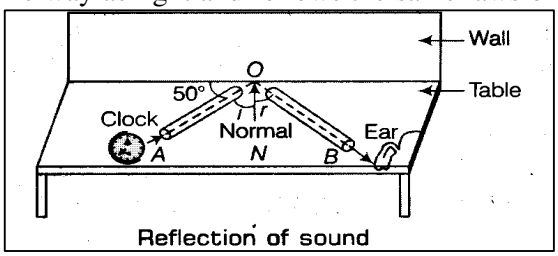
Reflection of sound wave: Like light, sound can also be made to change its direction and bounce back when it falls on a hard surface. The bouncing back of sound when it strikes a hard surface is known as reflection of sound. The reflection of sound does not require a smooth and shining surface like that of mirror, it can be reflected from any surface whether it is smooth or rough. Sound is reflected in the same way as light and follows the same laws of reflection, which are as follows:

1. The incident sound wave (AO), the reflected sound wave (OB) and the normal (ON) at the point of incidence, all lie in the same plane.
2. The angle of incidence (<AON) of sound is equal to the angle of reflection (<NOB) of sound.



Reflection of sound

Echo: When a person shouts in a big empty hall, we first hear his original sound, after that we hear the reflected sound of that shout. This reflected sound is an echo. An echo is nothing but just the reflected sound. So, the repetition of sound caused by reflection of sound waves is called an echo. The sensation of sound persists in our brain for about 0.1 s. To hear a distinct echo, the time interval between the original sound and the reflected one must be atleast 0.1 s. The speed of sound in air is 344 m/sec. The distance travelled by the sound in 0.1 s = speed x time = 344 x 0.1 = 34.4 m

So, echo will be heard, if the minimum distance between the source of sound and the obstacle is = 34.4 /2 m = 17.2 m. To hear an echo, our distance from the reflecting surface should be atleast 17.2 m. This distance will change with the change in temperature. Echoes may be heard more than once due to successive multiple reflections. The rolling of thunder is due to successive reflections of sound from a number of reflecting surfaces, such as clouds and the land.

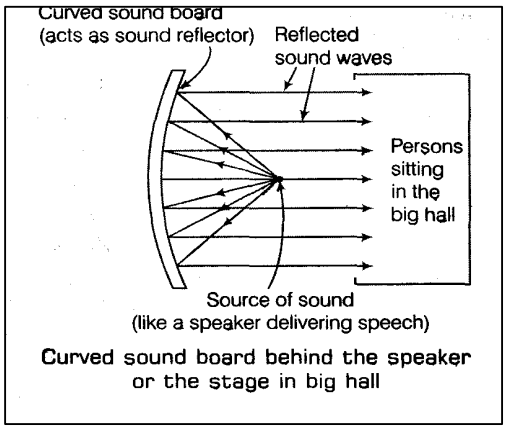
Reverberation: The persistence of a sound in a big hail due to repeated reflections from the walls, ceiling and floor of the wall is known as reverberation. A short reverberation is desirable in a concert hall, where music is being played, as it boosts the sound level. But excessive reverberation is highly undesirable because sound becomes blurred, distorted and confusing due to overlapping of different sounds. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound absorbent materials like compressed fibre board, rough plaster or draperies. The seat materials are also selected on the basis of their sound absorbing properties.

Uses of Multiple Reflection of Sound: The reflection of sound is used in the working of devices such as megaphone, horns, stethoscope and sound board. These devices involve multiple reflections of sound waves.

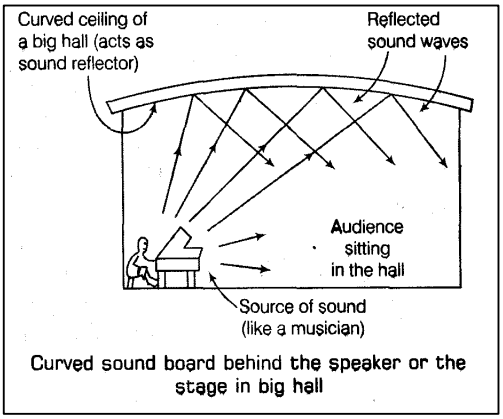
1. Megaphone and Horn: Megaphone is large cone shaped device used to amplify and direct the voice of a person who speaks into it. A horn is a cone shaped instrument used for signalling in bicycles, cars, buses, etc. When a person speaks into the narrow end of the megaphone tube, the sound waves produced are prevented from spreading by successive reflections from the wider end of the megaphone tube, hence sound of his voice can be heard over a longer distance.

2. Stethoscope: It is a medical instrument used by doctors to listen the sound produced within the heart and the lungs in human body. The sound of heart beats (or lungs) reaches the doctors ears by the multiple reflections of sound waves through the stethoscope tube.

3. Sound Board: It is a concave board (curved board) placed behind the stage in big halls, so that sound after reflecting from sound board, spreads evenly across the width of the hall.



Curved sound board behind the speaker or the stage in big hall



Curved sound board behind the speaker or the stage in big hall

Generally, the ceilings of the concert halls, conference halls and cinema hails are curved, so that sound after reflection reaches all corners of the hail.

Range of hearing: The average frequency range over which the human ear is sensitive is called audible range. The audible range of sound for human beings is from 20 Hz to 20,000 Hz. Children under the age of 5 and some animals such as dogs can hear up to 25000 Hz. As people grow older, their ears become less sensitive to higher frequencies.

Infrasonic Sound: The sound of frequencies lower than 20 Hz are known as infrasonic sounds or infrasound, which cannot be heard by human beings. Earthquakes and some animals like whales, elephants and rhinoceroses produce infrasonic sound of frequency 5 Hz. It is observed that some animals get disturbed and start running here and there just before the earthquakes occur. This is because earthquakes produce low frequency infrasound before the main shock waves begin which possibly alert the animals and they get disturbed.

Ultrasonic Sound: The sounds of frequencies higher than 20000 Hz are called ultrasonic sounds or ultrasounds which cannot be heard by human beings. Dogs can hear ultrasonic sounds of frequency to 50,000 Hz. This is why dogs are used for detective work by the police. Monkeys, bats, cats, dolphins, leopard and porpoises can also hear ultrasonic sounds.

Hearing Aid: This is a device used by people who are hard of hearing. It is an electronic, battery operated device. It receives sound through a microphone which converts the sound waves to electrical signals. These electrical signals are amplified by an amplifier. The amplified electrical signals are given to a speaker of the hearing aid. The speaker converts the amplified electrical signals to sound and then sends it to the ear for clear hearing.

Ultrasound and its Applications: Ultrasounds are high frequency waves. They travel in straight line without bending around the corners. They can penetrate into matter to a large extent. Due to these properties, ultrasound is used in industry and in hospitals for medical purposes. Some of the important applications of ultrasound are given below:

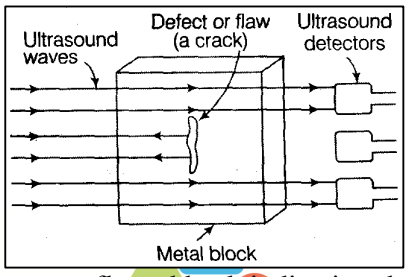
1. In Cleaning Minute Parts of Machines: Ultrasound is used to clean parts located in hard-to-reach-places, such as spiral tubes, odd-shaped machines and electronic components, etc. Objects to be cleaned are placed in a cleaning solution and ultrasonic waves are sent into the solution. Due to their high frequency, the ultrasound waves stir up the solution, hence the particles of dust, grease and dirt vibrate too much, become loose, get detached from the object and fall into solution. The objects, thus get thoroughly cleaned.

2. In Internal Investigation of Human Body: Ultrasound is used to investigate the internal organs of human body such as liver, gall bladder, pancreas, kidneys, uterus and heart, etc. Ultrasound waves can penetrate the human body and different types of tissues and get

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

reflected in different ways from a region where there is a change of tissue density. In this way, ultrasound helps us to see inside the human body and to give pictures of the inner organs by converting into electrical signals. These pictures or images are then displayed on a monitor or printed on a film. This technique is called ultrasonography. **Ultrasonography** is used for the examination of foetus during pregnancy to detect any growth abnormalities, which helps in taking the necessary action to rectify the abnormalities. **Ultrasonic scanner** is an instrument that helps the doctor to detect abnormalities, such as stones in the gall bladder and kidney or tumours in different organs and many other ailments. Ultrasound is also used for diagnosing heart diseases by scanning the heart from inside. This technique is echocardiography. Ultrasound may be employed to break small stones formed in the kidneys into fine grains which later get flushed out with urine. This way, the patient gets relief from pain.

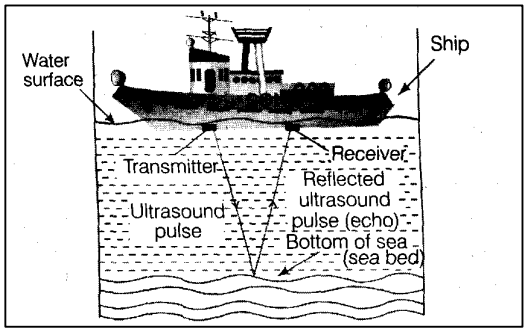
3. <u>In Industries</u>: Ultrasound is used in industry for detecting flaws (cracks, etc.) in metal blocks without damaging them. Metal blocks are used in the construction of big structures like bridges, machines and scientific equipment, etc. If there are some cracks and flaws in the metal blocks, which are invisible from outside reduces the strength of the structure. These can be detected by using ultrasound. This is based on the fact that an internal crack (or hole) does not allow ultrasound to pass through it. It reflects the ultrasound. Ultrasound waves are allowed to pass through one face of metal block (to be tested) and detectors are placed on the opposite face of the metal block to detect the transmitted ultrasound waves. If there is even a small defect, the ultrasound waves gets reflected back indicating the presence of the flaw or defect. Ultrasound reflected from a part of block, which shows that this metal block has a flaw or defect (like a crack) inside it. Ordinary sound waves cannot be used for detecting the flaws in metal blocks because they will bend around the corners of the defective location and therefore enter the detector.



<u>Use of Ultrasonic Waves by Bats:</u> Bats search out prey and fly in dark night by emitting and detecting reflections of 'ultrasonic waves. The method used by some animals like bats, tortoises and dolphins. The method used by some animals like bats, tortoises and dolphins to locate the objects by hearing the echoes of their ultrasonic squeaks is known as echolocation. Bats emit high frequency or high pitched ultrasonic squeaks while flying and listen to the echoes produced by reflection of their squeaks from the obstacles or prey in their path. From the time taken by the echo to be heard, bats can determine the distance of the obstacle or prey and can avoid the obstacle by changing the direction or catch the prey. However, certain moths can hear the high frequency ultrasonic squeaks of a bat and can know where the bat is flying nearby and are able to escape from being captured.

<u>SONAR:</u> The word SONAR stands for Sound Navigation And Ranging. Sonar is an apparatus used to find the depth of a sea or to locate the underwater things like shoals of fish, shipwrecks and enemy submarines. It uses ultrasonic waves to measure the distance, direction and speed of underwater objects. SONAR consists of two parts:

1. a transmitter (for emitting ultrasonic waves)
2. a receiver (for detecting ultrasonic waves)



The transmitter produces and transmits ultrasonic wav. These waves travel down the sea-water towards the bottom of the sea. When the ultrasonic sound pulse strikes t bottom of the sea, it is reflected back in the form of echo aid are sensed by the detector. The detector converts the ultrasonic waves into electrical signals which are appropriately interpreted. The distance of the object that reflected the sound wave can be calculated by knowing the speed of sound wave in water and the time interval between transmission and reception of the ultrasound. This will give us the depth of the sea. Let the time interval between transmission and reception of ultrasound signal be 't' and the speed of sound through sea-water be 'v;. The total distance, 2d travelled by the ultrasound is, then

2d = v x t This method is called echo-ranging. Sonar is used determine the depth of the sea and to locate underwater hills, valleys, submarine, ice-bergs, sunken ship, etc.

Q2. A submarine produces the ultrasonic waves of velocity 1500 m/sec in water. The officer receives signal after 50 s of emission of ultrasonic waves. Find the distance of object which is present at the bottom of sea. [37.5 km]

Q3. Using the SONAR, sound waves are emitted at the surface of water, which after being reflected from bottom of water, are detected. If the time interval from the emission to the detection of the sound waves is 4 s. Calculate the depth of the water. (Speed of sound in water is 1450 m/sec). [2900 km]

Q4. In a submarine, equipped with a SONAR, the time interval from the emission to the detection of the sound pulse is found to be 77 s. What is the distance of enemy submarine? [Speed of sound in water is 1450 m/sec]. [55825 m]

HUMAN EAR: The ears are the sense organs which helps us in hearing sound. It allows us to convert pressure variations in air with audible frequencies into electric signals which travel to the brain via auditory nerve. The ear consists of three compartments: Outer ear, Middle ear and Inner ear.

1. Outer Ear: The part of ear which we see outside the head is outer ear. It consists of a broad part pinna and about 3 cm long passage ear canal. At the end of ear canal, a thin, elastic and circular membrane, eardrum is present, which is also called tympanum or tympanic membrane.

2. Middle Ear: contains three small bones- hammer, anvil and stirr up, which are connected with each other. One end of hammer is touching the eardrum and the free end of stirr up is touched to oval-window of inner ear. The lower part of middle ear has a narrow tube called eustachian tube going to the throat. It ensures that the air pressure inside the middle ear is the same as that on the outside.

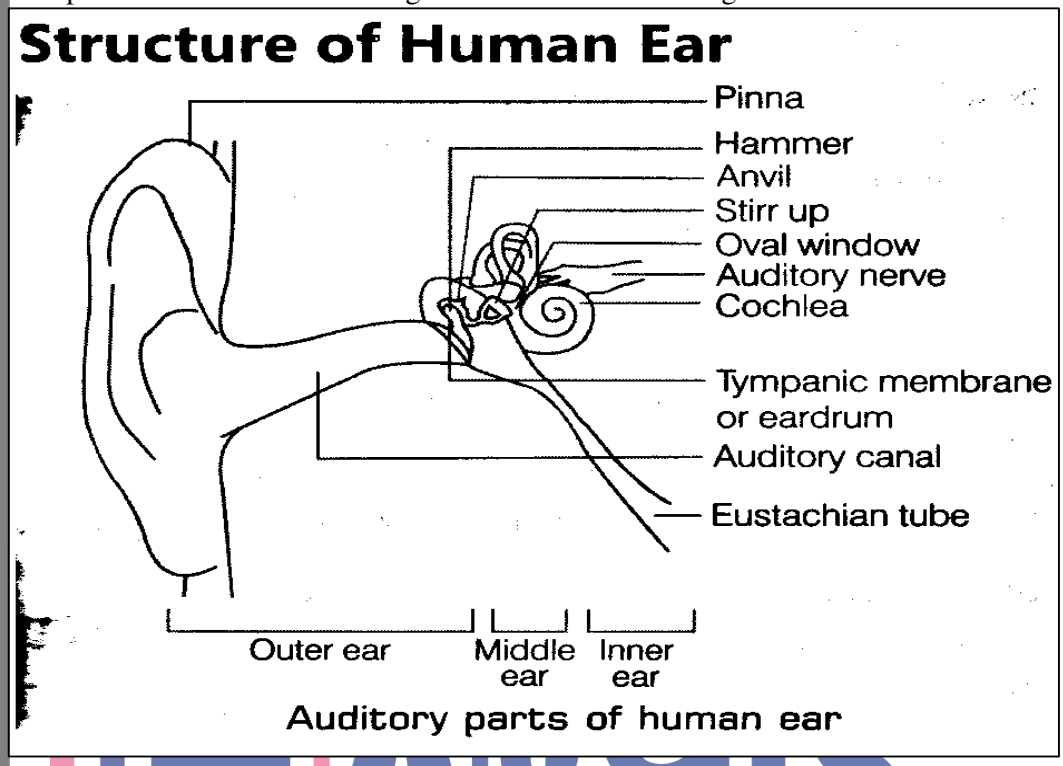
3. Inner Ear: has a coiled tube, cochlea. One side of cochlea is connected to middle ear through elastic membrane over the oval window. A liquid is filled in cochlea, which contains nerve cells that are sensitive to sound. The other side of cochlea is connected to auditory nerve going into the brain.

Working of Human Ear: Pinna collects the sound waves from the surroundings. These collected sound waves pass through the ear canal (auditory canal) and fall on the eardrum. Since, sound waves are longitudinal waves, these waves consist of compressions (high pressure regions) and rarefactions (low pressure regions).

When a compression of the medium reaches the eardrum, the pressure on the outside of the membrane (eardrum) increases and forces the eardrum inward. Similarly, when the rarefaction of sound wave falls on the eardrum, the pressure on the outside of the membrane (eardrum) decreases and it moves outward. In this way, when sound waves fall on the eardrum, it starts vibrating back and forth rapidly.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

These vibrations are amplified several times by the three bones (hammer, anvil and stirr up) in the middle ear and then passes to the liquid in the cochlea. Due to this, the liquid in the cochlea begins to vibrate and the pressure variations are turned into electrical signals by the cochlea. These electrical signals are carried by auditory nerve to the brain. The brain interprets them as sound and we get the sensation of hearing.



ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in