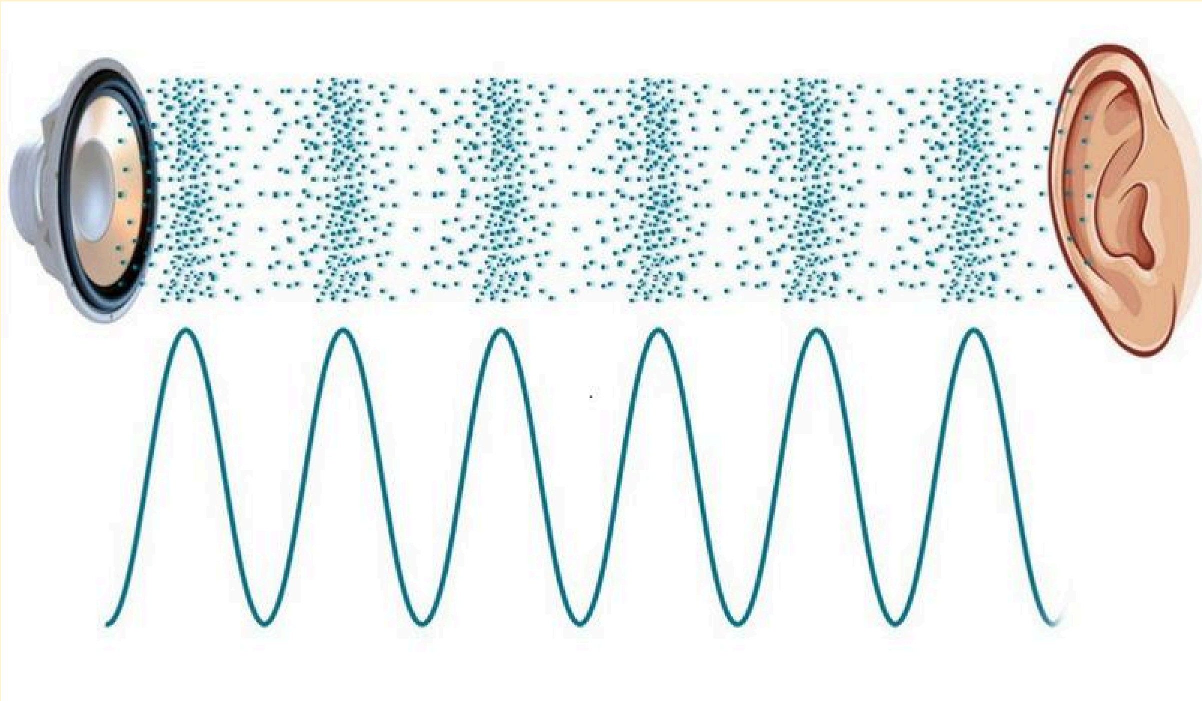
Chapter-12 : Sound

Production of sound : Sound is produced due to the vibration of objects. Vibration is the rapid 'to and fro' motion of an object. e.g. – The sound of human voice is produced due to the vibration of the vocal cords. A stretched rubber band when plucked, it vibrates and produces sound.



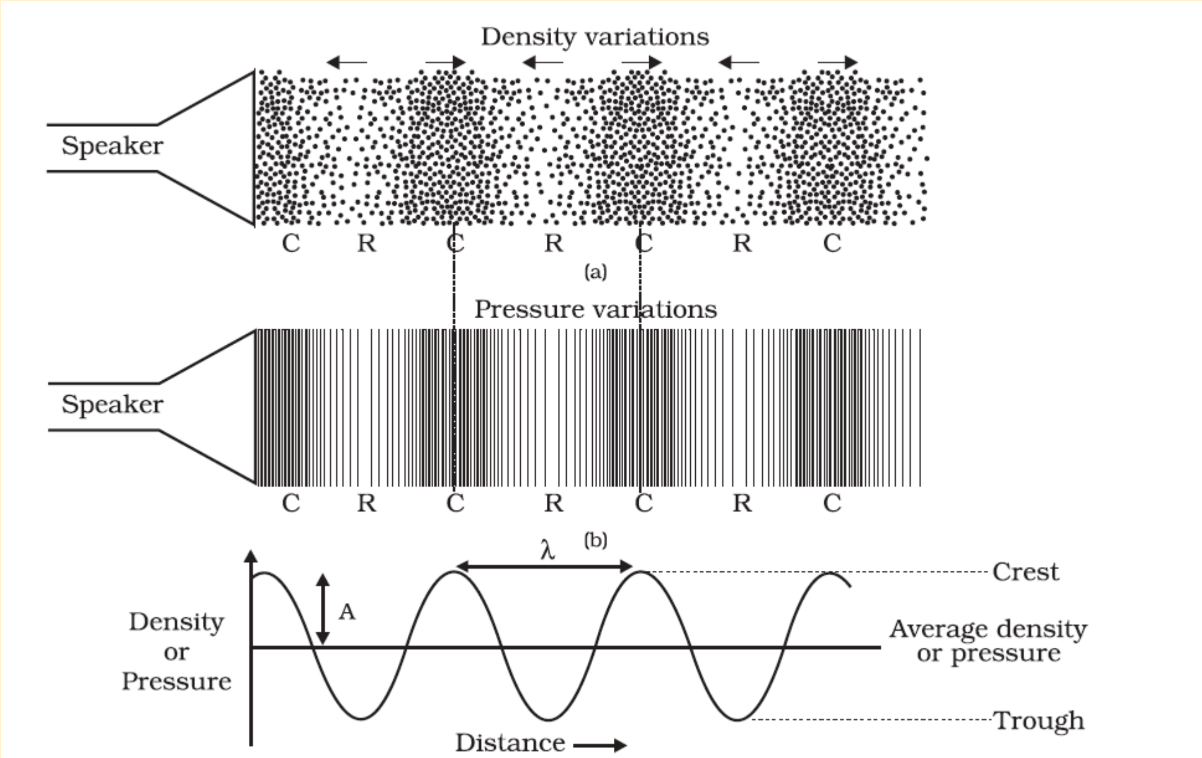
Activity for production of sound : Strike the prongs of a tuning fork on a rubber pad and bring it near the ear. We can hear a sound. If a suspended table tennis ball is touched with the vibrating prong, the ball is pushed away repeatedly. This shows that the prong is vibrating and vibrating objects produces sound.

Propagation of sound :

- The sound produced by a vibrating object travels through a medium to the listener. The medium can be solid, liquid or gas.

- When an object vibrates, the particles around the medium vibrates. The particle in contact with the vibrating object is first displaced from its equilibrium position. Then, it exerts a force on the adjacent particle and the adjacent particle is displaced from its position of rest. After displacing the adjacent particle, the first particle comes back to its original position. This process repeats in the medium till the sound reaches to the ear.
- 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. Since sound waves are produced due to the vibration of particles of the medium, sound waves are called mechanical waves.

Propagation of sound through air : 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 forming a region of high pressure called compression (C). The compression moves away from the vibrating object. When the vibrating object moves backward, it forms a region of low pressure called rarefaction (R). As the object moves 'to and fro' rapidly, it produces a series of compressions and rarefaction in the air which makes the sound to propagate in the medium.



Sound needs a medium to travel : Sound is a mechanical wave and needs a medium for propagation. Sound travels through solids, liquids and gases.

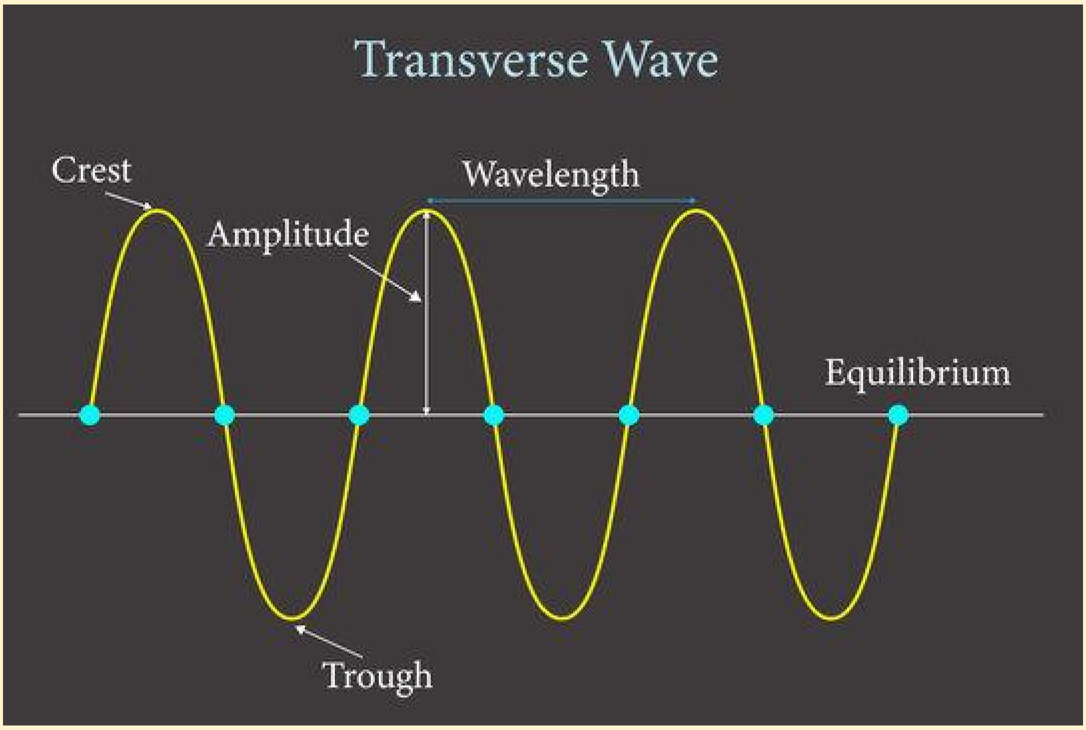
Sound does not travel in vacuum.

Activity for showing Sound needs a medium to travel : Suspend an electric bell in an air tight bell jar. Connect the bell jar to a vacuum pump. If the switch is pressed, we can hear the sound of the bell. If air is pumped out through the vacuum pump, we cannot hear the sound of the bell. This shows that sound needs a medium to travel and sound cannot travel in vacuum.

Sound waves are longitudinal waves :

- Sound propagates in a medium as a series of compressions (C) and rarefactions (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.

- There is another kind of waves called transverse waves. In these waves, the particles oscillate up and down which is perpendicular to the propagation of the direction of disturbance.



Activity for longitudinal wave : Stretch a slinky and push and pull it alternately at one end. If we mark a dot on the slinky, the dot moves back and forth parallel to the direction of the propagation of the disturbance.

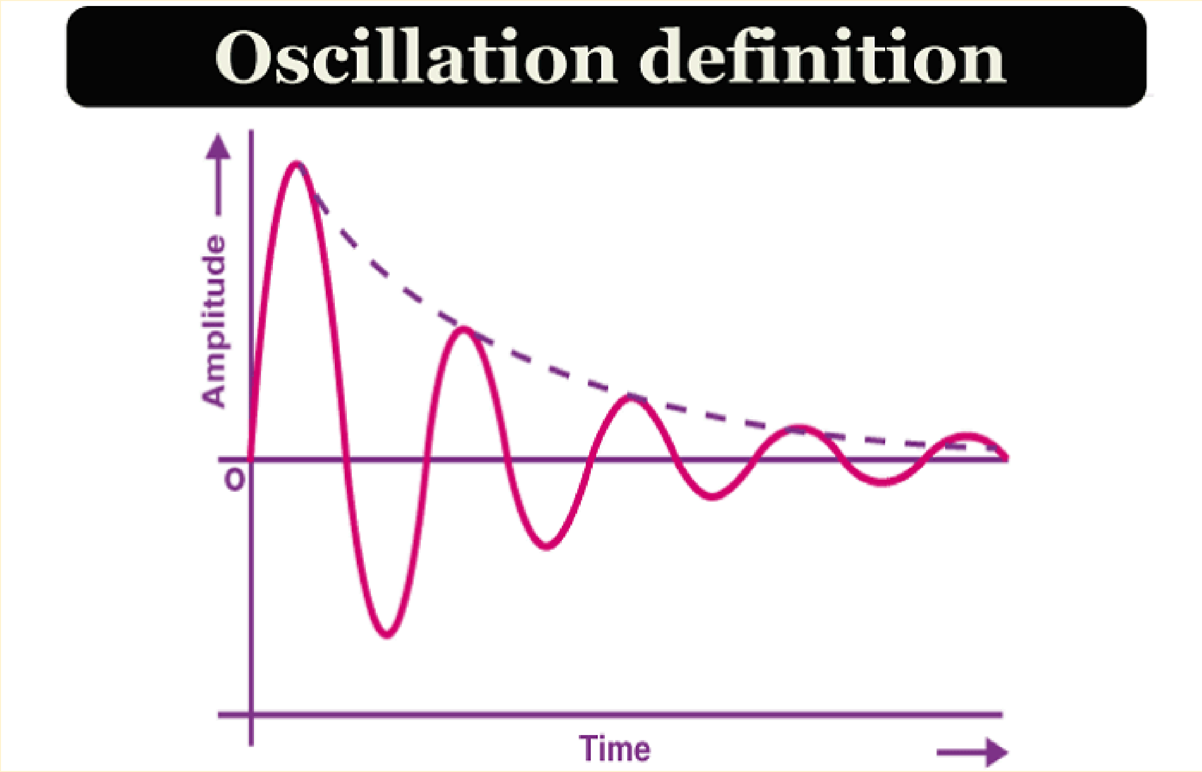
Characteristics of a sound wave :

- Sound wave can be described by its frequency, amplitude and speed.
- Sound can be graphically represented as a wave. There is changes in the density and pressure as sound moves in a medium.
- 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.
- The distance between two consecutive compressions (crests) or two consecutive rarefactions(troughs) is called wave length. It is represented by the symbol 'λ' (Greek letter lamda). Its SI unit is metre (m).

Frequency of sound wave :

- When sound is propagated through a medium, the density of the medium oscillates between a maximum value and a minimum value. The change in the density of the medium from a maximum value to a minimum value and again to the maximum value is one oscillation.
- The number of oscillations per unit time is called the frequency of the sound wave.
- It is represented by the symbol 'v' (Greek letter nu).
- Its SI unit is hertz (Hz).



Time period of sound wave :

- The time taken for the change in the density of the medium from a maximum value to a minimum value and again to the maximum value is the time period of the sound wave.
- The time taken for one complete oscillation in the density of the medium is called the time period of the sound wave.
- It is represented by the letter 'T'.
- The SI unit is second (s).
- Frequency and time are represented as follows :

$$T = 1 / v \text{ or, } v = 1 / T$$

Amplitude of sound wave :

- The magnitude of the maximum disturbance in the medium on either side of the mean value is the amplitude of the sound 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 wavelength i.e. metre (m).

Pitch and loudness of sound :

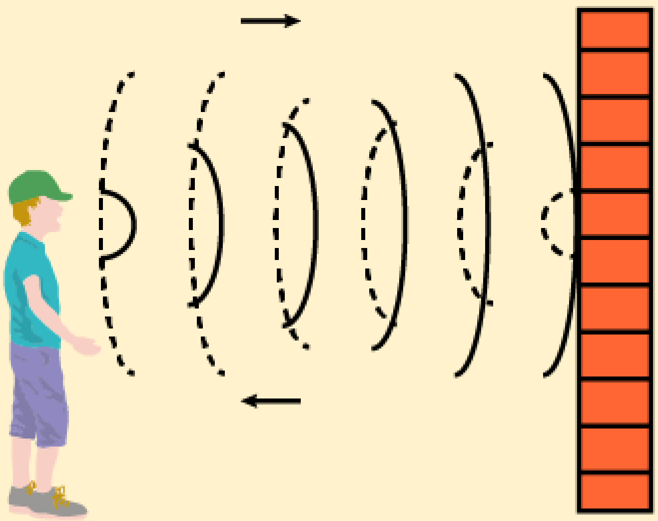
- The pitch of sound (shrillness or flatness) depends on the frequency of vibration.
- If the frequency is high, the sound has high pitch and if the frequency is low, the sound has low pitch.
- The loudness of sound depends upon the amplitude of vibration.
- If the amplitude is high, the sound is loud and if the amplitude is low, the sound is soft.

Speed of sound :

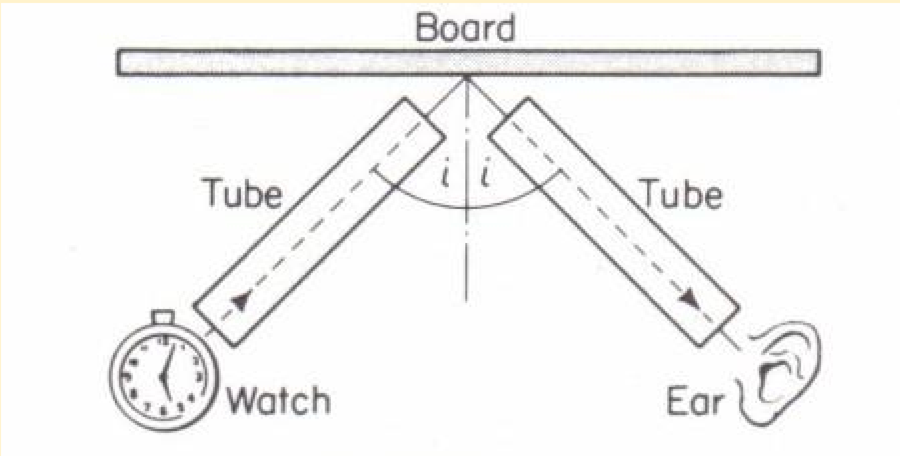
- The speed of sound is different in different media. The speed of sound is more in solids, less in liquids and least in gases.
- The speed of sound also depends on the temperature of the medium. If the temperature of the medium is more, the speed of sound is more.
- Relationship between Speed (v), frequency (ν) and wavelength (λ) :Speed = wavelength x frequency

$$v = \lambda \times \nu$$

Reflection of sound : Like light, 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.



Activity for reflection of sound : Take two pipes of the same length and arrange them on a table near a wall or metal plate. Keep a clock near the open end of one pipe and try to hear the sound of the clock through the other pipe by adjusting the position of the pipe. Now, measure the angles of incidence and reflection. Then, lift the second pipe and try to hear the sound. It will be seen that the angle of incidence is equal to the angle of reflection. The incident ray, the reflected ray and normal all lie in the same plane.



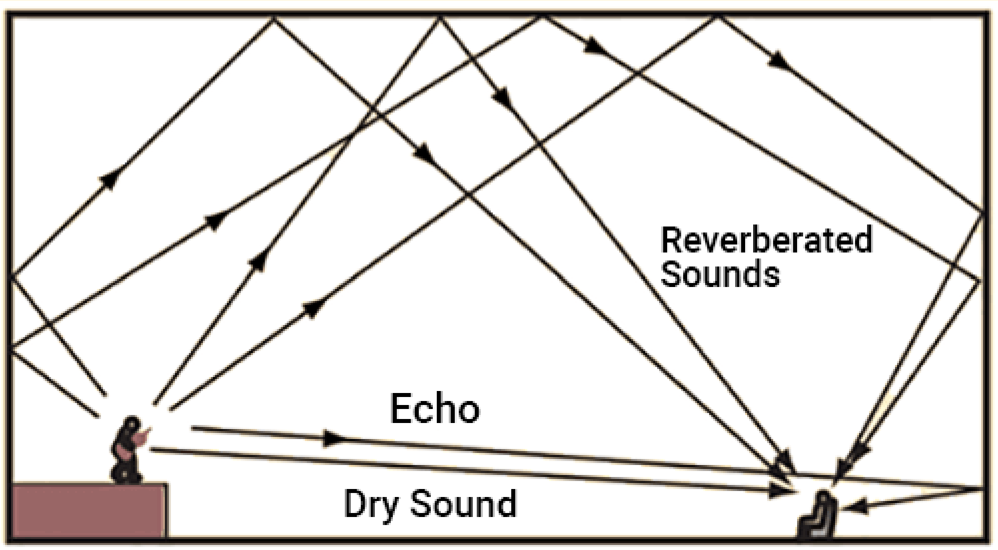
Echo :

- 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 second.
- Since, the speed of sound in air is 344 m/s. The distance travelled by sound in 0.1 second = 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 i.e. 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 :

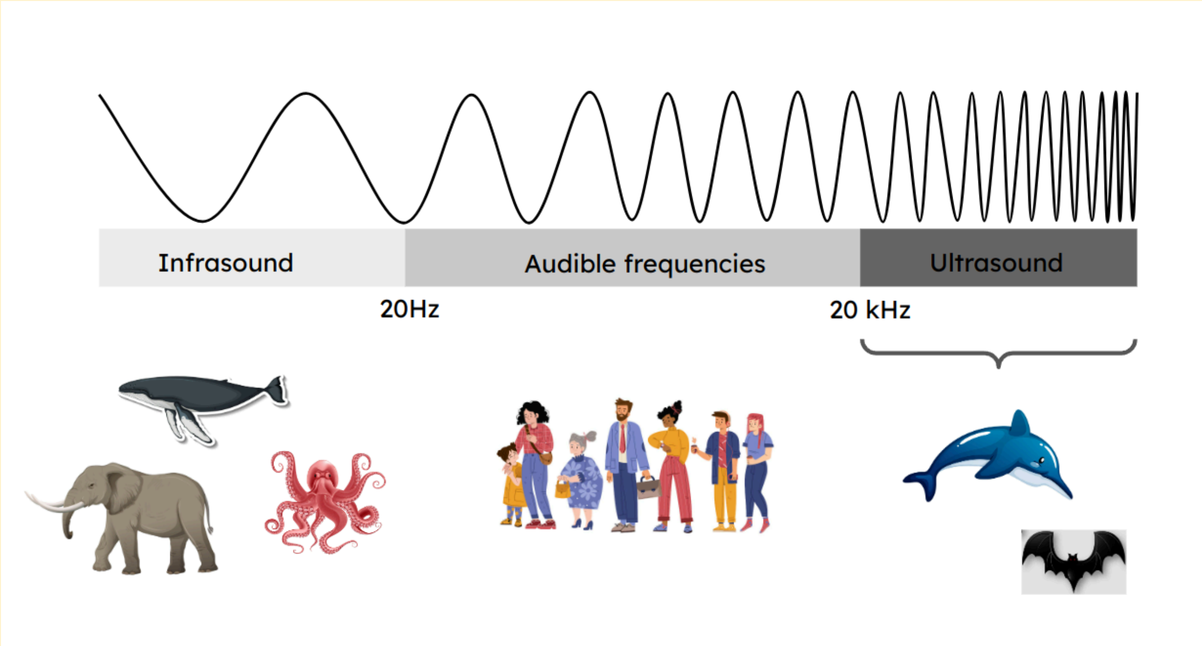
- Megaphones, horns, musical instruments like trumpet, shehnai etc. are deigned to send sound by multiple reflection in a particular direction without spreading in all directions.

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

- 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.

Range of Hearing :

- Human beings can hear sound frequencies between 20 Hz and 20,000 Hz.
- Sound whose frequency is less than 20 Hz is called infrasonic sound. Animals like dog, elephant, rhinoceros, whale etc. produce and hear infrasonic sound.
- Sound whose frequency is more than 20,000 Hz is called ultrasonic sound. Animals like dolphin, bat, rat porpoise etc. produce and hear ultrasonic sound.
- Bat uses reflection of ultrasonic sound waves to detect an obstacle or its prey.

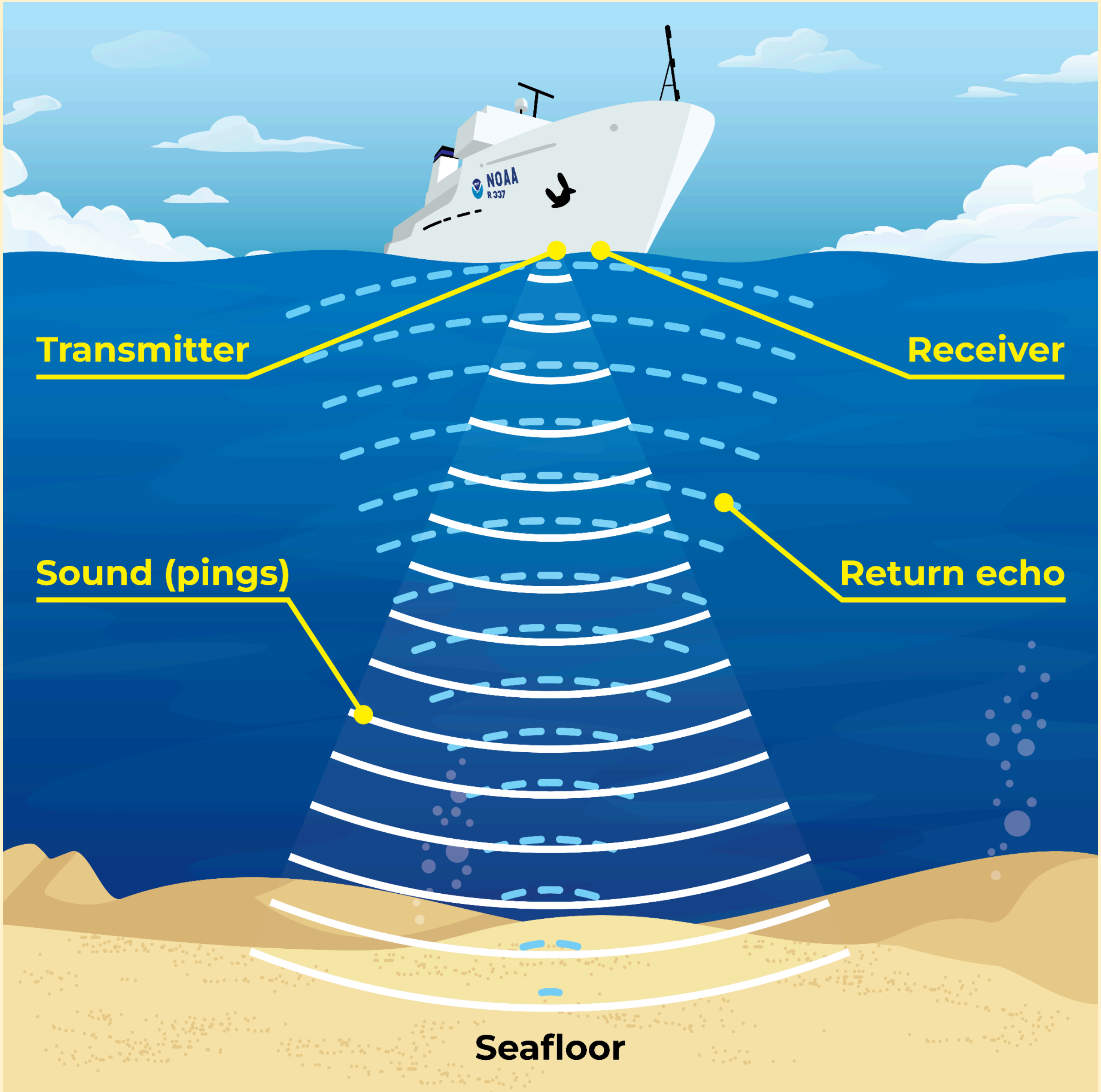


Uses of ultrasonic sound :

- Ultrasonic sound is used to clean objects like electronic components. The electronic components to be cleaned are kept in a cleaning solution and ultrasonic waves are sent into the solution. Due to the high frequency, the dirt particles get detached from the electronic components.
- Ultrasonic sound is used to detect cracks in metal blocks. Ultrasonic waves are sent through the metal blocks and if there are cracks, the waves are reflected back and the cracks can be detected.
- Ultrasonic sound is used in ultrasound scanners for getting images of internal organs of the human body.
- Ultrasonic sound is used to break small stones formed in the kidneys into fine grains so that they are removed through the urine.

SONAR :

- SONAR stands for 'Sound Navigation And Ranging'. It is a device which uses ultrasonic waves to measure distance, direction and speed of underwater objects.

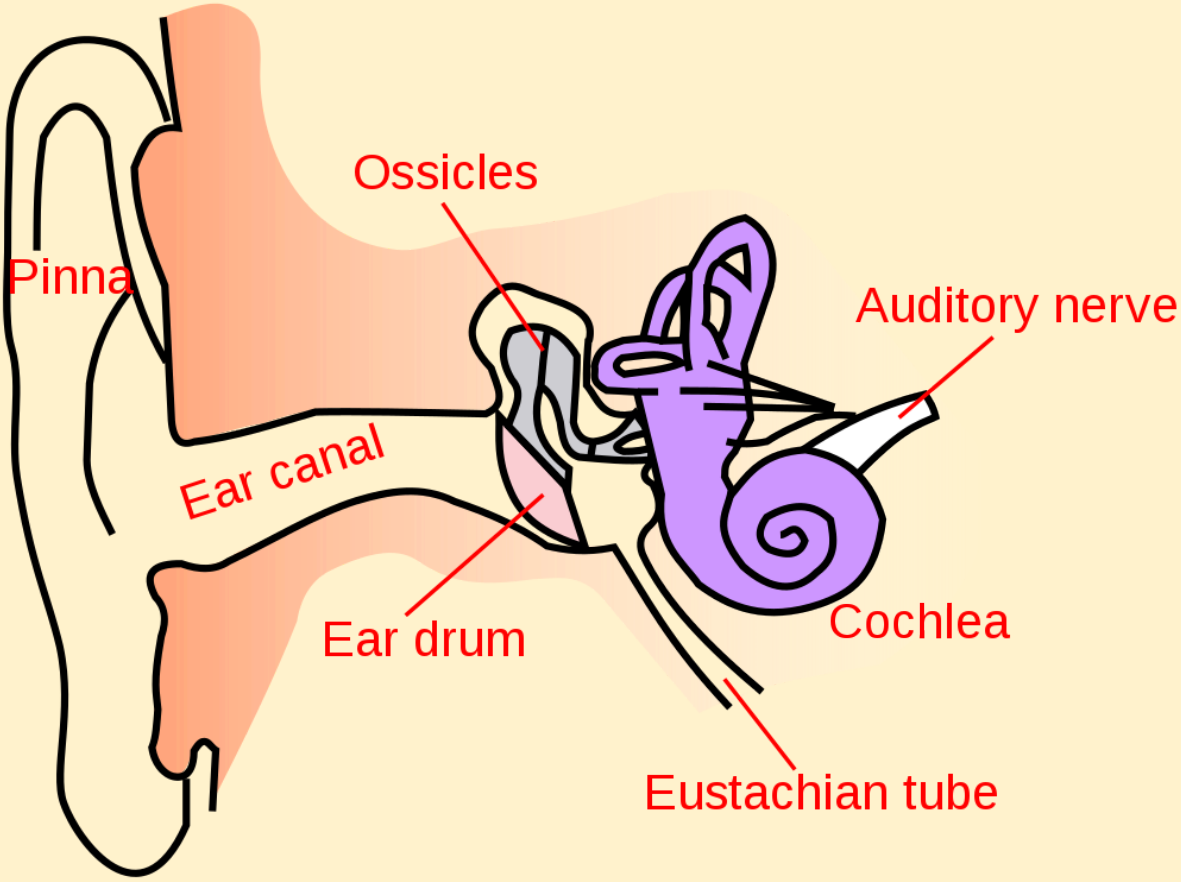


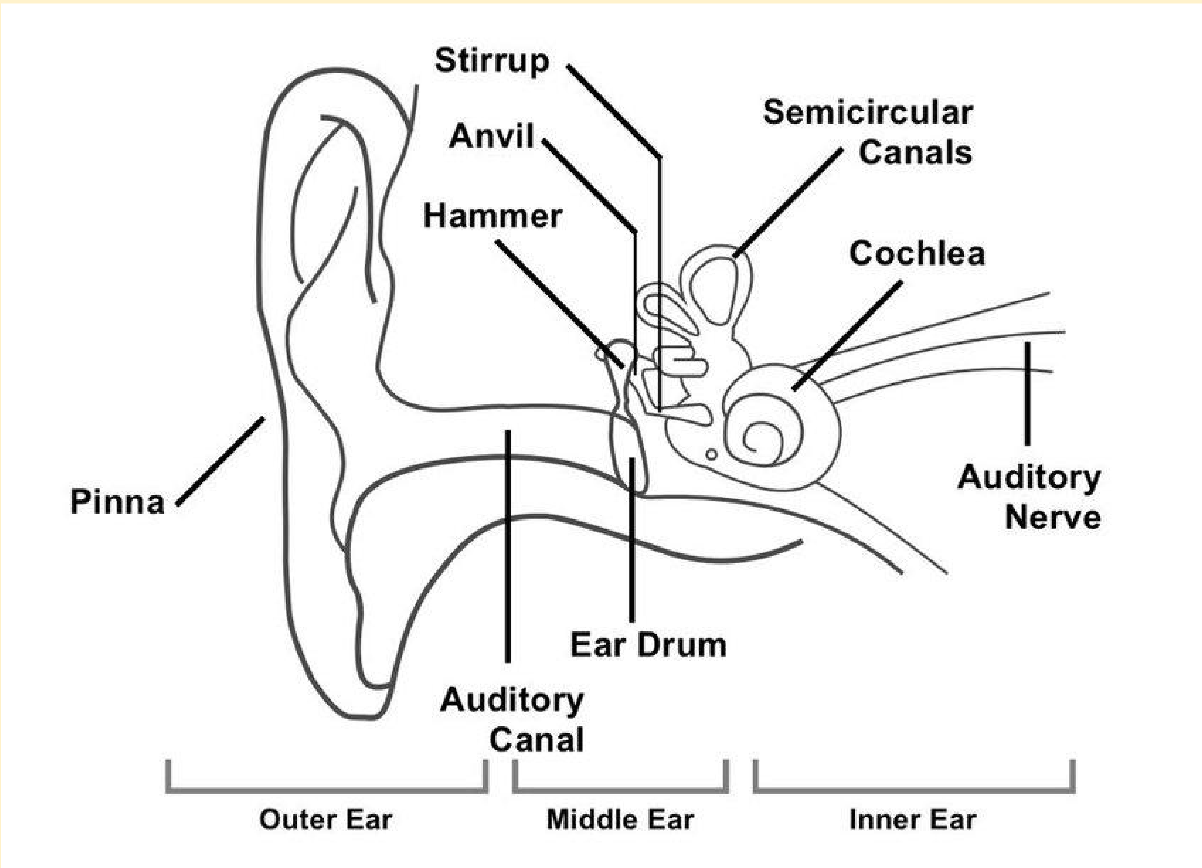
- Sonar has a transmitter and a detector installed in ships. The transmitter produces ultrasonic sound waves which travel through the water and after striking the object in the sea bed is reflected back to the detector.
- The distance of the object can be calculated by knowing the speed of sound in water and the time taken between the transmission and reception of ultrasound.

- If the time taken for the transmission and reception of ultra sound is t and the distance travelled is 2d by the ultra sound, then $2d = v \times t$

$$d = (v \times t)/2$$

Structure of the human ear : The outer ear is called pinna which collects the sound waves. The sound waves passes through the ear canal to a thin membrane called eardrum. The eardrum vibrates. The vibrations are amplified by the three bones of the middle ear called hammer, anvil and stirrup. The middle ear then transmits the sound waves to the inner ear. In the inner ear, the sound waves are converted into electrical signals by the cochlea and sent to the brain through the auditory nerves. The brain then interprets the signals as sound.


Ossicles
Pinna
Auditory nerve
Ear canal
Ear drum
Cochlea
Eustachian tube


Stirrup
Anvil
Hammer
Semicircular Canals
Cochlea
Pinna
Auditory Nerve
Ear Drum
Auditory Canal
Outer Ear
Middle Ear
Inner Ear