough.



LONGITUDINAL WAVE – The wave formed because of the oscillation; parallel to the disturbance; is called longitudinal wave. For example; sound waves. ause of forward and backward movement of particles of the medium. If a slinky is pushed and pulled backward and forward, the wave formed in slinky is similar to longitudinal wave.



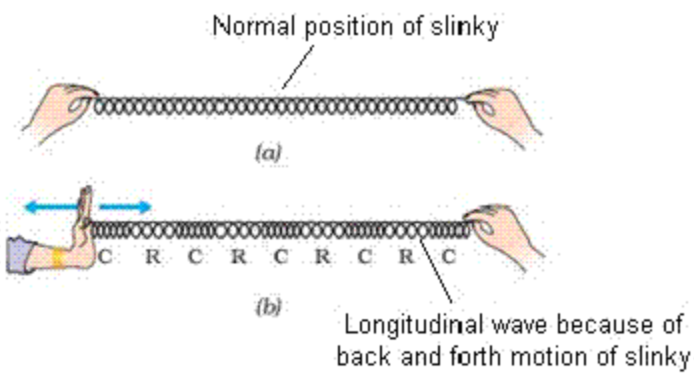
Ref: NCERT Book - Sound - class - IX

Sound Wave is longitudinal wave – Sound propagates because of oscillation of particles of medium parallel to the disturbance, thus sound wave is longitudinal wave.

Compression and Rarefaction:

When a slinky is jerked to and forth, two phenomena take place simultaneously. First, the coils come closer to each other while; on the other hand; some of the adjacent coils go farther from each other. This phenomenon continues and the wave goes forward.

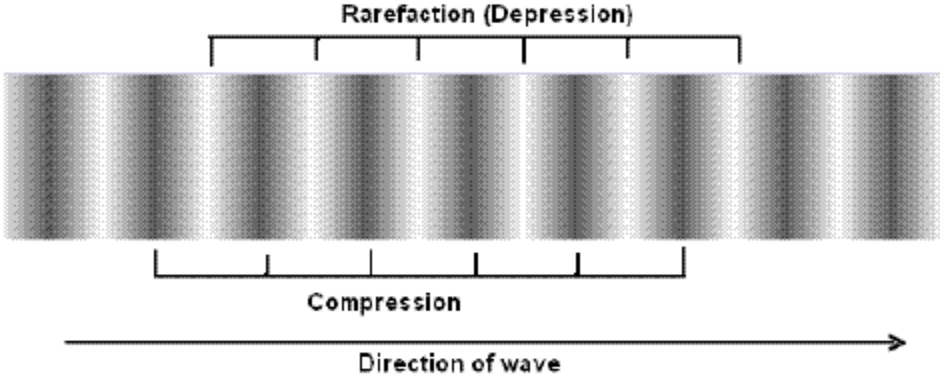
The action when coils come closer is called compression and when coils go farther from each other is called rarefaction.



Ref: NCERT Book - Sound - class - IX

In the given figure the area of compression is denoted by letter 'C' and the area of rarefaction is denoted by letter 'R'.

When sound wave travels through a medium, say air, the particles of medium disturb in the same fashion, i.e. compression and rarefaction (depression). When air particles come closer it is called compression. On the other hand, when particles go farther than their normal position it is called rarefaction. This is similar to the compression and rarefaction produced in the slinky. In the condition of compression, molecules of medium come closer to each other and in the condition of rarefaction, molecules of medium go farther from each other; compared to their normal positions.



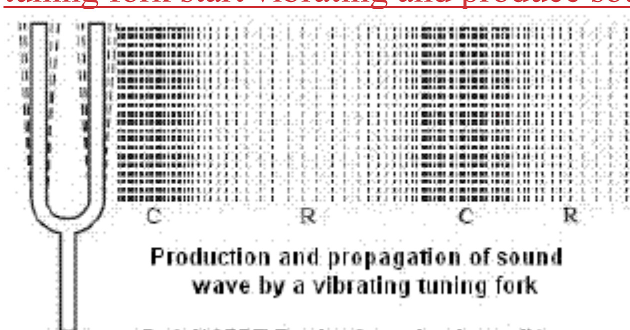
Density, pressure and disturbance:

When compression takes place in the medium, the density and pressure of the medium increase. When rarefaction takes place in the medium, density and pressure of the medium decrease. This increase and decrease in density and pressure are temporary.

Thus, compression is called the region of high density and pressure. Rarefaction is called the region of low density and pressure.

Production of sound in laboratory:

In laboratories, sound wave is produced by striking a tuning fork over a rubber pad. When prongs of the tuning fork are struck over a rubber pad, the prongs of tuning fork start vibrating and produce sound.



Production and propagation of sound wave by a vibrating tuning fork

Ref: NCERT Book - Sound - class - IX

One can feel the vibration of prongs by touching them after striking over the rubber pad. The vibration produces sound energy. This sound energy creates disturbance in the medium by making compression and rarefaction and the sound wave propagates forward.

Characteristics of sound wave:

Following are the main characteristics of sound wave:

Wavelength.

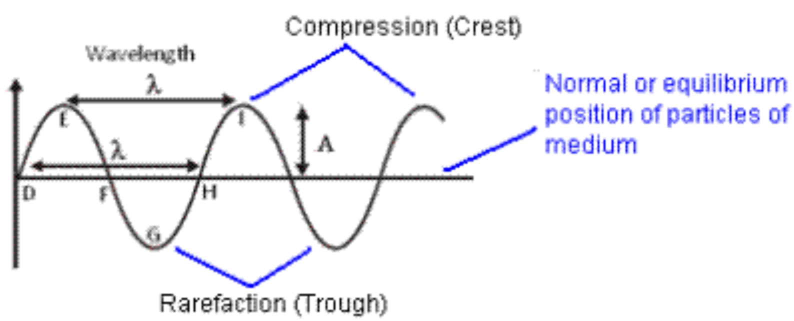
Amplitude.

Time period

Frequency

Velocity (Speed)

To discuss the characteristics of wave, a graphical representation of sound wave is considered.



Graphical representation of sound wave

The peak of a wave is called compression or crest. The valley of a wave is called rarefaction or trough.

WAVELENGTH:

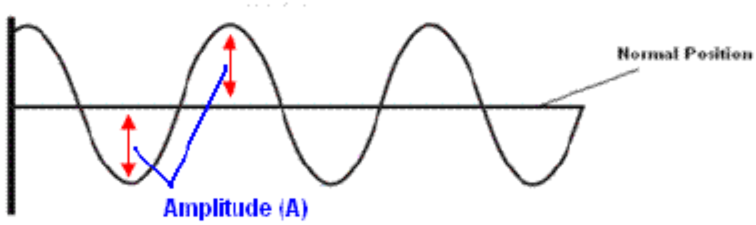
Wave length is the length between two consecutive peaks, i.e. crest or two consecutive valleys, i.e. trough of a wave. Wave length is represented by Greek letter λ (lambda).

Louder sound has shorter wavelength and softer sound has longer wavelength.

The SI unit of wavelength is metre (m).

AMPLITUDE:

Magnitude of maximum disturbance on either side of the normal position or mean value in a medium is called amplitude. In other words, amplitude is the distance from normal to the crest or trough.



Amplitude is the energy of sound. Louder sound has greater amplitude and softer sound has shorter amplitude. Thus, louder or softer sound is determined by its amplitude. Since louder sound has greater energy consequently greater amplitude, thus it travels to a longer distance. Softer sound has smaller energy consequently shorter amplitude, thus it travels to a shorter distance.
Amplitude is denoted by letter 'A'. The SI unit of amplitude is metre (m).

TIME PERIOD:
Time required to produce one complete wave is called time period or time taken to complete on oscillation is called the time period of the sound wave. In other words, time in which a wave moves a distance equal to its wavelength is called time period.
The time period of sound wave is represented by letter 'T'. The SI unit of time period is second (s).
FREQUENCY:
The number of sound waves produced in unit time is called the frequency of sound waves. For example, if a source of sound produces 20 sound waves in one second then the frequency is 20 Hz.
Time taken to calculate frequency is in second. Frequency is denoted by Greek letter 'ν' (nu). The SI unit of frequency is 'hertz'.
This name had been given after the German Scientist Heinrich Rudolph Hertz.

Relation between time-period and frequency
If 1 sound wave is produced by a source, in T second.
Therefore, in 1 second number of wave produced =1T=1T
Since, frequency is the rate of production of wave
∴ Frequency=1TFrequency=1T
⇒Frequency=1Time period⇒Frequency=1Time period
⇒ν=1T⇒ν=1T
Where, ν = frequency and T = time period
Thus frequency is the reciprocal of the time period of wave. This means the frequency is increased with decrease in time and vice versa.

VELOCITY:

Distance covered by sound wave in unit time is called the velocity of sound wave.

∴ Velocity=DistanceTime takenVelocity=DistanceTime taken

If distance =λ=λ and Time =T=T

∴ Velocity=λTVelocity=λT

Or, v=λTv=λT ---(i)

SI unit of λλ is meter (m) and SI unit of time is second (s)

Therefore, SI unit of velocity =ms−1=ms-1

Therefore, velocity can be defined as distance travelled per second by sound wave.

Since, Frequency (ν)=1TFrequency (ν)=1T

Therefore, equation (i) can be written as

v=λT=1T=ν·λv=λT=1T=ν·λ

⇒v=ν·λ⇒v=ν·λ

Where, vv = velocity

λλ = Wavelenght

And ν(nu)ν(nu) = Frequency

Thus, velocity of sound wave = frequency X wavelength

This is called **WAVE EQUATION**. WAVE EQUATION is applied to all types of waves.

Thus, velocity of sound wave is the product of frequency and sound wave

Quality of Sound

Timbre: The quality of sound is called timber of sound. Timber is one of the characteristics of sound that enables us to differentiate between two different types of sound.

Because of timbre; the sound of flute and harmonium or other musical instruments can be differentiated. For example; the frequency of a particular note 'Do' or 'Sa' produced by all the musical instruments is equal. In spite of that, because of different timbre one can differentiate the sound of same frequency of different musical instruments.

Different persons produce sound of different timbre. Because of different timbre in sound, the voice of different persons can be recognized.

Tone and Note of sound:

Sound of a single frequency is called tone and sound of mixture of several frequencies is called note. A note is pleasant to listen.

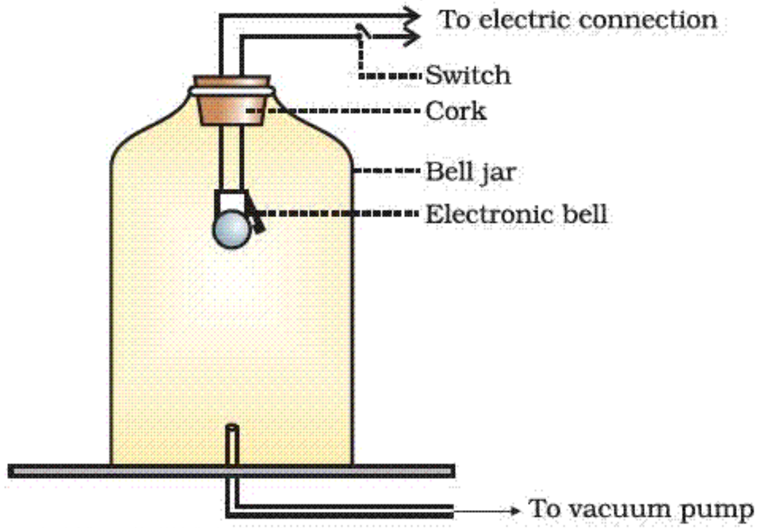
Noise is unpleasant to hear.

Music is pleasant to hear because of good quality, i.e. timbre while noise is unpleasant because of bad quality.

Medium is a must for propagation of sound wave:

Since sound wave travels by the compression and rarefaction of the particles, so a medium is necessary for propagation of sound wave. Sound cannot propagate without a medium.

Sound wave cannot propagSound wave cannot propagate through vacuum. This can be demonstrated using the bell jar apparatus.



Bell jar Experiment to show that medium is necessary for the propagation of sound

Ref: NCERT Book - Chapter - Sound

When all air is vacuumed out of bell jar, the sound of the bell is not heard outside. This happen because there is no medium present, consequently no particles present for compression and rarefaction in the bell jar through which sound waves could propagate.

Propagation (travelling) of sound through different media:

Sound propagates through solid, liquid and gas. In all these media; sound wave propagates by the compression and rarefaction of particles of the medium.

Velocity of sound wave in different media:

The velocity of sound waves depends upon the following three factors:

Nature of the medium, Temperature, Humidity present in air

Nature of medium: The velocity of sound is maximum in solid, moderate in liquid and minimum in gas. For example:

Medium	Velocity of sound
Iron	5130 m/s
Water	1500 m/s
Air	344 m/s

Temperature: The velocity of sound is directly proportion to temperature. This means, velocity of sound increases with increase in temperature. For example:

sound wave at 0^0C in air is 332m/s. The velocity of sound waves at 20^0C in air is 344m/s. This is the reason, we hear more clearly on a hot day than on a cold day.

Humidity present in air:

Since, velocity of sound wave in water is more than that in air, so humidity in air increases the velocity of sound. Therefore, an increase in humidity in air increases the velocity of sound and a decrease in humidity in air decreases the velocity of sound. This is the cause that we can hear more clearly in rainy season than in summer.

Reflection of Sound

Sound wave also gets reflected as light waves do. Bouncing back of sound wave from the surface of solid or liquid is called reflection of sound.

Reflection of sound follows the Laws of Reflection as light wave does. This means the angle of incident wave and reflected wave to the normal are equal.

For reflection of sound a polished or rough and big obstacle is necessary.

Use of Reflection of Sound:

Reflection of sound is used in many devices. For example; megaphone, loudspeaker, bulb horn, stethoscope, hearing aid, sound board etc.

Loudspeaker, Megaphone, bulb horn:

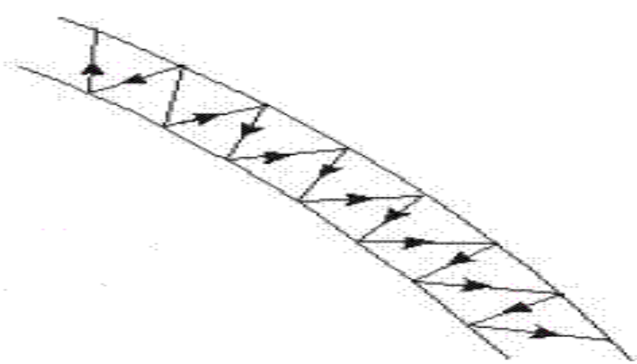
Loudspeaker, Megaphone and bulb horn are devices used to send the sound in desired direction without spreading the sound all around. These devices act on the laws of reflection of sound wave.

In such devices, a funnel like cone shaped tube is used. Sound is introduced at the narrower end of tube and let to come out from wider end. Because of successive reflections, the amplitude of sound is added up which makes the sound louder. The name 'Loudspeaker' is given as it is used to make the sound louder.

Stethoscope: –

Stethoscope is used to hear the sounds of internal organs of a patient; for diagnostic purposes. It works on the laws of reflection of sound.

Stethoscope



Muliple reflection of sound in the tube of stethoscope

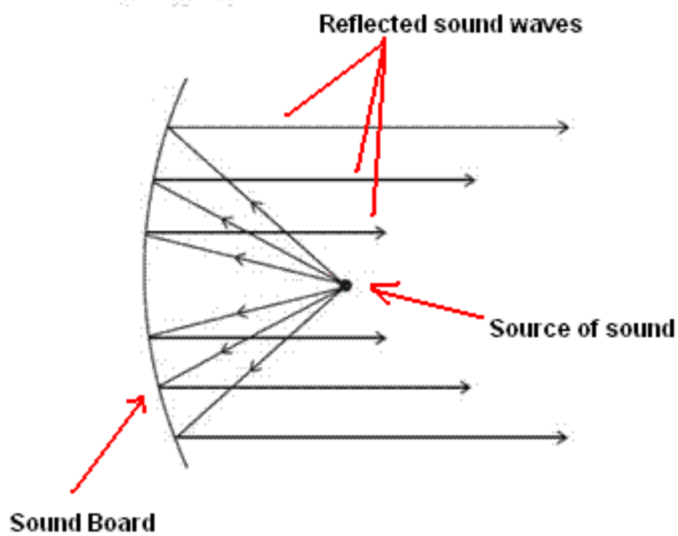
In stethoscope, sound is received by chest piece and sent to the earpieces by multiple reflecting through a long tube. Doctors diagnose the condition of an organ of the human body by hearing the sound using the stethoscope. Stethoscope has become the symbol of the medical profession since its invention.

Soundboard –

Sound board is used to send the sound towards audience in big hall or auditorium. This works on the basis of laws of reflection of sound waves.

Sound board is a big concave board and is set in such a fashion behind the stage that speaker is at the focus. Sound coming from speaker falls over sound board and gets reflected towards the audience. As a result, the audience sitting in the hall even at far distance from the speaker can clearly hear what the speaker is saying.

Additionally, the ceiling of the auditorium is also made curved so that it also acts like sound board. The curved surface of the ceiling reflects the sound waves and facilitates better hearing.



Echo:

The sound which we hear after reflection is called echo or echo of sound. One can hear the echo by shouting loudly in a big hall. After shouting loudly, the same sound reaches the ears after reflecting from the surface of the wall. Echo of sound can be heard by producing sound at place surrounded by hills or big buildings.

Thus, repetition of sound because of multiple reflection of sound wave is called echo.

Condition necessary for creation of echo:

One does not experience any echo sound in a small room. This does not mean that sound does not get reflected in a small room, but necessary conditions for production of echo are not present.

Any sound persists on one’s brain upto 0.1 second of time. So echo can only be heard if the same sound comes to one’s ear after a lapse of 0.1 second.

Thus, reflection of sound must reach to the brain after a lapse of 0.1 second.

Explanation:

Since, sound covers 344 m in air in 1 second.

Thus, in 0.1 second sound would cover a distance of 344 m x 0.1 = 34.4 m

Thus, to hear an echo sound the reflecting surface must be at a distance of 17.2 m, so that sound has to cover a distance which is more than 17.2 m x 2 = 34.4 m; before reaching the ears.

So, if reflecting surface is at a distance of more than 17.2 m, the sound would reach to our brain after 0.1 second and we would be able to hear the echo of sound.

Thus, there are two conditions to experience the echo of sound –

(a) Sound must come back to the person after 0.1 second.

(b) For above condition, the reflecting surface must be at a minimum distance of 17.2m.

Multiple Echo:

You may have heard the echo of your yahoo in hilly areas. This happens because of multiple reflection of sound wave and is often called multiple echoes.

The rolling sound of thunder is heard because of the multiple reflections of thunder sound or multiple echoes. The sound of thunder comes to us many times because of reflections from clouds and earth surface.

Use of multiple reflection of sound:

(a) In measuring the depth of sea/ocean.

(b) For the detection of the position of any objects, such as shipwrecks, sea rocks, hidden ice-berg in the sea and ocean.

(c) Investigating any problem inside the human body.

For above mentioned purposes, sound of high frequency is produced so that reflections can be received from various surfaces. The time taken for reception of reflected sound waves is analyzed by a computer to detect the problem.

Reverberations:

Persistence of sound wave for a long time because of multiple reflections is called reverberation. Usually, this happens in big halls. Sound becomes too blurred and distorted to be heard in big concert halls because of reverberation. This can often lead to annoyance.

To overcome this problem, sound absorbent materials, such as curtains, plant fibre, compressed fireboard, carpets, etc. are used in the auditorium.

These materials absorb undesired reflected sound and reduce reverberation.

Range of Hearing or Audible Range

The human ear can hear the sound between frequencies of 20 Hz to 20,000 Hz. Thus, audible range or range of hearing is between 20 Hz to 20,000 Hz; for human beings. However, children under 5 years of age can hear the sound upto 25000 Hz.

Sound beyond audible range of human being: Infrasound and Ultrasound

Infrasonic Sound or Infrasound

Sound, below the frequency of 20Hz is called infrasonic or infrasound. Infrasound is produced because of very slow vibration. For example; simple pendulum produces sound below 20Hz. Human being cannot hear infrasound as their ears are not adapted to hear the sound of such range.

Many animals; such as whale, elephant, rhinoceros, etc. can produce and hear sound having frequencies below 20 Hz.

Ultrasound or Ultrasonic Sound

Ultrasound or ultrasonic sound:- Sound, above the frequency of 20000 Hz is called ultrasound. Humans cannot hear the ultrasonic sound. However, many animals such as dogs, cat, bat, monkey, deer, etc. can hear ultrasound.

Bats catch their prey by producing ultrasound. Bat produces ultrasound and detects the reflected sound waves coming from any obstacle; such as a prey. By detecting the reflection of ultrasound, bat understands the position and type of prey or of any obstacle in the way. Some aquatic animals, such as dolphin, also use ultrasound to catch their prey.

USE OF ULTRASOUND

Ultrasound is sound waves of high frequency. Because of high frequency, ultrasound is associated with more energy and can penetrate upto a large extent. This characteristic of ultrasound makes it very useful for many purposes. Some of its uses are given here:

In detection of ailments in the human body.

In cleaning of machinery parts which are beyond reach without disassembling of parts.

Detection of any deformities in metal blocks.

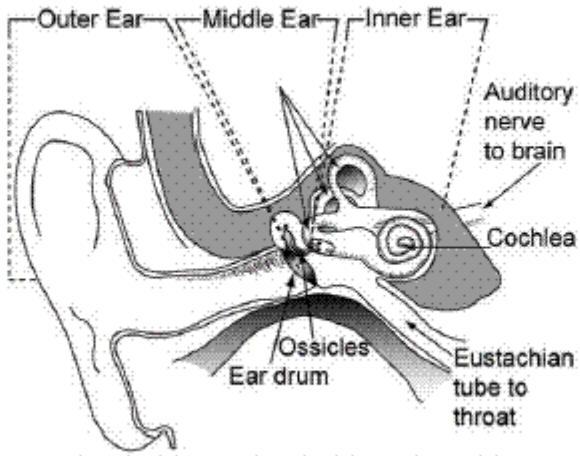
Detection of any blockade in pipe lines.

SONAR :-

SONAR: The full form of SONAR is SOund Navigation And Ranging. This is a device which is used to measure depth of sea bed, locate scraps, wrecks, submarines of enemies, etc. in the water by producing ultrasound. It is fitted over ships and submarines.

Ultrasonic sound waves are produced by SONAR and when these waves return after reflection from anything in water, they are analyzed with the help of computer. The shape and position of objects under sea and ocean is detected on the basis of speed and nature of reflected ultrasound waves.

Human Ear:



Structure of Human Ear:

The human ear can be divided into three main parts, viz. external ear, middle ear and internal ear.

External Ear: The external ear is outside the body and is also called pinna. It extends into the ear canal.

Middle Ear: The middle ear is composed of the ear drum or tympanum and the bone ossicles. There are three bone ossicles, viz. the hammer, the anvil and the strirrup.

Internal Ear: The internal ear is composed of a cochlea and three semi-circular canals. The cochlea makes the hearing apparatus and the auditory nerve from it goes to the brain.

Working of Human Ear: The external ear catches sound waves and channelizes them to the ear drum, via the ear canal. During compression, the pressure increases outside the ear drum which forces the eardrum to move inwards. During rarefaction, the pressure decreases outside the ear drum which forces the eardrum to move outwards. Thus, a vibration is produced in the eardrum. Further, the three bones amplify the sound wave, by vibrating in turns. In the inner ear, the vibrations are converted into electrical signals. These signals are transmitted by the auditory nerve to the brain. Finally, the brain interprets those signals as sound.

Question: 1 - How does the sound produced by a vibrating object in a medium reach your ear?

Answer:- Vibrations in an object create disturbance in the medium and consequently compressions and rarefactions. Because of these compressions and rarefactions sound reaches to our ear.

Question: 1 - Explain how sound is produced by your school bell.

Answer:- School bell starts vibrating when heated which creates compression and rarefaction in air and sound is produced.

Question: 2 - Why are sound waves called mechanical waves?

Answer: Since sound waves do some mechanical work while making disturbance in medium, hence sound waves are called mechanical wave.
Question: 3 -Suppose you and your friend are on the moon. Will you be able to hear any sound produced by your friend?
Answer: Since sound waves require medium to propagate and there is no medium present on the moon. So, I will not able to hear the sound of my friend on the moon.
Question: 1 - Question: 1 - Which wave property determines (a) loudness, (b) pitch?
Answer: (a) Amplitude of sound waves determines loudness. Louder sound has greater amplitude and vice versa.
(b) Frequency of the sound waves determined pitch of the sound.
Question: 2 - Guess which sound has a higher pitch: guitar or car horn?
Answer: Sound of the car horn has higher pitch.
Question: 3 - What are wavelength, frequency, time period and amplitude of a sound wave?
Answer: Wavelength: Wavelength is the distance between two consecutive compressions or rarefaction of wave.
Frequency: The number of sound wave produced in one second is called frequency.
Time period: Time period is the time taken to produce one wave of sound.
Amplitude: Amplitude is the maximum displacement along the mean position of the particles of medium.
Question: 4 - How are the wavelength and frequency of a sound wave related to its speed?
Answer: The relation between frequency and wavelength of sound wave is given as follows:
Velocity (v)=Wavelength(λ)X Frequency (ν), $v = \lambda X \nu$
This means the speed is equal to the product of wavelength and frequency of the sound wave.
This equation is also called the 'wave equation' and applicable to all types of wave.
Question: 5 - Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 m/s in a given medium.
Answer:
Given,
Frequency (ν) = 220 Hz
Velocity (v) = 440m/s
Wavelength (λ) =?
We know;

$$v = \lambda \times v$$
$$Or, 440m/s = \lambda \times 220Hz$$
$$Or, \lambda = \frac{440\ ms^{-1}}{220Hz} = 2m$$

Thus, wavelenght = 2m

Question: 6 - A person is listening to a tone of 500 Hz sitting at a distance of 450 m from the source of the sound. What is the time interval between successive compressions from the source?

Answer: Since, the time interval between successive compressions is called time period or time interval.

Here given,

Frequency (ν) = 500Hz

T (Time period) =?

We know that;

$$Frequency = \frac{1}{T}$$
$$Or, T = \frac{1}{Frequency}$$
$$Or\ T = \frac{1}{500\ Hz} = 0.002\ s$$

Thus, time interval between two consecutive compression of the given wave = 0.2 s

Question: 7 - Distinguish between loudness and intensity of sound.

Answer: Loudness of sound is determined of amplitude and intensity of the sound wave is determined by frequency of sound waves.

Question: 1 - In which of the three media; air, water or iron does the sound travel the fastest at a particular temperature?

Answer: At particular temperature sound travels fastest in iron.

Question: 1 - An echo returned in 3 s. What is the distance of the reflecting surface from the source, given that the speed of sound is 342 m /s?

Answer: To return an echo sound has to cover distance of two way.

Here, given,

Speed of sound = 342 m/s

Time = 3s

Thus,

Distance = speed X time

⇒ Distance = 342m/s×3 s=1026 m

Thus,the distance between the source and reflecting surface=1026÷2=513m

Question: 1 -Why are the ceilings of concert halls curved?

Answer: Since, concert halls are big, so audience at the back rows of the hall may not hear clear sound of speaker. To overcome this problem, the ceiling of the concert halls is made concave. Concave ceiling helps the sound wave to reflect and send to farther distance which makes the concert hall enable to send clear sound to the audience even sitting in back rows of hall.

Question: 1 - What is the audible range of the average human ear?

Answer: 20 Hz to 20000 Hz

Question: 2 - What is the range of frequencies associated with

(a) Infrasound

(b) Ultrasound

Answer:

(a) Infrasound: Less than 20 Hz

(b) Ultrasound: More than 20000 Hz

Question: 1 - A submarine emits a SONAR pulse, which returns from an underwater cliff in 1.02 s. If the speed of sound in salt water is 1531 m/s, how far away is the cliff ?

Answer: To return the SONAR pulse back, its wave has to travel two way.

Here, given,

Velocity (v) of sound wave = 1531m/s

Time (T) = 1.02 s

Thus, Distance = speed X time

Distance=1531 ms^(-1)×1.02 s=1561.62 m

So, the distance between the source and reflecting surface=1561.62÷2=780.81m

Question: 1 - What is sound and how is it produced?

Answer: Sound is a kind of energy produced in the form of waves. When anything is set to vibration, it produces sound.

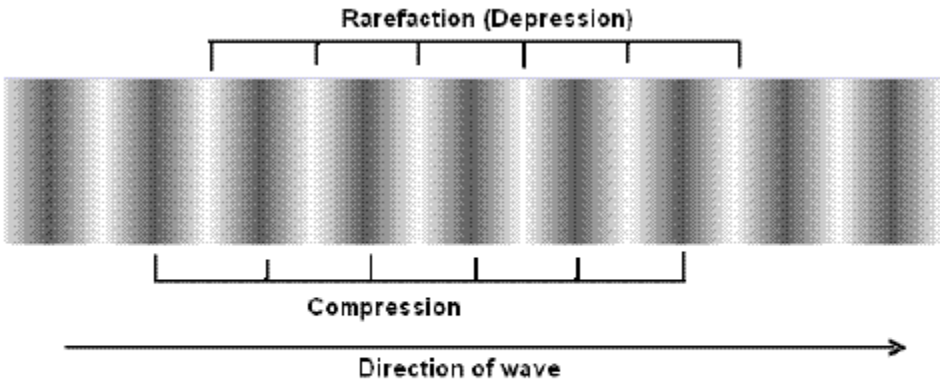
Question: 2 - Describe with the help of a diagram, how compressions and rarefactions are produced in air near a source of sound.

Answer:- Compression and rarefaction in air – Compression and rarefaction are produced because of the disturbance in medium caused by sound wave. Sound wave propagates because of compression and rarefaction of the particles of the medium.

When an object starts vibrating, it creates disturbance in medium. Because of the disturbance particles of medium come closer to each other compare to their normal position on the other hand adjacent particles go farther to each other. Both happen simultaneously.

The region where particles are come closer to each other is called compression and region where particles go farther to each other is called rarefaction.

In the given figure straight lines are showing the normal position of air particles. Dense lines are showing the region of compression and less dense lines are showing region of rarefaction of air particles.



Question: 3 - Cite an experiment to show that sound needs a material medium for its propagation.

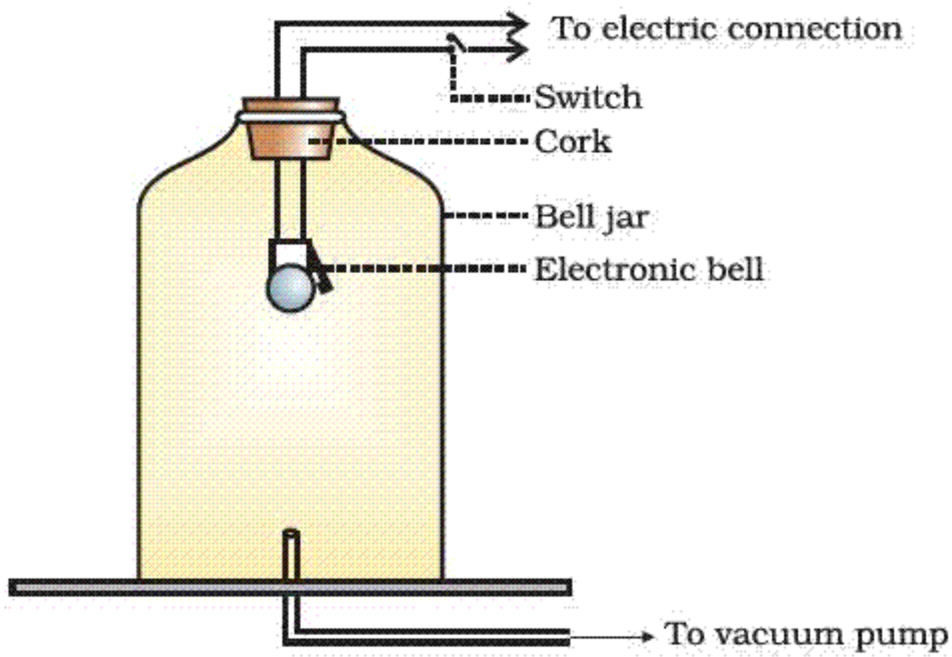
Answer:- Activity:

Take a glass bell jar, connect it with vacuum pump and suspend an electric bell in it.

Connect electric bell with a battery.

Switch on the electric bell and hear the sound of bell.

Now remove the air completely from the bell jar using vacuum pump and observe the sound of electric bell.



Bell jar Experiment to show that medium is necessary for the propagation of sound

Ref: NCERT Book - Chapter - Sound

It is observed that sound of electric bell does not come out after pumping out air from the bell jar.

This happens because after creating vacuum in the bell jar there were no air present through which sound wave can propagate.

This experiment shows that without medium sound cannot propagate and hence for the propagation of sound medium must be present.

Question: 4 - Why is sound wave called a longitudinal wave?

Answer: Since sound wave creates oscillation in the particles of the medium parallel to the disturbance in the direction of propagation, thus sound waves are called longitudinal wave. This would be more clear by taking the definition of longitudinal wave into account.

Longitudinal wave: When oscillation is created parallel to the disturbance of the particles of medium in the direction of propagation.

Question: 5 - Which characteristic of the sound helps you to identify your friend by his voice while sitting with others in a dark room?

Answer: Timbre and pitch are the characteristics of sound which help to identify the sound of different voice. Thus, because of difference in timbre and pitch of the sound wave I or any other can identify the voice of his friend sitting with others even in dark room.

Question: 6 - Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen, why?

Answer: This happens because of the difference in the velocity of light and sound waves. Light travels with much faster velocity than sound. That's why thunder is heard a few seconds after the flash of thunder is seen instead of both are produced simultaneously.

Question: 7 - A person has a hearing range from 20 Hz to 20 kHz. What are the typical wavelengths of sound waves in air corresponding to these two frequencies? Take the speed of sound in air as 344 m/s.

Answer:

Given, velocity of sound = 344 m/s

We know that

Velocity = wavelength X frequency

$$\Rightarrow Wavelength = \frac{Velocity}{Frequency}$$

Thus, in the case of sound of frequency of 20 Hz

$$Wavelength = \frac{344\ m/s}{20\ Hz} = 17.2\ m$$

In the case of sound of frequency of 20 kHz = 20000 Hz

$$Wavelength = \frac{344\ m/s}{20000\ Hz} = 0.00172\ m$$

Question: 8 - Two children are at opposite ends of an aluminium rod. One strikes the end of the rod with a stone. Find the ratio of times taken by the sound wave in air and in aluminium to reach the second child.

Answer:

We know that,

The speed of sound in air = 344 m per second

The speed of sound in aluminium = 5100 m per second

Hence, the ratio of time taken by the sound to travel through air and through aluminium

$$= \frac{Velocity\ of\ sound\ in\ aluminium}{Velocity\ of\ sound\ in\ air}$$

$$= \frac{5100\ m\ per\ second}{344\ m\ per\ second} = 150 : 1$$

Question: 9 - The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute?

Answer:

Given, frequency = 100 Hz

This means the source of sound vibrates 100 times in one second.

Therefore, number of vibrations in 1 minute, i.e. in 60 seconds = 100 x 60 = 6000 times.

Question: 10 - Does sound follow the same laws of reflection as light does? Explain.

Answer: Yes, the sound wave follows the same laws of reflection as the light does. The laws of reflection of sound are as follows:

The incident sound wave, the reflected sound wave and the normal at the point of incident, all lie in the same plane.

The angle of incidence of sound wave and angle of reflection of sound wave to the normal are equal.

When sound waves reflected from a surface, the angle of incidence is equal to the angle of reflection to the normal and the incident wave, normal and reflected wave are in the same plane. This can be proved by experiment.

Thus, sound wave obeys the laws of reflection.

Question: 11 - When a sound is reflected from a distant object, an echo is produced. Let the distance between the reflecting surface and the source of sound production remains the same. Do you hear echo sound on a hotter day?

Answer: To hear the sound of echo depends upon the distance from source of sound and reflecting surface. The distance between both must be equal to or more than 17.2 meter. If the given distance is more than 17.2 meter then one can hear the echo sound on a hotter day also.

Although, in hotter day the velocity of sound increases, thus it is necessary to hear the sound of echo the distance should be more than 17.2 meter. If the given distance is equal to 17.2, then to hear the sound in hotter day would not be possible.

Question: 12 - Give two practical applications of reflection of sound waves.

Answer: Bulb horn and Stethoscope are examples of practical applications of reflection of sound waves.

In bulb horn sound is amplified and sent to the desired direction because of reflection. In stethoscope also sound is sent to the desired direction because of its reflection characteristic.

Question: 13 - A stone is dropped from the top of a tower 500 m high into a pond of water at the base of the tower. When is the splash heard at the top? Given, g = 10 m^{-2} and speed of sound = 340 m/s.

Answer:

Given,

Height of tower = 500 m

g = 10m/s

Velocity of sound = 340 m/s^2

Thus, to calculate the time of splash sound, first of all time taken to reach the stone in the water is to be calculated.
We know that,

$$s = ut + \frac{1}{2}at^2$$

$$Or, s = ut + \frac{1}{2}gt^2$$

Here,

s = 500 m and g = 10 m/s^2

$$\Rightarrow\ 500\ m = 0 \times t + \frac{1}{2} \times 10\ ms^{-2} \times t^2$$

$$\Rightarrow\ 500\ m = 5ms^{-2} \times t^2$$

$$\Rightarrow\ t^2 = \frac{500m}{5m\ s^{-2}} = 100\ s^2$$

$$\Rightarrow\ t = 10\ s$$

Now, we know that the distance = speed X time

$$\Rightarrow Time = \frac{Distance}{Speed}$$

$$\Rightarrow Time = \frac{500m}{340\ ms^{-1}} = 1.47\ s$$

$$So, total\ time\ to\ hear\ the\ sound\ of\ splash = 10\ s + 1.47\ s = 11.47\ sec$$

Question: 14 - A sound wave travels at a speed of 339 m/s. If its wavelength is 1.5 cm, what is the frequency of the wave?
Answer:
Given,
Velocity (v) of sound = 339 m/s
Wavelength (λ) = 1.5 cm = 0.015 m
Frequency (ν) =?
We know that, speed = wavelength X frequency
⇒339 m/s = 0.015 m X frequency

$$\Rightarrow Frequency = \frac{339\ m/s}{0.015\ m} = 22600\ Hz$$

Thus, frequency = 22600 Hz
Multiple Choice Questions
Question: 1 -Note is a sound
(a) of mixture of several frequencies
(b) of mixture of two frequencies only
(c) of a single frequency
(d) always unpleasant to listen

Answer: (a) of mixture of several frequencies
Question:- 2 - A key of a mechanical piano struck gently and then struck again but much harder this time. In the second case
(a) sound will be louder but pitch will not be different
(b) sound will be louder and pitch will also be higher
(c) sound will be louder but pitch will be lower
(d) both loudness and pitch will remain unaffected
Answer:- (d) both loudness and pitch will remain unaffected

Question: 3 - In SONAR, we use
(a) ultrasonic waves
(b) infrasonic waves
(c) radio waves
(d) audible sound waves
Answer: (a) Ultrasonic waves
Question:- 4 - Sound travels in air if
(a) particles of medium travel from one place to another
(b) there is no moisture in the atmosphere
(c) disturbance moves
(d) both particles as well as disturbance travel from one place to another.
Answer:- (c) Disturbance moves

Question: 5 - When we change feeble sound to loud sound we increase its
(a) Frequency
(b) Amplitude
(c) Velocity
(d) Wavelength
Answer: (b) Amplitude
Question: 6 - In the curve (Figure) half the wavelength is

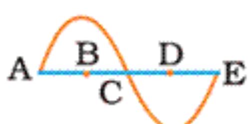


Fig.

(a) A B
(b) B D
(c) D E
(d) A E
Answer: (a) AB

Question: 7 - Earthquake produces which kind of sound before the main shock wave begins
(a) Ultrasound
(b) Infrasound
(c) audible sound
(d) none of the above
Answer: (b) Infrasound
Question: 8 - Infrasound can be heard by
(a) Dog
(b) Bat
(c) Rhinoceros
(d) human beings
Answer: (c) Rhinoceros

Question: 9 - Before playing the orchestra in a musical concert, a sitarist tries to adjust the tension and pluck the string suitably. By doing so, he is adjusting
(a) intensity of sound only
(b) amplitude of sound only
(c) frequency of the sitar string with the frequency of other musical instruments
(d) loudness of sound
Answer: (c) Frequency of the sitar string with the frequency of other musical instruments

Introduction to Sound

Sound is a form of energy that travels in the form of vibrations through the air or any another medium.
Vibration is defined as a rapid to and fro or up and down movement about a mean position.
Vibrations travel through a medium such as air and reach our ears where they are interpreted by the brain as sound.
Human beings are capable of producing sound which originates from the larynx or the voice box in the neck. The sound produced is controlled by thin membranous structures known as vocal cords that stretch across the larynx.
The vibrating body can be- a stretched animal hide (as in drums and table), stretched strings (as in guitar and sitar), or air columns (as in flute or pipes).
Simple pendulum
You can produce slower vibration in a simple pendulum. It consists simply of a weight hanging by a thread. When the ball is given a small push, it performs to and fro movements which you can easily observe. These slow vibrations are also

known as oscillations.

Characteristics of vibration
The important characteristics of vibrations are its frequency, amplitude and time period. These determine the characteristics of the sound produced.

Frequency:
The number of vibrations made by the vibrating body in one second is known as its frequency.
The SI unit of frequency is the hertz (Hz).
Amplitude:
The maximum extent of vibration of the vibrating body from its mean position is known as its amplitude.

Time period:
The time taken by the vibrating body for one complete vibration is known as the time period of vibration. It is denoted by T.
$T=1/f$ and $f=1/T$
Time period and frequency are reciprocals of each other.

Characteristics of sound
Sound can be characterized by the loudness, pitch and quality.

Loudness:
Based on the amplitude of a sound wave, we can determine the loudness of the sound. When the amplitude is high, it will produce a sound that is loud and when the amplitude is low, it will produce a sound that is soft.
Loudness is proportional to the square of the amplitude. This means that if the amplitude is doubled, the loudness increases four times.
Pitch:
Pitch denotes the shrillness or flatness of a sound. Sound can be high or low.
A woman's voice generally has a high pitch than a man's voice. This is because the frequency of a woman's voice is higher.
Quality (Timbre):
The quality of a sound is that property by virtue of which two sounds of the same pitch and loudness produced by the two different musical instrument or people can be distinguished.

How sound travel?

Sound travels through a medium in the form of waves. When vibrations take place, they are transmitted through a medium and form alternate compression and rarefactions.
Compressions are regions in the medium where the particles are closer whereas rarefactions are regions in the medium where the particles are spread out.
Speed of sound:
The speed of sound changes with the change in medium. Speed also depends on the physical state and temperature of the medium. At higher temperature, the speed of sound is higher, while at lower temperature, the speed decreases.
The speed of sound is maximum in solids (5920m/s in steel), lesser in liquids (1480m/s in water) and minimum in gases (330m/s in air).

How does human hear sound?
Sound travels in the form of waves of vibrating air molecules. When these waves reach our ears we hear the sound.
The ear has three parts: Outer ear, Middle ear and Inner ear.

Outer Ear:
It consists of the pinna, ear canal, and the eardrum or the tympanum. The pinna gathers the sound waves and then leads to the ear canal from where they strike the eardrum.

Middle Ear:
The vibrations from the eardrum are transmitted to three closely-packed bones called the hammer, anvil and stirrup. These three bones finally transmit the vibrations to the inner ear.

Inner Ear:
This consists of cochlea, which is a long coiled tube. It contains a fluid and has numerous cells with hair. These sensitive hair cells transmit the vibrations to the brain through the auditory nerve, for the brain to register the sound.

Important Notes Sound

Production of Sound
Sound is produced due to the vibration of objects. Vibration is the rapid to and fro motion of an object. Vibrating objects are the source of all sounds Irregular, chaotic vibrations produce noise Regular, controlled vibration can produce music All sound is a combination of pure frequencies A stretched rubber band when

plucked vibrates and produces sound.

Propagation of Sound

When an object vibrates, the particles around the medium vibrate. The particle in contact with the vibrating object is first displaced from its equilibrium position The disturbance produced by the vibrating body travels through the medium but the particles do not move forward themselves.

A wave is a disturbance which moves through a medium by the vibration of the particles of the medium. So sound is considered as a wave.Sound waves Require medium for transmission.Sound waves are called mechanical waves. When a vibrating object moves forward, it pushes andcompresses the air in front of it forming a region of high pressure called compression (C). When the vibrating object moves backward, it forms a region of low pressure cal led rarefaction (R).

A vibrating object producing a series of compressions (C) and rarefaction (R)
In these waves the particles move back and forth parallel to the direction of propagation of the disturbance. Such waves are called longitudinal waves.

Compressions are the regions of high pressure and density where the particles are crowded and are represented by the upper portion of the curve called crest. Rarefactions are the regions of low pressure and density where the particles are spread out and are represented by the lower portion of the curve called trough

Sound is a Mechanical Wave:

Sound requiers medium for its propagation it can travel through solid, liquid and gas but not vaccum. The waves which require a material medium for their propagation are called mechanical waves.

Sound is Longitudnal Wave

The wave in which the particles of the medium oscillate along the direction of propagation of the wave is called a longitudinal wave

Transverse wave

The wave in which the particles of the medium oscillate in a direction perpendicular to the direction of propagation of the wave is called a transverse wave.Light waves are transverse waves.They do not require medium for their propagation.Light can travel through vaccum.

Pulse: A wave of short duration which is confined to a small portion of a medium at any given time is known as a pulse.

Characteristics of a sound wave

Frequency of sound wave The number of oscillations per unit time is called the frequency of the sound wave.
It is represented by the symbol ν (Greek letter nu). Its SI unit is hertz (Hz)

The pitch of a sound depends upon the frequency, higher the frequecy higher will be the pitch and vice versa.

Time Period:Time taken to complete one oscillation

Time period= 1/f

Amplitude of the Sound: The maximum displacement of particles of the medium from their mean positions during the propagation of a wave is known as amplitude of the wave.The amplitude of sound wave is the height of the crest or tough.It is represented by the letter A.
The SI unit is the same as that of density or pressure.

Velocity: The distance travelled by a wave in one second is called wave velocity.It depends upon the nature of the medium through which it passes.

v=frequency X Wavelength

Audible Frequency: The human ears can hear only those waves whose freqnecy lies between 20 Hz and 20,000HZ.

Infrasonic Waves: The waves having freqnecy less than 20 Hz are infrasonic

Ultrasonic Waves: The waves having frequency more than 20.000 Hz are ultrasonic waves

Reflection of Sound

Sound gets reflected at the surface of a solid or liquid and follows the laws of reflection.

i) The angle of incidence is equal to the angle of reflection.

ii) The incident ray, the reflected ray and normal at the point of incidence all lie in the same plane.

Echo

If we shout or clap near a reflecting surface like tall building or a mountain, we hear the same sound again. This sound which we hear is called echo. It is caused due to the reflection of sound.

To hear an echo clearly, the time interval between the original sound and the echo must be at least 0.1 s.

Since the speed of sound in air is 344 m/s, the distance travelled by sound in 0.I s = 344 m/s x 0.1 s = 34.4 m

So to hear an echo clearly, the minimum distance of the reflecting surface should be half this distance that is 17.2 m.

Reverberation

Echoes may be heard more than once due to repeated or multiple reflections of sound from several reflecting surfaces. This causes persistence of sound called reverberation. In big halls or auditoriums to reduce reverberation, the roofs and walls are covered by sound absorbing materials like compressed fibre boards, rough plaster or draperies.

Uses Of Multiple Reflection Of Sound

i)Megaphones, horns, musical instruments like trumpets, etc. are deigned to send sound by multiple reflection in a particular direction without spreading in all directions.

ii) Doctors listen to sounds from the human body through a stethoscope. The sound of heartbeat reaches the doctor's ears by multiple reflection.

iii) Generally the ceilings of cinema halls and auditoriums are curved so that sound after multiple reflection reaches all parts of the hall.

Sometimes a curved sound board is placed behind the stage so that sound after multiple reflection spreads evenly across the hall.

Speed of sound in Different Medium

Sound travels with different speeds in different medium. The speed of sound also depends upon the temperature of the medium. Sound travels faster in solids than in air. The speed of sound in solids is much more than the speed of sound in liquids or gases.

Average speed of sound at room temperature is 332 m/s

Application of Ultrasound

They are used to establish ship to ship communication.

They are used to find the depth of a sea.

They are used to diagnose the disease in a human body

They are used to kill bacteria in liquids.

They are used for welding plastics

SONAR

SONAR stands for Sound Navigation and Ranging. It is based on the principle of the reflection of sound wave. The ultrasonic waves from the transmitter of SONAR are sent towards the bottom of the sea whose depth is to be measured. These waves are reflected back from the bottom of the seas and are received by the receiver of the SONAR the transmitter and the receiver are suitably placed on the ship The time taken by the ultrasonic waves to go from the ship to the bottom of the sea and then back to the ship is recorded Time taken by the waves to go from the ship to the bottom of the sea is =t/2.If V is the velocity of wave, the required distance S is given by.

$s= v(t/2)$

Human Ear

The ear mainly consists of three basic parts the outer ear, the middle ear, the the inner ear. Each part of the ear serves a specific purpose in the task of the detecting and interpreting sound. The outer ear serves to collect and channel sound to the middle ear. The middle ear serves to transform the energy of a sound wave into the internal vibrations of the bone structure and ultimately transform these vibrations into a compressional waves in the inner ear. The inner ear serves to transform the energy of a compressional wave with the inner ear fluid into nerve impulses which can be transmitted to the brain.

Audible and inaudible sounds:
Audible sounds are those that can be heard while inaudible sounds are those that cannot be heard.
Human can hear sounds with frequency between 20Hz and 20,000Hz.
Low frequency sounds which cannot be hear are called infrasonics.
Objects that vibrate at frequencies of above 20,000Hz produce sound which also cannot be heard by us. Such sounds are called ultrasonics.
Reflection and absorption of sound:
The echo:
Sound heard after reflection from a surface is called echo.
Just like heat or light, when sound falls on a surface, it is partly reflected and partly absorbed.
Soft surfaces are better absorbers of sound whereas hard surfaces are better reflectors of sound.
Uses of Echo:
Echo is used in SONAR (Sound Navigation and Ranging) to find the depth of seas or distance of submarines.
In concert halls, echo is desirable to some extent, because it enhances the sound and produces a pleasing effect.
Bats use the principle of echolocation to avoid hitting against obstacles in their path.
Musical sounds and noise:
Sounds can be classified as musical sounds and noise.

Musical sounds:
The sounds produced by a tuning fork, violin, veena, flute and piano are pleasing to the ear. They are called musical sounds. They are produced by regular, periodic vibrations.

Noise:
Certain sounds such as thunder, the rattling of wheels on a rough road, or a large number of people talking at the same time inside a room are unpleasant to hear. These sounds are called noise and produced by irregular and non-periodic vibrations.

Musical instruments:
Musical instruments are categorized into three types:
Stringed instruments, wind instruments and percussion instruments.

Stringed instruments:

Stringed instruments make use of a string or wire to produce vibrations and sound.
The frequency of sound is varied by varying the length of the vibrating wire.
In a sitar, the shorter the length of the wire, the higher the pitch it produces.

Wind instruments:

Wind instruments use the principle of a vibrating air column to produce sound. The frequency is varied by changing the length of the vibrating air column.
Flute, shehnai and clarinet are some well known wind instruments.

Percussion instruments:

They are instruments in which vibrations of a stretched animal hide produce sound.
The frequency of vibration can be increased by stretching the hide more.
Table, drums and mrindangam are some examples of percussion instruments.

Noise pollution:

Too much noise in our surroundings is known as noise pollution.
The loudness of sound is measured in decibels (dB).

Sources of noise pollution:

The sources of noise pollution include road traffic, jet planes, trains, construction sites, factories, uses of loudspeakers, lighting of crackers during festivals, and noise from radio and television.

Harmful effects of noise pollution:

Sudden exposure to high noise level can cause permanent deafness by rupturing the eardrum.
Noise environment causes headache and inability to concentrate on work.
High noise levels can also lead to nervous tension and increase of blood pressure.

How to control noise pollution?

Vehicles should be fitted with more effective silencers.
Restricting the use of loudspeakers or amplifiers in public places.
Using sound absorbing materials like curtains and rugs inside the home and planting trees along the roadside helps to reduce noise.

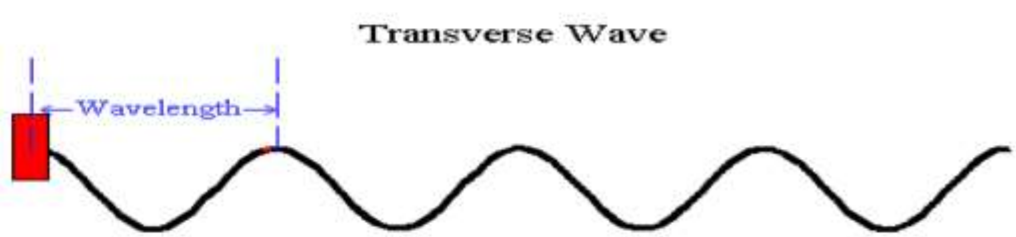
Practice questions for Sound

1. How sound is produced?
2. What do you understand by a ‘wave’?
3. Write three differences between sound and light waves.
4. What do you understand by “sound energy cannot be produced”?

5. What is the name of the wave that can travel through vacuum?
6. Explain by some experiment that sound waves require medium for their propagation.
7. How sound waves travel through some medium?
8. Why sound waves do not propagate through vacuum?
9. What is the scientific name for the following? The number of vibrations made per second.
10. Why a sound cannot be heard on the moon?
11. Give two points of difference between longitudinal and transverse waves.
12. How will you prove that the sound waves exhibit longitudinal behaviour?
13. What are rarefaction and compression in case of sound waves?
14. Distinguish between crests and troughs.
15. Write the SI unit of velocity of a wave.
16. What are the factors that describe the sound wave and define them?
17 Why is a thundering sound heard later than lightening?
18. How RADAR is different from SONAR?
19. How far is a compression and its nearest rarefaction in a longitudinal wave?
20. Define sound ranging.

Waves:-

Wave motion:- Wave motion is the disturbance, set up in the medium, due to the repeated periodic motion of the particles of the medium and travels from the particle to particle, the particles themselves keep vibrating about their mean positions.

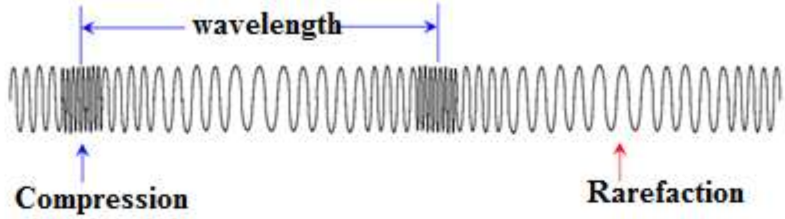


Wave Equation:- $d^2y/dt^2 = v^2\,(d^2y/dx^2)$

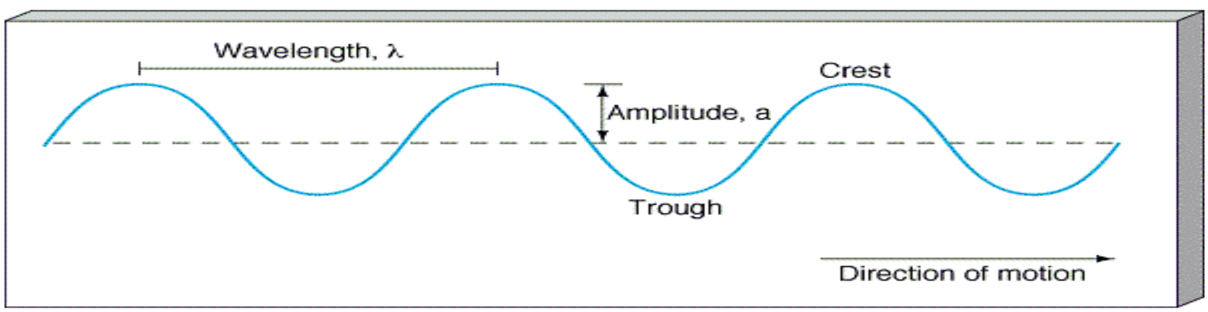
Transverse wave motion:-It is the type of wave motion in which the particles of the medium are vibrating in a direction at right angles to the direction of propagation of wave.

(a) Velocity of transverse wave, $V_t = \sqrt{T/m} = \sqrt{T/\pi r^2 \rho}$

(b) Vibrations of the particles of medium are normal to the direction of wave propagation.
??Longitudinal wave motion:-It is the type of wave motion in which the particles of the medium vibrate in the direction of propagation of wave.



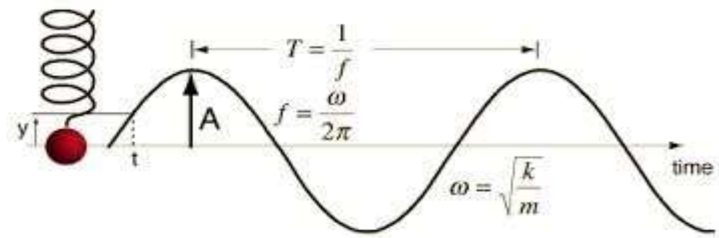
(a) Velocity of longitudinal wave, $V_1 = \sqrt{E/\rho}$
(b) Vibrations of the particles are parallel to the direction of wave propagation.
Terms related to wave motion:-
(a) Wave length(λ):-
(i) It is defined as the distance travelled by a wave during the time particle executing SHM completes one vibration.
(ii) It is the distance between two consecutive particles executing SHM in same phase.
(iii) It is the distance between two consecutive crests or troughs.



(b) Wave number (n):- Wave-number of a wave is defined as the reciprocal of wavelength of weave.
$n = 1/\lambda$
Unit of weave number is meter.
(c) Velocity of wave:- It is the distance (λ)travelled by the wave during the time (T), a particle completes one vibration.
velocity of wave = (frequency) (wavelength)
$v=f\lambda$
(d) Phase:- Phase of a particle is its state which expresses its position and direction of motion.
(e) Phase difference (*?*):-Phase difference, between two particles, is the difference between their instantaneous phases.
Relation between phase difference (*?*) and path difference (λ):-

$? = (2\pi/\lambda)\times$(path difference)

Simple Harmonic Motion:-A wave which originates from a source, undergoing simple harmonic motion, is called a simple harmonic



wave.

Equation:-$y = r\sin\omega t$

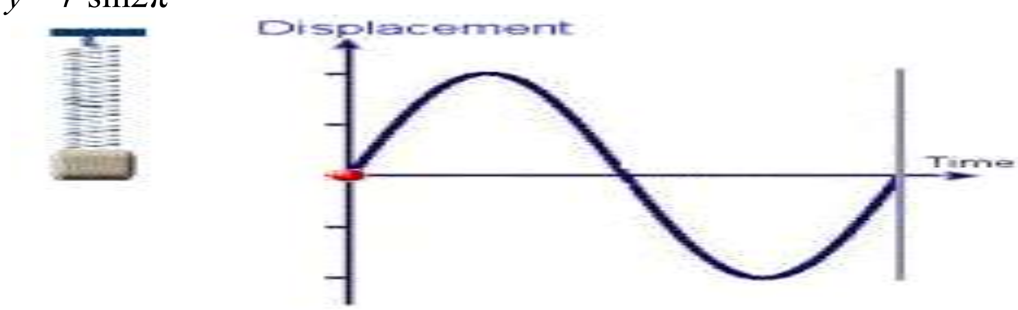
$= r \sin 2\pi ft$

$= r\sin 2\pi(v/\lambda)t$

$= r \sin 2\pi x/\lambda$

Equation of progressive wave:- A relation between the instantaneous displacement of a particle executing SHM and time is called equation of progressive wave.

$y = r \sin 2\pi$ $(\omega t \pm ?)$



$y = r \sin [(\omega t \pm (2\pi/\lambda)x]$

$y = r \sin (\omega t \pm kx)$

$y = r \sin 2\pi (t/T \pm x/\lambda)$

$y = r \sin 2\pi/\lambda (vt \pm x)$

Angular wave number (k): $k = 2\pi/\lambda$

Relation between particle velocity (V) and wave velocity (v):-

$V = (2\pi r/\lambda) v\cos[(2\pi/\lambda)(vt \pm x)]$

$V_{max} = (2\pi r/\lambda) v$

Energy transmission in a progressive wave:-$E = ½ m\omega^2 r^2$

Energy per unit volume:- $E = ½ \rho r^2\omega^2$ Here ρ is the density of medium.

Intensity of a wave:-

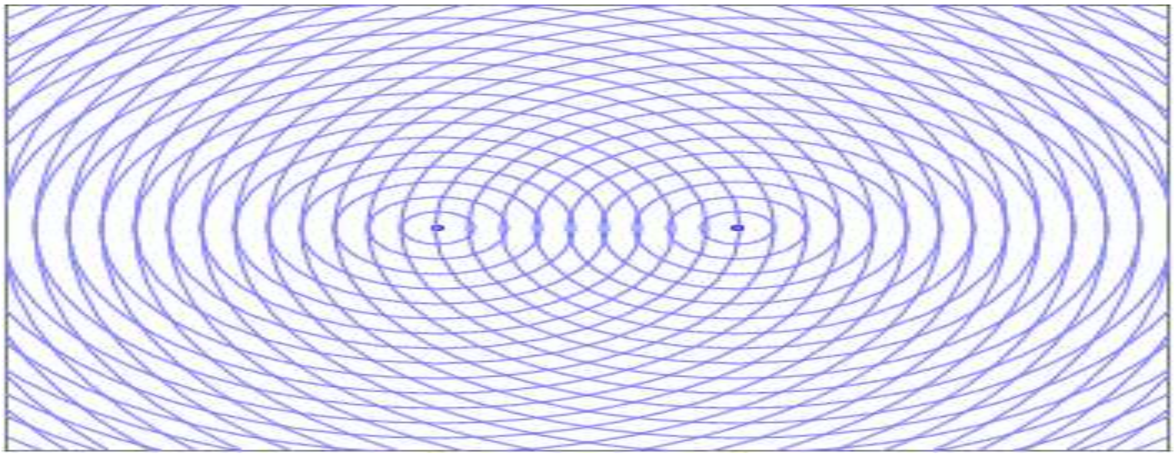
$I = 2\pi^2 \rho v f^2 r^2$

Intensity of a wave varies directly as the square of its amplitude.

So, $I \propto r^2$

Velocity of transverse wave in stretched string:-$v = \sqrt{(T/m)}$, Here, T is the tension in the string.

Interference:- Interference is the phenomenon by virtue of which there is a modification in the distribution of energy due to super position of two or more waves.



$y_1 = a_1 \sin\omega t$, $y_2 = a_2 \sin(\omega t + ?)$

$y = y_1 + y_2$

Amplitude, $A = \sqrt{[a_1^2 + a_2^2 + 2\, a_1\, a_2 \cos ?]}$

Intensity, $I = kA^2$ and $I = I_1 + I_2 + 2(\sqrt{I_1 I_2}) \cos ?$

Here, $I_1 = ka_1^2$ and $I_2 = ka_2^2$

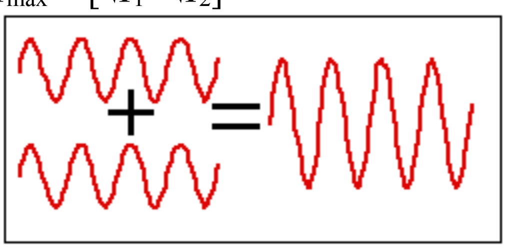
Angle, $\theta = \tan^{-1}[a_2 \sin ?/(a_1 + a_2 \cos ?)]$

Constructive interference:-

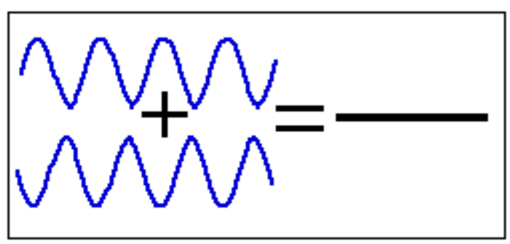
Phase difference, $? = 2n\pi$, $n = 0,1,2,3\ldots$

$A = a_1 + a_2$

$I_{max} = [\sqrt{I_1} + \sqrt{I_2}]^2$



Constructive Interference



Destructive Interference

Path difference, $x = 2n(\lambda/2)$

Destructive interference:-

Phase difference, $? = (2n+1)\pi$, $n = 0,1,2,3\ldots$

$A = 2a \cos ?/2$

$I = 4a^2 k \cos^2 ?/2$

$I_{max} = 4a^2 k$

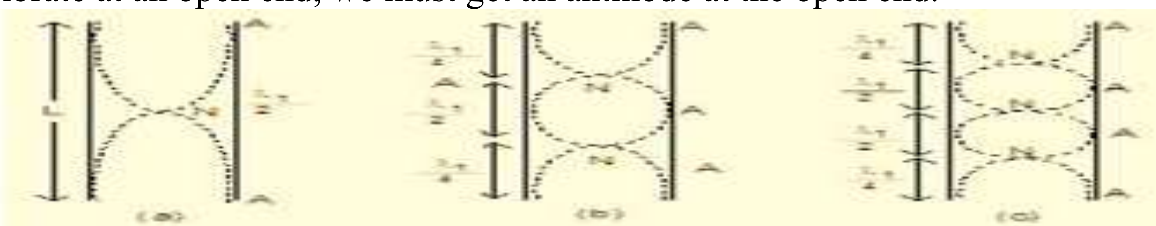
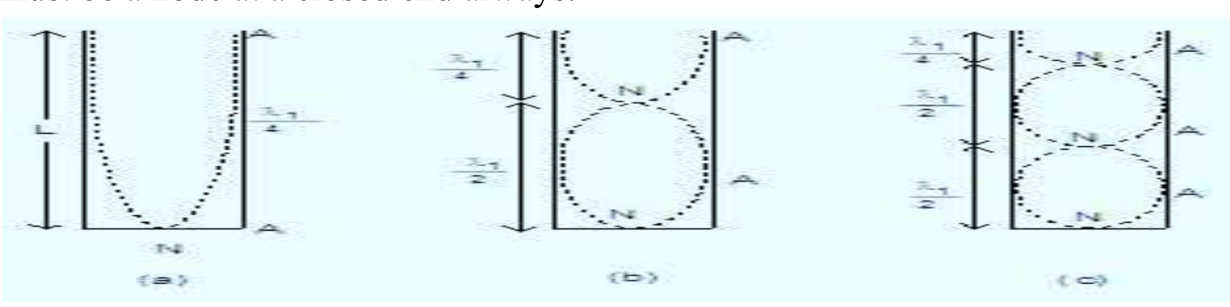
$I_{min} = 0$

Path difference, $x = (2n+1)(\lambda/2)$

Condition for interference:-

(a) The two sources must emit continuous waves having same frequency and wavelength.
(b) The amplitudes of two waves must either be equal or nearly equal.
(c) The two sources should be situated close to each other.
(d) The two sources should be coherent one.
Stationary Wave:-
Wave equation, $y = 2a\cos(2\pi/\lambda)\, x \sin(2\pi/\lambda)\, vt$
Amplitude, $A = 2a\cos(2\pi/\lambda)\, x$
Condition for maxima (anti-nodes), $x = k(\lambda/2)$
Condition for minima (nodes), $x = (2k+1)(\lambda/4)$
Frequency of transverse vibrations in stretched string:-
$f=(1/2l)\,\sqrt{(T/m)}$, Here l is the length, T is the tension and m is the mass.
$f=(1/lD)\,\sqrt{(T/\pi\rho)}$, Here l is the length, T is the tension, D is the diameter and ρ is the density.
Harmonics in stretched strings:-
(a) First harmonic (fundamental frequency), $f_0=(1/2l)\,\sqrt{(T/m)}$
(b) Second harmonic (first overtone), $f_1 = 2f_0=(2/2l)\,\sqrt{(T/m)}$
(c) Third harmonic (second overtone), $f_2 = 3f_0=(3/2l)\,\sqrt{(T/m)}$
(d) p^{th} harmonic (p-1 overtone), $f_{p-1} = pf_0=(p/2l)\,\sqrt{(T/m)}$
Here, p=1,2,3…
Frequency of tuning fork:-
$f\propto(t/l)\sqrt{(E/\rho)}$
Here, t is the thickness, l is the length, E is the elastic constant and ρ is the density.
Phenomenon of Beats:-Periodicvariations of amplituderesulting from the superposition of two waves of slightly different frequencies is known as phenomenon of beats.
If m is the number of beats per second, then, $m = f_1\text{-}f_2$. Here f_1 and f_2 are the frequencies of the two waves.
$y_1 = a\sin2\pi f_1 t$, $y_2 = a\sin2\pi f_2 t$
$y = y_1+y_2 = A\sin2\pi ft$
Amplitude, $A = 2a\cos2\pi(f_1\text{-}f_2/2)t$, Frequency, $F = f_1\text{-}f_2/2$
(a) Maxima:- $t = f/f_1\text{-}f_2$
(b) Minima:- $t = 2f+1/2(f_1\text{-}f_2)$
Beat period (t_b):- It is defined as the time interval between consecutive beats or it is the time between two consecutive maxima or minima of intensity of sound.
$t_b = 1/f_1\text{-}f_2$
If m is the number of beats per second, then,
$m = 1/\text{beat period} = f_1\text{-}f_2$
This signifies, the number of beats per second is equal to the difference in frequencies of two waves.

Sound Waves:-
It is the form of energy which produces, in us, the sensation of hearing.
Properties:-
(a) Longitudinal in nature.
(b) It requires a material medium for its propagation.
(c) Sound waves can be reflected.
(d) Sound waves suffer refraction.
(e) Sound waves show the phenomenon of interference
(f) Sound waves shows diffraction
(g) Sound propagates with a velocity much smaller than that of light.
(h) Sound gets absorbed in the medium through which it passes.
Loudness (L)or Intensity (I):-
$L \propto \log I$
So, $L = K \log_{10}(I_1/I_0)$
Unit of intensity of sound is bel.
Intensity (I) and Amplitude (A):- $I \propto A^2$
Intensity(I) and distance from the source (r):- $I \propto 1/r^2$
Pitch or Shrillness:-Pitch is a sensation which determines the shrillness of sound. It is subjective and cannot be measured quantitatively. It depends up on frequency and relative motion between the sources and the listener.
Quality or Timber:- It is that characteristic of a musical sound which enables us to distinguish between two notes of the same pitch and loudness produced by two different sources.
Velocity u of longitudinal wave (sound) [Newton's Formula]:-
$u = \sqrt{E/\rho}$
Here E is the coefficient of elasticity and ρ is the density of medium.
Velocity of sound in solids:-
$u = \sqrt{Y/\rho}$
Here Y is the young's modulus of elasticity and ρ is the density.
Velocity of sound in liquids:-
$u = \sqrt{B/\rho}$
Here B is the Bulk modulus of elasticity and ρ is the density.
Velocity of sound in gases:-
$u = \sqrt{\gamma P/\rho}$
Here, γ ($= c_P/c_V$) is the adiabatic ratio, P is the pressure and ρ is the density.
Various factors affecting velocity of sound:-
(a) Effect of density:- The velocity of sound in a gas varies inversely as the square root of its density. $u_1/u_2 = \sqrt{[\rho_2/\rho_1]}$
(b) Effect of moisture:-$u_m/u_d = \sqrt{[\rho_d/\rho_m]}$
Since, $\rho_m < \rho_d$, then, $u_m > u_d$

This signifies sound travels faster in moist air.
(c) Effect of pressure:- $u=\sqrt{\gamma P/\rho}=\sqrt{\gamma k}$ = constant
This signifies, change of pressure has no effect on the velocity of sound.
(d) Effect of temperature:- $u_t/u_0 = \sqrt{\rho_0/\rho_t} = \sqrt{T/T_0}$
Thus, velocity of sound varies directly as the square root temperature on Kelvin's scale.
(e) Temperature coefficient of velocity of sound (α):- $\alpha = u_0/546 = (u_t-u_0)/t$
Overtones in open pipe:-An open pipeis openat both ends. Since air is free to vibrate at an open end, we must get an antinode at the open end.

(a) Fundamental frequency:-
Wavelength, $\lambda=2l$
Frequency, $f=u/2l = (1/2l)\sqrt{(\gamma P/\rho)}$
Here l is the length of the pipe and u is the velocity of sound.
(b) First overtone (Second Harmonic):-
Wavelength, $\lambda_1=l$
Frequency, $f_1=2f$
(c) Second overtone (Third Harmonic):-
Wavelength, $\lambda_2=2l/3$
Wavelength, $f_2=3f$
Overtones in closed pipe:-Since air, at a closed end, is not free to vibrate, there must be a node at a closed end always.

(a) Fundamental frequency:-
Wavelength, $\lambda=4l$
Frequency, $F=u/4l = (1/4l)\sqrt{(\gamma P/\rho)}$
Here l is the length of the pipe and u is the velocity of sound.
(b) First overtone (Third Harmonic):-
Wavelength, $\lambda_1=(4/3)l$
Frequency, $F_1=3F$

(c) Second overtone (Fifth Harmonic):-
λ_2=4l/5
F_2=5F
Comparison of fundamental frequencies of a closed end of an open pipe:- f = 2F
Doppler's Effect:-Theapparent change in pitch of a note, due to the relative motion between the source and the listener is called Doppler's effect.
(a) Source in motion, listener at rest:-
(i) Source approaching the listener:-
Modifying wave length, λ' = V-a/f
Apparent frequency, f' = [V/V-a]f
Change in frequency, ?f = (a/V-a)f
Here V is the velocity of sound in air and a is the velocity of source when it moves towards the listener.
(ii) Source going away from the listener:-
Apparent frequency,f' = [V/V+a]f
Change in frequency, ?f = -(a/V+a)f
(iii) Source crossing the listener:-
Apparent frequency of the source before crossing = (V/V-a) f
Apparent frequency of the source after crossing = (V/V+a) f
Change in frequency, ?f = -(2aV/V^2-a^2)f
(b) Source at rest, listener in motion:-
(i) Listener moving away from source:-
Apparent frequency,f'= [V-b/V]f
Change in frequency, ?f = (-b/V)f
Here b is the velocity of listener.
(ii) Listener moving towards the source:-
Apparent frequency:-f'= [V+b/V]f
Change in frequency, ?f = (+b/V)f
(iii) Listener crossing the source:-
Apparent frequency of the source before crossing = (V+b/V) f
Apparent frequency of the source after crossing = (V-b/V) f
Change in frequency, ?f =-2fb/V
(c) Source and listener both in the medium:- Change in frequency due to relative motion of source and listener.

Source *(S)*#	Listener (*L*) (*X*)	Nature of velocities	Expression for f'
# $\xrightarrow{a}$	$\times\xrightarrow{b}$	+ve, +ve	$f' = (V\text{-}b/V\text{-}a)\,f$
# $\xrightarrow{a}$	$\xleftarrow{-b}\times$	+ve, -ve	$f' = (V+b/V\text{-}a)\,f$
$\xleftarrow{-a}$ #	$\xleftarrow{-b}\times$	-ve, -ve	$f' = (V+b/V+a)\,f$

$\xleftarrow{-a}$ #	$\times\xrightarrow{b}$	-ve, +ve	$f' = (V\text{-}b/V\text{+}a)\,f$

(d) Effect of motion of medium:-

Apparent frequency:-$f' = [(R-b)/(R-a)]\,f$

Here, $R = V+\omega\cos\theta$, ω is the velocity of wind, θ is the angle between direction of propagation of sound and that of wind.

Q.1 How does a sound making object differ from one that is silent?
Answer: Sound making object can vibrate easily.

Q.2 How does sound from a sound producing body travel through air to reach our ears?
Answer: Sound from a sound producing body travel through air to reach our ears by making regular compression and rarefaction.

Q.3 Why are the voices of men, Women and children different?
Answer: The voices of men, women and children differ from each other due to the following factors:
(i) The pitch is one of the most essential factors to determine the voice of the individual. For example, men have lower-pitched voices while women have higher-pitched voices.
(ii) Second factor which brings in the difference in the voices is the length and the thickness of vocal cords.

Q.4 Why a sound cannot be heard on the moon?
Answer: A sound cannot be heard on the moon due to absence of medium air

Q.5 How do astronauts talk to one another on the surface of moon and Why?
Answer: Astronauts communicate with the help of radio waves on moon because these waves do not need a medium to travel

Q.6 If you want to hear a train approaching from far away, why is it more convenient to put the ear to the track?
Answer: This is because sound can travel through railway track (solid) faster than through air.

Q.7 State one observation from everyday life which shows that sound travels

much more slowly than light?
Answer: We hear thunder after lightining.

Q.8 What is the scientific name for the following? The number of vibrations made per second.
Answer: Frequency

Q.9 Why do we not hear the screams of a bat?
Answer: This is because the screams are ultra sonic(above 20,000 hertz) which human ear cannot hear.

Q.10 Which of the following frequency of sound can be heard by a dog but not by a man? (a) 50,000 hertz (b) 15,000 hertz
Answer: A sound of frequency 50,000 hertz can be heard by a dog but not by a man

Q.11 Explain how, noise pollution {or excessive loud noise} is harmful to human beings.
Answer: Noise pollution can lead to a number of health-related problems. Some of them are as follows:
(i) Hearing loss (ii) inability to sleep (iii) Hypertension (iv) Severe headache (v) Stress

Q.12 State the various measures which can be taken to control {or reduce} noise pollution in our surroundings.
Answer: Noise pollution can be reduced by using silencers in vehicles, industrial machines, and home appliances reducing use of vehicle horns, running TV, radio and music systems at low volumes. Planting of trees along roads and buildings also help to reduce noise pollution.

Q.13 Give two causes of noise pollution from the homes.
Answer: . In the home noise pollution is caused by television radio and music systems at high volume, some kitchen appliances, desert coolers, air conditioners etc.

Q.14 Sound of different pitch can be produced using a flute. Explain, how?
Answer: If we blow a flute, the air column vibrates and produces sound. Flute contains small air columns, when air is bowed through the mouth piece the air columns start vibrating which produces sound.

Q.15.How does Sound produced by humans?
Answer: In humans sound is produced by the vioce box or larynx. It is the upper part of the wind pipe. Two vocal cords are stretched across the voice box leaving a narrow slit. When the lungs force air through the slit, it vibrates and produces sound.

Q. 16. How Jal Tarang produces sound?
Answer: In Jal-tarang musical instrument the cup containing minimum water produces the sound of lowest frequency or lowest pitch. As the amount of water in the cup goes on increasing, the frequency (or the pitch) of the sound produced also goes on increasing.

Q. 17. If 125 oscillations are produced in 5 seconds, what is the frequency in hertz?
Answer: in 5 seconds 125 oscillations are produced
So, in 51 seconds 125/5 = 25 oscillations are produced Hence, the frequency = 25Hz

Q. 18. What is the frequency of a vibrating body whose time-period is 0.05 second?
Answer: f = 1/t = 1/0.05 = 100/5 = 20HZ

Q. 18. State true or false
(i) Sound can be produced by beating an object irrespective of whether there are vibrations or not.
(ii)The sound of a tabla normally has a lower pitch than the sound of a violin.
(ii)A short flute will produce sound of lower pitch than a long flute.

Answer:
(i) –False [Sound is produced from a vibrating object.]
(ii) -True [The sound of a tabla normally has a lower pitch than the sound of a violin.]
(iii) –True[A short flute will produce sound of lower pitch than a long flute.]

Q.19. Give reasons Why Trees planted along the roads reduce noise?
Answer: Trees are planted along the roads and around buildings so that it could cut off sound vibrations produced from vehicles speakers etc. by absorbing them, hence leading in prevention of Noise pollution.

Q.20. what are transverse and longitudinal waves?
Answer: Longitudinal waves: A wave in which the particles of the medium vibrate

back and forth in the same direction in which the wave is moving is called longitudinal wave. Example: sound waves.
Transverse waves: A wave in which the particles of the medium vibrate at right angles to the direction, in which the wave is moving, is called transverse wave. Example: Light waves.

Q.21. Explain how bats use ultrasounds to catch a prey ?
Ans: Bats search out prey and fly in dark night by emitting and detecting reflections of ultrasonic waves. The high pitched ultrasonic squeaks of the bat are reflected from the obstacles or prey and returned to bat's ear. The nature of reflection tells the bat where the obstacle or prey is and what it is like.

Q.22. Explain how moths of certain families are able to escape capture from a bat ?
Ans: Moths of certain families have very sensitive hearing equipment. These moths can hear the high frequency squeaks of the bat and know where a bat is flying nearby and are able to escape capture.

Q. 23.How does the ear drum of human ear vibrate ?
When a compression of the medium reaches the eardrum the pressure on the outside of the membrane increases and forces the eardrum inward. Similarly the eardrum moves outward when a rarefaction reaches it. In this way the eardrum vibrates.

Q. What is the role of hammer bone, anvil bone, stirrup bone and cochlea of human ear in hearing a sound
Ans: The vibrations due to the ear drum is amplified several times by three bones in the middle ear. The pressure variations in the inner ear turned in to electrical signals by the cochlea.

Q.24. How does the stethoscope help the doctors in listening to the sound of the patients heart beat?
Ans. In a stethoscope, the sound produced within the body of a patient is picked up by a sensitive diaphragm and then reaches the doctor's ear by multiple reflections.
Q.3. Explain how defects in a metal block can be detected using ultrasound. Ans. To detect minor cracks or flaws in metal block, ultrasonic waves are allowed to pass through metal blocks and detectors are used to detect the transmitted waves. If there is a crack in metal block, these waves get reflected back

Q.25. How is ultrasound used for cleaning?

Ans. The object to be cleaned is put in a tank fitted with ultrasonic vibrator. The tank is filled with cleaning solution. As the ultrasonic vibrator is switched on, high frequency vibrations are set up and the dust, grease and dust particles get detached and the object gets thoroughly cleaned.