LONG QUESTIONS

11.1 Sound Waves:

Q.1 What is sound wave? How sound is produced? Give examples.

Sound Wave

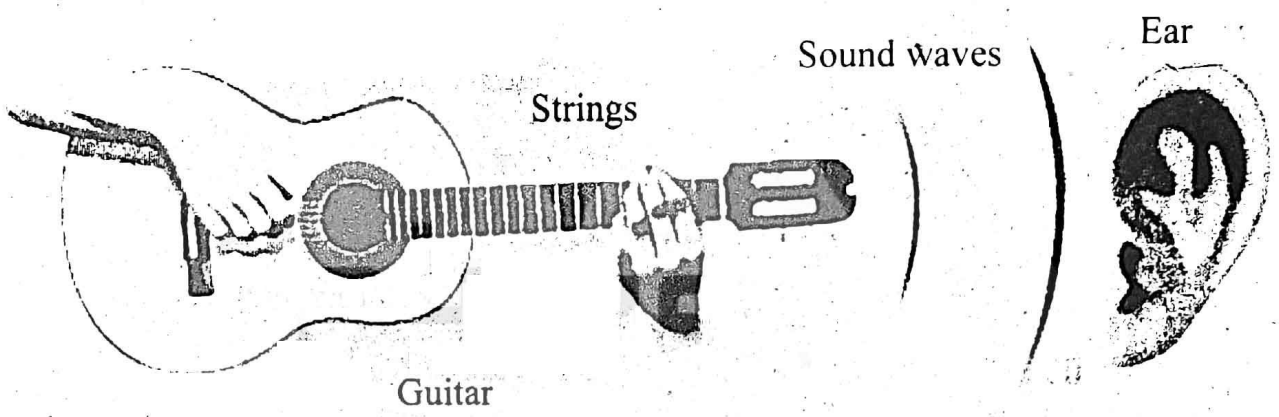
A sound wave is a pattern of disturbance caused by the movement of energy traveling through medium as it propagate away from source of sound.

Production of Sound

Like other waves sound is also produced by vibrating bodies. Due to vibration of bodies the air around them also vibrates. And the air vibration produces sensation of sound in our ear.

Examples:

- In a guitar, sound is produced due to the vibrations of its strings as shown fig (a).



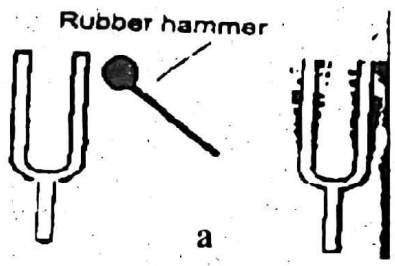
(a)

- Our voice results from the vibrations of our vocal chords.
- Human heart beats and vibrations of other organs like lungs also produce sound waves. Doctors use stethoscope to hear this sound.

Q.2 With the help of an activity make it clear that sound is produced by vibrating body.

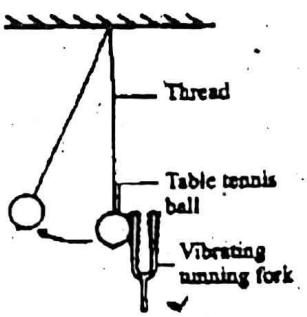
Activity:

In school laboratories, we use a device called tuning fork which produces a particular sound. If we strike the tuning fork against rubber hammer, the tuning fork will begin to vibrate as shown in fig (a).



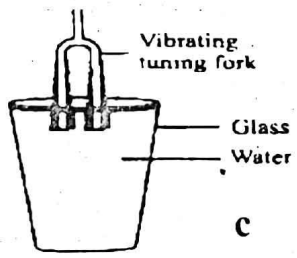
a

We can hear the sound produced by tuning fork by bringing it near our ear. We can also feel the vibration by slightly touching one of the prongs of the vibrating tuning fork with a plastic ball suspended from a thread as shown in fig (b).



b

ouch the ball gently with the prong of a vibrating tuning fork. The tuning fork will push the ball because of its vibration. Now if we dip the vibrating tuning fork into a glass of water, we will see a splash (fig c) vibrations make the water splash?



c

Conclusion:

From this activity we can conclude that sound is produced by vibrating bodies.

Q.3 With the help of an experiment, show that a material medium is required for propagation of sound.

Sound requires material medium for its propagation (Activity:)

Sound waves require some material medium for their propagation, this can be proved by bell jar apparatus (as shown in fig. a). The bell jar is placed on the platform of a vacuum pump.

An electric bell is suspended in the bell jar with the help of two wires connected to a power supply. By setting on the power supply, electric bell will begin to ring. We can hear the sound of the bell. Now start pumping out air from the jar by means of a vacuum pump. The sound of the bell starts becoming more and more feeble and eventually dies out, although bell is still ringing. When we put the air back into the jar we can hear the sound of the bell again.

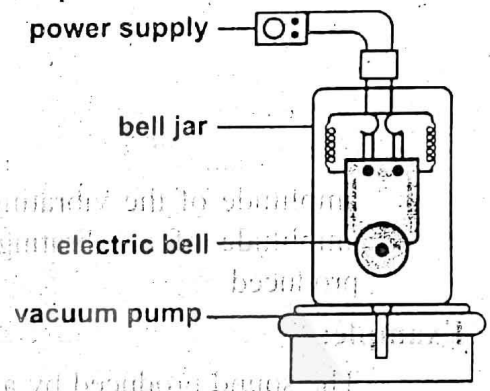


Fig. 11.5: Bell jar apparatus

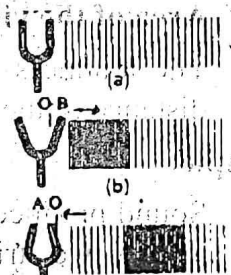
Conclusion:

From this activity we conclude that sound waves can only travel/ propagate in the presence of air (medium).

Q.4 Explain longitudinal nature of sound waves.

Propagation of sound waves produced by vibrating tuning fork can be understood by a vibrating tuning fork (as shown in fig.1).

Before the vibration of tuning fork, density of air molecules on the right side is uniform as shown in fig 1(a).



1

Vibrations of tuning fork after striking with a rubber hammer

When the right prong of tuning fork moves from mean position O to B, it exerts some pressure on the adjacent layer of air molecules and produces a compression. This compressed air layer inn turn compresses the layer next to it and so on as shown fig 1(b).

A moment later, the prong begins to move from B towards A (fig.1(c). Now the pressure in the adjacent layer decreases and a rarefaction is produced. This rarefaction is transferred to the air layer next to it and so on. As the tuning fork moves back and forth rapidly, a series of compressions and rarefactions are created in the air. In this way, sound wave propagates through the air.

Conclusion:

As in the figure the direction of propagation of sound wave is along the direction of oscillating air molecules. This shows the longitudinal nature of sound waves. Distance between two consecutive compressions or rarefactions is the wavelength of sound wave.

11.2 Characteristics Of Sound:

Q.5 Define loudness of sound and what are the factors affecting it?

Ans: Definition

"The characteristic of sound by which a loud and faint sound can be distinguished is called loudness of sound".

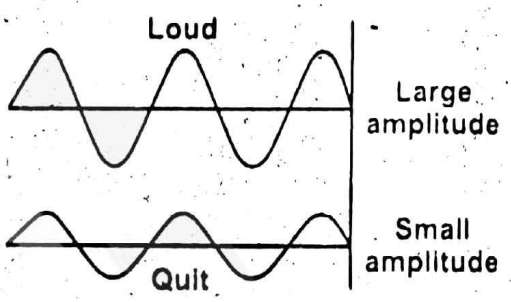
Factors affecting loudness of Sound

Following are the factors that affect the loudness of sound.

(i) Amplitude of vibrating body
(ii) Area of vibrating body
(iii) Distance from vibrating body
(iv) Physical condition of ear

(a) Amplitude of the vibrating body:

The loudness of the sound varies directly with the amplitude of the vibrating body (fig.1). The greater the amplitude of a vibrating object the louder the sound produced



Example:

The sound produced by a sitar will be loud if we pluck its wires more violently. Similarly, when we beat a drum forcefully, the amplitude of its membrane increases and we hear a loud sound.

(b) Area of the vibrating body:

The loudness of sound also depends upon the area of the vibrating body. "Lesser the distance of the listener from the vibrating body louder is the sound produced?

Example:

Sound produced by a large drum is louder than that by small one because of its vibrating area. If we strike a tuning fork on a rubber pad, a feeble sound will be heard. But if the vibrating tuning fork is placed vertically on the surface of a bench, we will hear a louder sound.

From this we can conclude that the loudness increases with the area of the vibrating body and vice versa.

(c) Distance from the vibrating body:

Loudness of sound also depends upon the distance of the vibrating body from the listener.

Example

We move away from a drum being beaten violently to avoid uncomfortably loud sound. We also experience that sound is heard to be louder if it travels in the same direction in which the wind blows. It seems to be faint if it travels in the opposite direction.
It is caused by the decrease in amplitude due to increase in distance.

Physical condition of ear

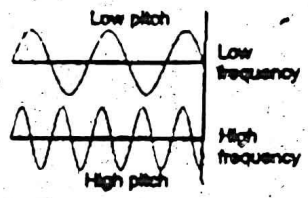
Loudness of sound also depends on the physical condition of ear. A sound appears louder to a person with sensitive ears than to a man with defective ears

Q.6 Pitch: Define pitch of the sound and explain the relation between pitch and frequency with an example?

Ans: The characteristic of sound by which a shrill sound can be distinguished from a grave one is called the pitch of the sound.

Dependence on Frequency

It depends upon the frequency, the greater the frequency, the higher the pitch and lower the frequency, the lower the pitch.



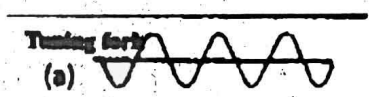
Example:

The frequency of the voice of ladies and children is greater than that of men. Therefore, the voice of ladies and children is shrill and is of high pitch as compared to men.

Q.7 What is meant by quality of sound?

Quality:

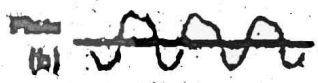
The characteristic of sound by which we can distinguish between two sounds of same loudness and pitch is called quality.



Sound wave form produce by tunning fork

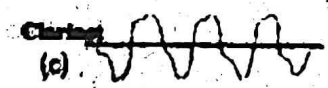
Examples:

While standing outside a room, we can distinguish between the notes of a piano and a flute being played inside the room. This is due to the difference in the quality of these notes.



Sound wave form produce by flute

Fig.1(a),(b),(c) shows the waveform of the sound produced by a tuning fork, flute and clarinet. The loudness the pitch of these three sounds are the same but their waveforms are different. So their quality is different and they can be distinguished from each other.



Sound wave form produce by clarinet

Q.8 What is intensity of sound and how you will relate intensity of sound with loudness of sound?

Ans: Intensity of sound

"Sound energy flowing per second through a unit area held perpendicular to the direction of propagation of sound waves is called the intensity of sound"

Unit

The unit of intensity of sound is watt per square meter ($\mathbf{Wm^{-2}}$). Intensity is a physical quantity and can be measured accurately.

Intensities of Faintest and Loudest sound

The intensity of faintest sound is $\mathbf{10^{-12}\ Wm^{-2}}$ and the intensity of the loudest sound, which can be heard without pain, is $\mathbf{1\ Wm^{-2}}$.

Comparison of intensity with the loudness of sound

It may be remembered that intensity of sound is a physical quantity and it does not depend on condition or sensitiveness of the ear whereas the magnitude of the sensation produced on the ear by a sound is called loudness. The loudness of a sound depends not only on the intensity of sound but also on the physical condition of the ear.

Weber Fechner Law

It has been proved experimentally loudness (L) of a sound is directly proportional to the logarithm of intensity that is given as under:

$$L \propto \log I$$

$$L = K \log I \quad \ldots\ldots\ldots\ldots (1)$$

Above equation (1) is the mathematical representation of the Weber Fechner law and K is the constant of proportionality.

If L_0 represents the loudness of the faintest audible sound of intensity I_0 and L is the loudness of an unknown sound of intensity I then equation (1) can be written as:

$$L_0 = K \log I_0 \quad \ldots\ldots\ldots\ldots (2)$$

Intensity Level or Sound Level

The difference between the loudness of any unknown sound and faintest sound $(L - L_0)$ is called the intensity level or sound level.

By subtracting equation (2) from equation (1), we have

$$\text{Sound level} = L - L_0 = K \log I - K \log I_0$$

$$\text{Sound level} = L - L_0 = K (\log I - \log I_0)$$

$$\text{Sound level} = K \log \frac{I}{I_0} \quad \ldots\ldots\ldots\ldots (3)$$

The value of K depends not only on the unit of I and I_0 but also on the unit of intensity level.

Unit of Intensity Level or Sound Level

The unit of intensity level or sound level is Bel.

Bel

If the intensity of any unknown sound is 10 times greater than the intensity I_0 of the faintest audible sound i.e. $I = 10I_0$ then the intensity level of such sound is taken as unit, called Bel.

- It is SI unit of sound level.
- Bel is very large unit of sound level.

The value of K becomes 1 in Weber Fechner law equation. By substituting K = 1, equation (3) becomes:

$$\text{Sound Level} = \log \frac{I}{I_0} \text{(Bel)} \quad \ldots\ldots\ldots\ldots (4)$$

Decibel

- Generally a smaller unit called decibel is used.
- Decibel is abbreviated as (dB).
- 1 Bel is equal to 10 dB.

If sound level is to measured in decibels then equation (4) can be written as:

$$\text{Sound Level} = 10 \log \frac{I}{I_0} \text{ (dB)} \quad \ldots\ldots\ldots\ldots (5)$$

Calculation of Sound Level of different sounds

Example 1 (Sound level of faintest audible sound)

Intensity or sound level of faintest audible sound can be calculated by substituting $I = I_0 = 10^{-12}\ Wm^{-2}$ in equation (5), we have

Sound level of faintest audible sound is $= 10\log\frac{I}{I_0} = 10\log\frac{I_0}{I_0} = 0\ (dB)$

Example 2 (Sound level of rustle of leaves)

By substituting $I = 10^{-11}$ in equation (5), we have

Sound level of rustle of leaves $= 10\log\frac{I}{I_0} = 10\log\frac{10^{-11}}{10^{-12}} = 10\ \log\ 10 = 10dB$

Example 3 (Sound level of whispering)

By substituting $I = 10^{-10}$ in equation (5), we have

Sound level of whispering $= 10\log\frac{I}{I_0} = 10\log\frac{10^{-10}}{10^{-12}} = 10\ \log\ 100 = 20dB$

Intensity level of faintest audible sound $= 10\ \log\frac{I}{I_0}$

$= 10\ \log\frac{I}{I_0}$

$= 0dB$

((b) As the intensity of the rustle of leaves is $I = 10^{-11}\ Wm^{-2}$

Therefore,

Intensity level due to rustling of leave $= 10\ \log\ 10^{-11}/10^{-12}$

$= 10\ \log 10 = 19dB$

11.3 Reflection (Echo) Of Sound:

Q.9 How reflection (Echo) of sound can be defined and explained.

OR

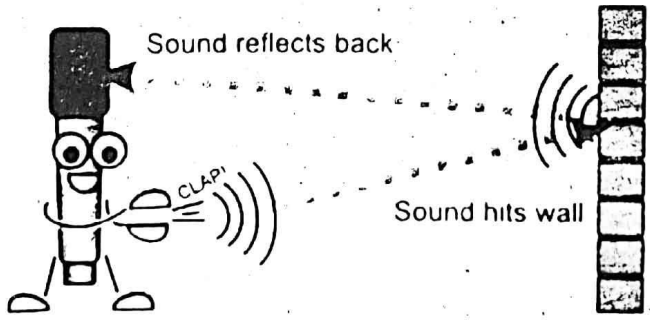
Define Echo and explain it. Also calculate minimum distance to hear Echo.

Echo:

"When sound is incident on the surface of a medium it bounces back into the first medium. This phenomenon is called echo or reflection of sound".

Explanation:

When we clap or shout near a reflecting surface such as a tall building or a mountain, we will hear the same sound again a little later. What causes this? This sound which we hear is called as echo and is a result of reflection of sound form the surface.



Minimum Distance to hear Echo:

The sensation of sound persist in our brain for about 0.1s. to hear a clear echo, the time interval between our sound and the reflected sound must beat least 0.1s. If we consider speed of sound to be 340 ms-1 at a normal temperature in air, we will hear the echo after 0.1s. The total distance covered by the sound form the point of generation to the reflecting surface and back should be at least 340 ms^{-1} × 0.1 s = 34.0 m. Thus, for hearing distance echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is 17m. Echoes may be heard more than once due to successive or multiple reflections.

11.4 Speed Of Sound:

Q.10 How can calculate speed of sound?

Sound waves can be transmitted only be any medium containing particles that can vibrate. It cannot pass through vacuum. However, the nature of the medium will affect the speed of the sound waves. In general, the speed of sound in a liquid is five times that in gases, the speed of sound in solid is about fifteen times that in gases. The speed of sound in air is affected by changes in some physical conditions such as temperature, pressure and humidity etc.

The speed of sound in air is 343 ms^{-1} at one atmosphere of pressure and room temperature (21°(C). The speed varies wit temperature and humidity. The speed of sound in solids and liquids is faster than in air. Following relation can be used to find the speed of sound.

$V = f\lambda$ ..... (11.6)

Where v is the speed, f is the frequency and λ is the wavelength of sound wave.

Measuring speed of sound by Echo Method

Q.11 How can we measure speed of sound by Echo method?

Apparatus:

measuring tape. Stopwatch, flat wall that can produce a good echo.

Procedure:

1. Use the tape to measure a distance of 50 metres form the wall.
2. Now clap you hands in front of the wall at a distance of 50 metres and check if you can clearly hear an echo form the wall. Make sure the echo is not coming from any other wall in the area. The time taken by the sound to travel 100 metres is the time difference between the clap and the echo.
3. Now restart the clapping and start the stopwatch at the first clap. Count the number of claps. And stop the clapping and the stopwatch when you hear the echo of the 10^{th} clap (say)
4. Now find the average time for 10 claps. After calculating the time interval t between claps and using the formula s = vt, we can calculate the speed of the sound.

11.5 Noise Pollution:

Q.12 What is noise pollution? Explain its sources and effects. How it is reduced?

OR

Differentiate between music and noise. Explain effects of noise and safe level of noise.

Music:

"Such sounds which are pleasant to our ears are called musical sounds."

Examples:

- We enjoy the programmes of radio or television by hearing sounds of different qualities.
- In musical programmes, we hear sound produced by musical instruments such as flute, harmonium, violin, drum etc.

  Sound of these instruments cast pleasant effect on our ears.

Noise:

"Sound which has jarring and unpleasant effect on our ears is called noise. Noise corresponds to irregular and sudden vibrations produced by some sounds."

Examples:

- Sound of machinery
- The slamming of a door,
- Sounds of traffic in big cities.

Sound of above mentioned examples cast unpleasant effect on our ears

Noise Pollution and its Sources:

Noise pollution has become a major issue of concern in big cities. Noise is a undesirable sound that is harmful for health of human and other species. The sources of noise pollution are given below.

- Transportation equipment
- Heavy machinery

These are the main sources of noise pollution. For example, noise of machinery in industrial areas, loud vehicle horns, hooters and alarms.

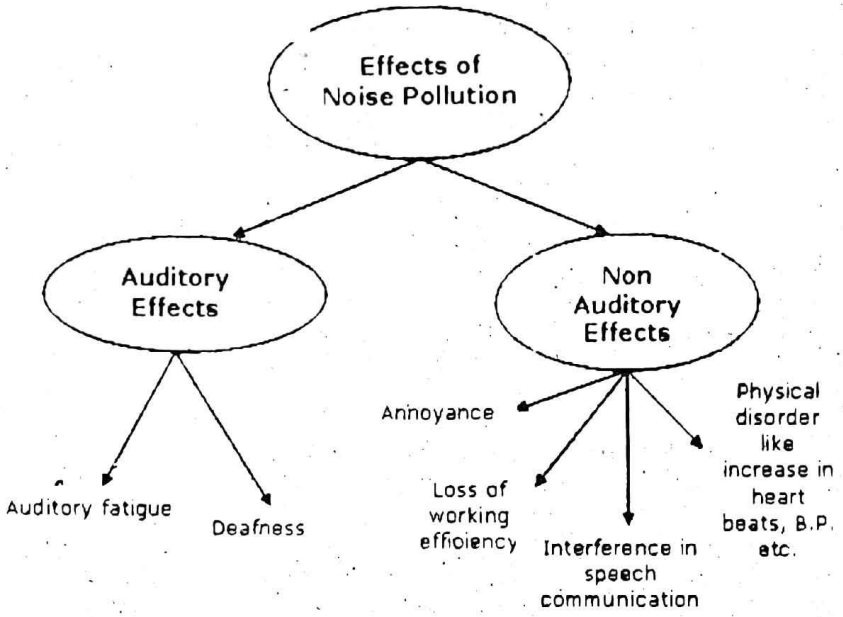
Effects of Noise:

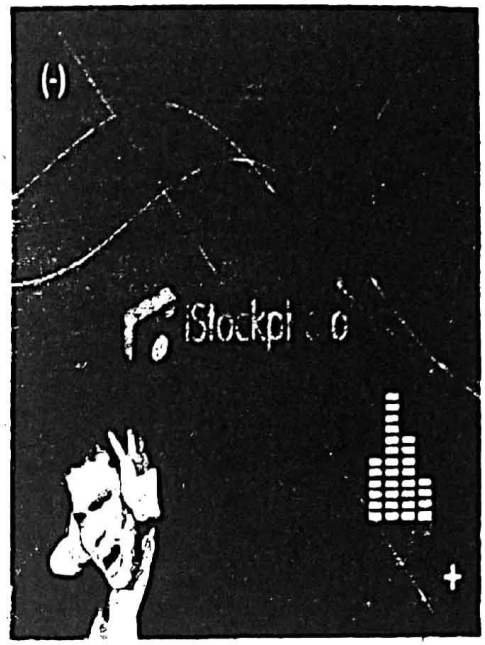
Noise has negative effects on human health as it can cause conditions such as

- Hearing loss
- Sleep disturbances
- Aggression,
- Hypertension
- High stress levels.
- Noise can also cause accidents by interfering with communication and warning signals.

Safe Level of Noise:

A safe level of noise depends on two factors: the level volume of the noise; and the period of exposure to the noise. The level of noise recommended in most countries is usually 85-90 dB over an eight hour workday. Noise pollution can be reduced to acceptable level by replacing the noisy machinery with environment friendly machinery and equipments, putting sound-reducing barriers, or using hearing protection devices.





Q.13 Define acoustics protection. Explain importance of acoustic protection.

Acoustics Protection.

"The technique or method used to absorb undesirable sounds by soft and porous surfaces is called acoustic protection."

Importance of Acoustic:

Reflection of sound is more prominent if the surface is rigid and smooth,, and less if the surface is soft and irregular. Soft porous materials, such as draperies and rugs absorb large amount of sound energy and thus quiet echoes and softening noises. Thus by using such materials in noisy places. We can reduce the level of noise pollution. However, if the surface of classrooms to public halls are too absorbent, the sound level may be low for the audience.

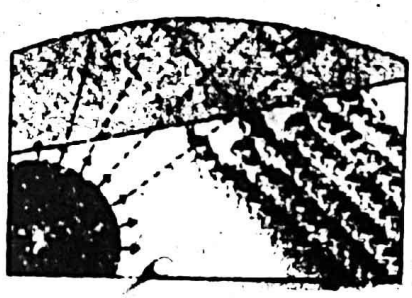
Reverberation:

When sound reflects from the wall, ceiling and floor of a room, the reflecting surfaces are too reflective and the sound becomes garbled. This is due to multiple reflections called reverberations.

In the design of lecture halls, auditorium or theatre halls, a balance must be achieved between reverberation and absorption. It is often advantageous to place reflective surfaces behind the stage to direct sound to the audience.

Curved ceiling of lecture halls:

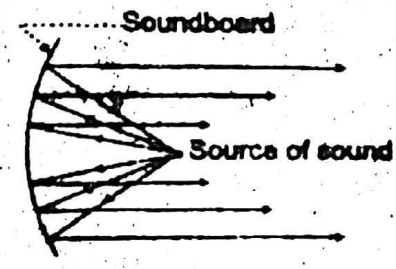
Generally the ceilings of lecture halls, conference halls and theatre halls are curved so that sound after reflection may reach all the corners of the hall (Fig a).



Curved ceiling of conference halls

Curved Sound Board:

Sometimes curved sound boards are place behind the stage so that sound after reflection distributed every across the hall (Fig. b)



Sound board used in big hall

11.6 Audible Frequency Range:

Q.14 What do you know about audible frequency range?

Audible Frequency Range:

"The range of the frequencies which a human ear can hear is called the audible frequency range."

Explanation:

We know that sound is produced by a vibrating body. A normal human ear can hear a sound only if its frequency lies between 20Hz and 20, 000 Hz, in other words, a human ear neither hears a sound of frequency less than 20Hz nor a sound of frequency more than 20,000 Hz. Different people have different range of audibility. It also decreases with age. Young children can hear sound of 20,000 Hz but old people

Cannot hear sounds even above 15,000Hz.

11.7 Ultrasound:

Q.15 What are ultrasonic? And write some of the uses of ultrasonic?

Ans: Ultrasound:

Sound of frequency higher than 20,000 Hz which are inaudible to normal human ear are called ultrasound or ultrasonic.

Why do we use ultrasonic in medical and technical field?

It has been seen that ultrasonic waves carry more energy that audible sound waves. Moreover, according to the relation $v = f\lambda$, the wavelength of ultrasonic waves is very small. Due to these characteristics they are usefully utilized in medical and technical fields. Some of the uses of ultrasonic are given as under:

A. Uses In Medical Field

For treatment of different diseases

Ultrasonic waves are being used to diagnose and treat different ailments. For diagnosis of different diseases ultrasonic waves are made to enter the human body. These waves are reflected differently by different organs, tissues, benign or malignant tumors. The reflected ultrasonic waves are then amplified and fed to a monitor which form an image of internal organs of the body which helps to detect the defects of these organs.

For diagnose purposes

Ultrasound can also be used to get the pictures of thyroid gland for diagnosis purposes.

Removal of Blood clots

Powerful ultrasonic are now being used to remove blood clots formed in the arteries.

Removal of Dirt from teeth

Ultrasonic waves are used for the scaling of teeth as their vibrations are so intense they remove easily the dirt and plaque sticking to the teeth.

Killing of Bacteria

Germs and bacteria in the liquids can be destroyed by using high intensity ultrasonics.

Removal of Kidney Stone

The kidney stones can be crushed and removed out through urine with the help of ultrasonics waves without any surgery

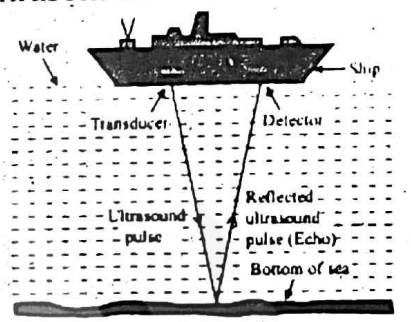
B. Use in Technical Fields

Searching of Oil and Gas

The source of oil and gas inside earth are searched by using ultrasonics.

Finding the Depth of water

Ultrasound is used to locate underwater depths or is used for locating objects lying deep on the ocean floor, etc. The technique is called SONAR, (sound navigation and ranging),. The sound waves are sent form a transmitter, and a receiver collects the reflected sound (Fig. 1 a). The time lapse is calculated, knowing the speed of sound in water, the distance of the object form the ocean surface can be estimated



Ultrasonic are used to measure depth of water by echo method (fig 1.a)

SONAR (sound navigation and ranging)

SONAR ranging is also used to see the shape and the size of the object.

Detection of Cracks

Cracks appear in the interior of moving parts of high speed heavy machines such as turbines, engines of ships and airplanes due to excessive use. These cracks are not visible form outside but they can be very dangerous. Such cracks can be detected by ultrasonic. A powerful beam of ultrasound is made to pass through these defective parts. While passing. These waves are reflected by the surface of these cracks and flaws. The comparison of the ultrasonic waves reflected form cracks and form the surfaces of these parts can give a clue of the existence of the cracks.