Sound:- Sound is a form of energy which executes in our ears the sensation of hearing. It is a longitudinal wave that is created by a vibrating object.

The word sound has two distinct meanings.

(a) Subjective or psychological meaning which refers to hearing sensation which ceases when the sound sensing organ is withdrawn from the scene.

(b) Objective or physical meaning which refers to the energy reaching the ear from outside. The energy continues to propagate even if no ear is present to detect it.

PRODUCTION OF SOUND: -

Sound is produced by vibrating bodies' .the following activity can show the production of sound:-

- Take a tuning fork and set it vibrating by striking its prong on a rubber pad. Bring it near your ear.
- Do you hear any sound?
- Touch one of the prongs of the vibrating tuning fork with your finger and share your experience with your friends.
- Now, suspend a table tennis ball or a small plastic ball by a thread from a support [takes a big needle and a thread, put a knot at one end of the thread, and then with the help of the needle pass the thread through the ball]. Touch the ball gently with the prong of a vibrating tuning fork.
- Observe what happens and discuss with your friends.

PROPAGATION OF SOUND:-

Sound is produced in vibrating objects. The matter or substance through which sound is transmitted is called a medium. It can be solid, liquid or gas. Sound moves through a medium form the point of generation to the listener. When an object vibrates, it sets the particles of the medium around it vibrating. The particles do not travel all the way from the vibrating object to the ear. A particle of the medium in contact with the vibrating object is first displaced from its equilibrium position. It then exerts a force on the adjacent particle. As a result of which the adjacent particles gets displaced from its position of rest. After displacing the adjacent particle the first particle comes back to its original position. This process continues in the medium till the sound reaches your ear.

The disturbance created by a source of sound in the medium travels through the medium and not the particles of the medium. A wave is a disturbance that moves through a medium when the particles of the medium set neighbouring particles into motion. They in turn produce similar motion in others. The particles of the medium do not move forward them selves , but the disturbance is carried forward .this is what happens during propagation of sound in a medium , hence sound can be visualized as a wave. Sound waves are characterized by the motion of particles in the medium and are called mechanical wave. Air is the most common medium through which sound travels. When a vibrating object moves forward, it pushes and compresses the air in front of it creating a region of high pressure. This region is called a compression (C). This compression starts to move away from the vibrating object. When the vibrating object. Moves backwards, it creates a region of low pressure called rarefaction (R). As the object moves back and forth rapidly, a series of compressions and rarefactions is created in the air. These make the sound wave that propagates through the medium. Compression is related to the number of particles of a medium in a given volume. More density of the particles in the medium gives more pressure and vice versa. Thus, propagation of sound can be visualized as propagation of density variations or pressure variations in the medium.

PITCH:-

The property by virtue of which our brain can distinguish between the deep (bass) sound and the sharp sound is called pitch. The pitch of the sound is determined by the frequency of sound. It has been found that

LOUNDNESS:

The loudness of sound is determined by the amplitude of its wave. The more is the amplitude, the louder is the sound. That is the reason when we hit a table with a spoon lightly, a soft sound is produced, but when we hit it with a large force, a loud sound is produced. The loud sound has more energy and can travel through longer distance as compared to less loud sound. The loudness is basically the effect produced in the brain by the sound of different frequencies.

Timber or Quality: The property by virtue of which two sounds of same pitch and same loudness can be distinguished from on another is called timbre or quality of sound. The quality of sound is produced because of the change in wave form.

Intensity of sound :- The intensity of a sound is defined as the amount of sound energy passing through a unit area per second.

$$\text{Intensity of sound} = \frac{\text{Energy}}{\text{Area x Time}}$$

DIFFERENCE BETWEEN LOUDNESS AND PITCH:-

Loudness	Pitch
1. It is amplitude dependent.	It is frequency dependent.
2. It results in a heavy voice.	It gives a shrill effect to the voice.
3. It transfers more energy to the eardrum.	It does not depend upon the energy transferred to the eardrum.
4. It does not control bass in music.	It controls basin music.
5. Men have a heavy voice due to loudness.	Women have a sharp voice due to pitch.

REFLECTION OF SOUND:-

Sound waves get reflected when these falls on the surface of an obstacle. The following experiment shows that sound shows reflection.

Experiment:-

(i) Place a large plane board, AB (of a metal, cardboard or wood) in the vertical position (i.e., perpendicular to the plane of the paper).

(ii) Take two hollow metallic tubes P and Q (each about 1 m long and about 8 to 10 cm in diameter) and place them in the plane of the paper and in positions inclined to the board.

(iii) Hold a small watch W at the free end of the tube P and try to hear the ticking sound of the watch by positioning the ear at E.

(iv) Put a cardboard screen S in between the two tubes so that the sound produced by the watch does not reach the ear directly.

(v) Turn the tube Q till the ticking sound of the clock is the loudest. In this position, it is found that the tubes are inclined to S at the same angle, i.e., I (angle of incidence of sound wave) = r (angle of reflection of the sound wave).

(vi) If the tube Q is lifted slightly vertically upwards, no sound is heard, this implies that the reflected sound wave (OE) lies in the same plane (i.e., the plane of the paper) as the incident sound wave.

The normal OS to the surface lies in the same plane as that in which the incident and reflected sound waves lie.

From this experiment, we obtain the following two laws for the reflection of sound waves. These laws are as follows.

First Law. The angle of reflection (r) is always equal to the angle of incidence (i), i.e.,

$$\angle r = \angle i \text{ Or } i=r.$$

Second Law. The incident wave, the reflected wave and the normal (at the point of incidence), all lie in the same plane.

USES OF REFLECTION OF SOUND:-

It is not that reflection of sound produces echoes only. It has various useful applications as well.

1. ***Stethoscope:*** You must have seen a stethoscope around a doctor's neck. Doctors use it to hear the sounds produced by various body parts (i.e., within the body), for example, heart and lungs. The sound from a patient's body parts reaches the doctor's ears through a connecting tube. The diaphragm connected at one end of the stethoscope picks up the body sound. The sound undergoes multiple reflections along its passage through the tube.
2. ***Curved Ceilings of Auditoriums***: Often the ceilings of auditoriums, concert halls and cinema halls have curved and polished surfaces. The polished surface reflects sound and the curved shape helps in making the sound available in each part of the auditorium.
3. ***Curved sound Boards at the Back of a Source of Sound:*** A sound board is a concave board which is used for evenly spreading sound in a big hall. The sound board is placed such that the person speaking (the source of sound) is at its focus. After reflection from the sound board, sound waves become parallel and are spread evenly towards the audience throughout the hall. Thus, even a person sitting at the end of the hall is able to hear the speaker clearly.
4. ***Megaphones, Horns and Loudspeakers:*** megaphones, horns (in cars, buses, etc.) and loudspeakers propagate sound in a particular direction. These instruments are specially designed with a conical opening in front of a small tube. Multiple reflections of sound from the conical part help in guiding the sound in a particular direction towards the audiences. These objects are used to address small gathering of people.
5. ***Musical Instruments and Mouth Cavity***: various musical instruments, like flute, shehnai, trumpet, and saxophone have shapes which help in guiding the out coming sound in a particular direction by the use of multiple reflections. In fact, the shape of our mouth cavity also helps in propagating the sound in a particular direction by multiple reflections.

ECHO :-

An echo is the phenomenon of repetition of sound of a source by reflection from an obstacle.

To distinguish an echo from the original sound, the obstacle must be situated at a suitable distance from the source of sound. This depends upon the type of sound produced, which may be simple or articulate.

(a) SIMPLE SOUND:

The sound produced by the tick of a clock, firing of a shot or thumping of a table is called simple sounds. The sensation of such sounds lasts in our brain for one-tenth of a second. This property is called the persistence of hearing. Therefore, to hear a distinct echo of a simple sound, the time taken by this sound to reach the listener after reflection should be $1/10^{th}$ of a second.

Let d = minimum distance of a reflector from the source

V = velocity of sound in air at the room temperature

T = total time taken by sound to reach the listener after reflection.

As total distance travelled = velocity x total time, Therefore we have

$$t = \frac{\text{Total distance travelled}}{\text{Speed of sound}} = \frac{2d}{v}$$

Put t = 0.1 s and velocity of sound at room temperature as 340 ms^{-1}, therefore the minimum distance d for an echo to be formed is

$$d = \frac{V \times t}{2} = \frac{340 \times 0.1}{2} = 17 \text{ m}$$

Thus to hear the echo for a sound distinctly, the reflecting surface should be at a minimum distance of 17 m from the observer. The minimum distance is not a constant because the velocity of sound changes with the change in temperature.

(b) ARTICULATE SOUND :-

The sound produced by human begins is called articulate sound . a person can neither utter nor hear distinctly more than five syllables in one second. Therefore for an echo to be formed the reflected sound should reach the ear at least 0.2 second after the original sound. Hence distance from an echo to be formed

$$d = \frac{V \times t}{2} = \frac{340 \times 0.2}{2} = 34 \text{ m}$$

REVERBERATION:-

When a sharp sound is made in a hall, the listener cannot hear it as such .it is found to get prolonged. The intensity of sound first reaches a maximum and then falls till it becomes inaudible. This happens on account of a number of reflections of sound from different parts of the hall. The sound energy goes on decreasing with successive reflections (till it is no longer audible). It is interesting to note that a sound wave suffers 300 reflections in a room of ordinary size before becoming inaudible. The phenomenon of persistence or prolongation of audible sound after the source has stopped emitting sound is called reverberation. The time for which reverberation persists until it becomes inaudible is called reverberation time.

HOW IS REVERBERATION REDUCED?

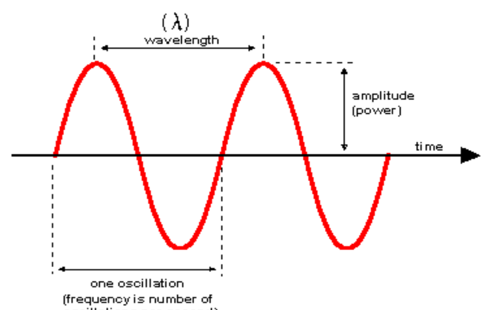
Since reverberation is due to repeated reflections of sound waves from the ceiling, floor, walls etc. of a hall or an auditorium, we can reduce it by increasing the absorption of sound energy. To achieve this:

(i) The walls are covered with some sound absorbing material like felt, fiber board, glass wool etc. or by heavy curtains with folds.
(ii) The floor is carpeted.
(iii) The furniture is upholstered.
(iv) False ceiling of a suitable sound absorbing material is used.

WAVELENGTH (W):

The linear distance between consecutive particles in the same phase of and oscillating medium is called Wavelength.

Wavelength is denoted by letter lambda ( ). In the above fig., the linear distance between the particles B and F or D and H or E and I represents wavelength Unit of Wavelength: Its unit in S.I system is metre (m).



AMPLITUDE:-

The maximum displacement of an oscillating particle about its mean position is called its Amplitude. In the above fig., BK or DL represents the amplitude of the motion. Units of amplitude: It is measured in Metres in S.I. system.

FREQUENCY:-

The number of oscillations executed by an oscillating particle of a medium about its mean position in one second is called the frequency of the wave motion.

OR

The number of waves passing through one particular point in a medium in one second is called the frequency of the wave motion. Frequency is denoted by letter (f). Units of Frequency: The unit of frequency in S.I. System is hertz (Hz).

1 Hz / Second = 1 wave

When one wave passes through a point in one second or when the particle of a medium completes one oscillation in one second, the frequency is said to be 1 Hz.

TIME PERIOD (T):-

The time required by an oscillating particle to complete one oscillation is called the Time Period.

OR

The time in which one complete wave passes through a point is called the time period. Time period is denoted by letter T and its Unit is Second.

WAVE VELOCITY:-

The distance covered by a disturbance in any particular medium is called its Wave Velocity in that medium. It is denoted by the letter V. Its unit in S.I. System is m/s.

LONGITYDINAL WAVES:-

When the particles of a medium oscillate in same direction in which the wave is being propagated, then the wave so formed is called a longitudinal wave.

Examples of Longitudinal Waves:

A long and light spring attached to hook in a wall and held horizontally, such that there is no tension in the spring.

When this spring is pushed towards the wall and then pulled away from the wall rapidly (above fig.), there appear regions, where the coils of the spring come very close. These regions where the coils of the spring come closer than normal are called compressions and denoted by C. Conversely, there appear regions where the coils of the spring are farther apart. These regions where the coils of the spring are farther apart than normal are called rarefactions and denoted by R.

2. The sound waves produced in air is an example of longitudinal wave. When the sound wave propagates through air, the particles of air oscillate in the direction of wave propagation, with the result the regions of compressions and rarefactions are formed in the air which alternate with one another. Thus, sound energy moves outward.

COMPRESSIONS AND RAREFACTIONS OF LONGITUDINAL WAVES:-

Compression:- A part of a longitudinal wave in which particles of air are closer to one another than normal, such that there is a momentary decrease in volume and increase in pressure is called the region of compression.

Rarefactions: A part of a longitudinal wave in which particles of air are farther away from one another than normal, such that there is a momentary increase in volume and decrease in pressure is called the the region of faction.

Compressions & Rarefactions in Longitudinal Wave

CHARACTERISTICSS OF LONGITUDINAL WAVES:-

i) They consist of compressions and rarefactions

ii) If T seconds is the time period of a longitudinal wave, then compression formed at a point alternates with rarefaction after T/2 seconds.
iii) The particles of a medium vibrate along the direction of propagation of the wave.
iv) The regions of compression have lesser volume, more pressure and higher density, whereas the regions of rarefaction have more volume, less pressure and lower density.
v) The longitudinal waves can propagate in all kinds of media, i.e., solids, liquids and gases.
vi) The wave velocity of a longitudinal wave in liquids and solids depends upon the density and the elasticity, and in case of gases, on the density and the pressure of the medium.

RELATION SHIP BETWEEN SPEED, FREQUENCY, AND WAVELENGTH:-

If a sound wave travels a distance'λ' (wavelength of the wave) in time 'T' (time period of the wave), then the speed of the sound wave 'v' is given by

$$V = \frac{\lambda}{T}$$

Since frequency of the sound wave is given by $V = \frac{1}{T}$ thus, on substituting this in the above equation we have

$$V = \nu\lambda$$

Thus, speed, frequency and wavelength of a sound wave are related as

Speed of sound wave (v) = Frequency (ν) x wavelength (λ)

INFRASONIC SOUND :-

Any sound with a frequency below the minimum audible frequency of 20 Hz is known as an infrasound or infrasonic sound. Human beings can not hear infrasonic sounds.

Examples of Infrasonic Sound:

- Vibration of a pendulum (a bob suspended from a thread) produces infrasonic sound.
- Whales also produce sounds in infrasonic range.

ULTRASONIC SOUND :-

Any sound with a frequency above the maximum audible frequency of 20 kHz is known as an ultrasound or ultrasonic sound. Human beings cannot hear ultrasonic sounds. The speed of ultrasound waves does not depend on their frequencies. Ultrasound waves travel faster in dense materials and slower in compressible materials.

Examples of Ultrasonic Sound:

- Bats are nearly blind; however, they rely on ultrasound waves for navigation (avoid obstacles on their way) and catching prey. Bats can produce and detect sounds of high pitch upto 1, 20,000 Hz.
- Children under the age of five years too can hear ultrasound wave's upto 25 kHz.

APPLICATIONS OF ULTRASOUND:-

Ultrasounds are high frequency waves. Ultrasounds are able to travel along well defined paths even in the presence of obstacles. Ultrasounds are used extensively in industries and for medical purposes.

i) Ultrasound is generally used to clean parts located in hard-to –reach places, for example, spiral tube, odd shaped parts, electronic components etc.
ii) Ultrasounds can be used to detect cracks and flaws in metal blocks, metallic components are generally used in construction of big structures like buildings, bridges, machines and also scientific equipment. The cracks or holes inside the metal blocks, which are invisible from outside reduces the strength of the structure. Ultrasonic waves are allowed to pass through the metal block and detectors are used to detect the transmitted waves. If there is even a small defect, the ultrasound gets reflected back indicating the presence of the flaw or defect.
iii) Ultrasound scanner is an instrument which uses ultrasonic waves for getting images of internal organs of the human body. A doctor may image the patient's organs such as the liver, gall bladder, uterus, kidney, etc. it helps the doctor to detect abnormalities, such as stones in the gall bladder and kidney or tumours in different organs.

iv) Ultrasound may be employed to break small 'stones' formed in the kidneys into fine grains. These grains later get flushed out with urine.

SONAR:-

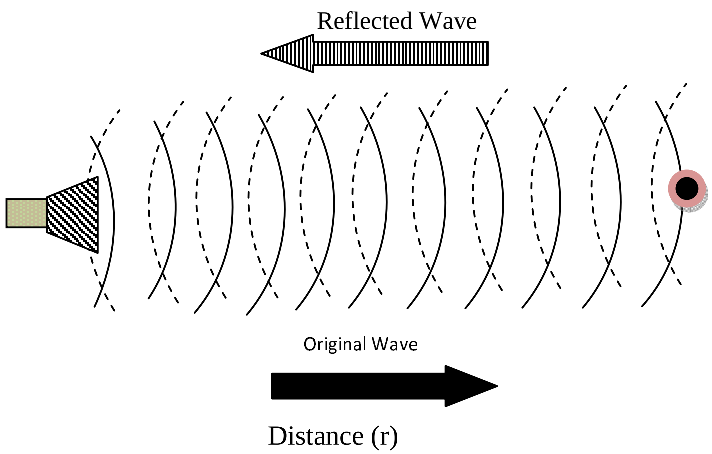
SONAR is an acronym for **S**ound **N**avigation and ranging. It is an apparatus or device that uses the principle of reflection of ultrasound waves or detect the presence of underwater objects and determine their distance (i.e., range) as well as speed and direction of motion (i.e., navigation).

Some common uses of SONAR are:-

1. Detecting enemy submarines
2. Determining sea depth
3. Finding fish
4. Finding ship wrecks
5. Locating underwater pipelines, icebergs, valley and hills
6. Mapping ocean floor
7. Ship to ship communication

WORKING PRINCIPLE OF SONAR :-

SONAR consists of an Ultrasound transmitter (sender) and a detector (or receiver). Usually, it is fitted at the bottom of a ship or boat. The transmitter produces and transmits high frequency ultrasound waves into water in search of an object. When these waves strike an object, they are reflected back. The detector collects the reflected waves. (The reflected waves are actually the echoes of the transmitted waves.) The reflected ultrasound waves are converted into electrical signals by appropriate devices. The electrical signals are then correctly interpreted to provide the required information regarding the distance, speed and direction of motion of the object.



working principle of SONAR

MEASUREMENT OF DISTANCE OF UNDERWATER OBJECTS :-

Let us assume that the underwater object as at a distance 'r' from the SONAR. If't' is the time taken by the ultrasound waves to travel from transmitter to the object and back to the detector and 'v' is the speed of ultrasound wave in water , then total distance travelled by the ultrasound wave in time 't' is '2r' . Thus, using the formula, Distance= Speed x Time, we have

$$2r = v \times t \text{ or } r = \frac{v \times t}{2}$$

Thus, distance of underwater object = $\frac{\text{Speed of ultrasound wave in water x Time taken}}{2}$

This equation can be used to find the distance of the underwater objects. This method of measuring distances of under water objects is called echo-ranging, as it is based on recording an echo. This technique can be used to determine the depth of seabed, underwater hills, valleys, submarines, icebergs, sunken ships, large fish colonies, Using the objects at known distances, the above equation can also be used to measure the speed of ultrasound waves in water.

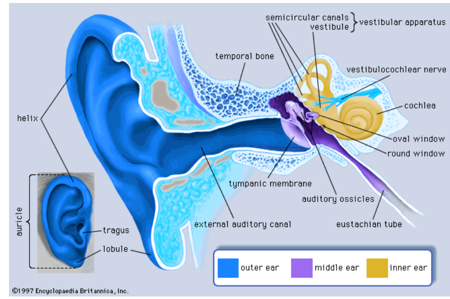
$$\text{Speed of ultrasound wave in water} = \frac{2 \times \text{Distance of underwater object}}{\text{Time taken}}$$

STRUCTURE OF HUMAN EAR :-

Ears act as receiver or detector of sound. The sounds received in the form of pressure variations in air are converted into electrical signals within the ear which on reaching our brain produce a sense of hearing.

The human ear can be considered to consist of the following three parts:

i) Outer ear,
ii) Middle ear, and
iii) Inner ear.



Outer Ear: The outer ear looks complicated but it is functionally the simplest part of the ear. It consists of the 'pinna' or auricle (the visible projecting portion of the ear), the external acoustic meatus (the outside opening to the ear canal), and the external ear canal that leads to the ear drum. In sum, there is the pinna, the meatus and the canal. That's all. The outer ear concentrates air vibrations on the ear drum and makes the drum vibrate. The outer ear is also called the external ear.

Middle Ear: The middle ear consists of an eardrum or tympanic membrane connected at he end of the auditory canal. The eardrum is a thin, tightly stretched membrane, also known as sheet ('***kaan ka parda***' in Hindi). The eardrum vibrates when compressions and rarefactions of sound wave hit it. A compression exerts an inward pressure on the outer surface of the eardrum. This forces the eardrum to move inward. However, a rarefaction does the opposite and moves the eardrum outwards. Hence, the eardrum is made to vibrate by the successive compressions and rarefactions.

The vibration of eardrum produces pressure variations within the middle ear. The three bones (hammer, anvil and stirrup) present in the middle ear amplify these pressure variations by several times. The middle ear then transmits the sound wave's amplified pressure variations to the inner ear.

Inner Ear: The inner ear has a job to convert the sound wave's amplified pressure variations into electrical signals. This work is done in the inner ear by cochlea, a snail-shaped organ. The cochlea is filled with a water-like fluid and its inner surface has large number of hair-like nerve cells. The amplified pressure variations produce vibrations in the nerve cells and they in turn release electrical impulses. The electrical impulses are transmitted to the brain along the auditory nerve. The brain interprets thee electrical impulses through a complex process, as sounds.