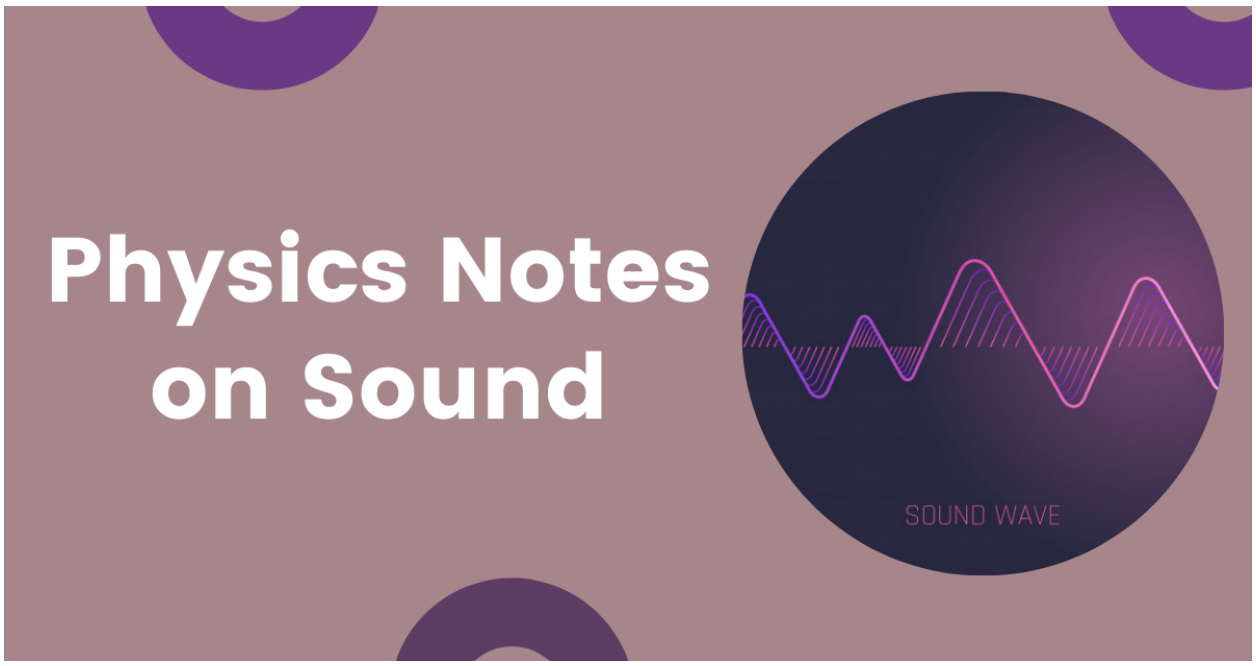


Physics Notes on Sound

A sound is a vibration that propagates through a medium in the form of a mechanical wave. The medium in which it propagates can either be a solid, a liquid or a gas. Sound travels fastest in solids, relatively slower in liquids and slowest in gases.

In physics, the sound is defined as

A vibration that propagates as an audible wave of pressure, through a medium such as a gas, liquid or solid.

➤SOUND

The speed of sound in a medium depends:

• temperature of the medium.

• pressure of the medium.

• The speed of sound decreases when we go from solid to gaseous state.

• In any medium as we increase the temperature the speed of sound increases.

• The velocity of sound through a gas is inversely proportional to the square root of the density of the gas.

• Sound is a mechanical energy which produces sensation of hearing. Sound is produced due to vibration of different objects.

• Sound wave propagates as compressions & rarefactions in the medium. Sound waves are longitudinal waves.

Production of Sound: Sound is produced by vibrating objects. Vibration means a kind of rapid to and fro motion of an object. The sound of the human voice is produced due to vibrations in the vocal cords.

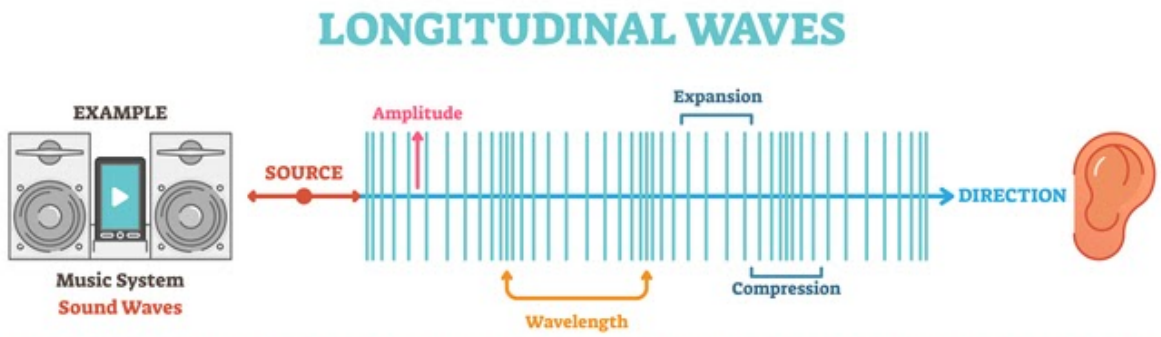
Propagation of Sound: The matter or substance through which sound is transmitted is called a medium. It can be solid, liquid or gas. Sound moves through a medium from the point of generation to the listener. Sound waves are produced due to variations in pressure & density of the medium.

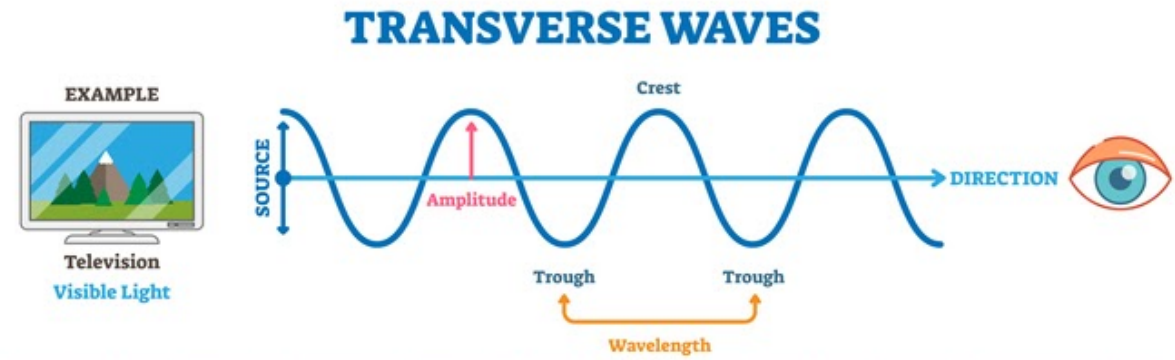
➤TYPES OF WAVES

On the basis of direction of propagation, waves can be divided into 2 types:

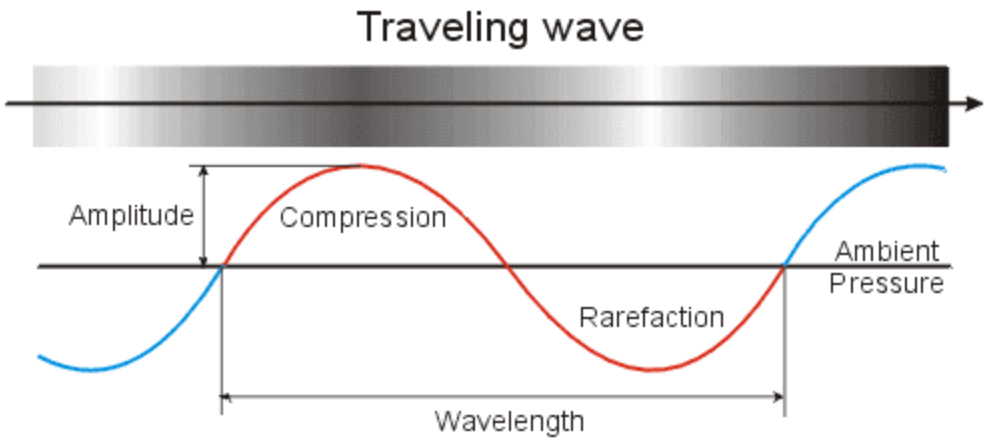
1. LONGITUDINAL WAVES: In these waves the individual particles of the medium move in a direction parallel to the direction of propagation of the disturbance. The particles do not move from one place to another but they simply oscillate back and forth about their position of rest. E.g. Sound waves.

2. TRANSVERSE WAVES: In these waves, particles do not oscillate along the line of wave propagation but oscillate up and down about their mean position as the wave travels. E.g. Light is a transverse wave.





➤CHARACTERISTICS OF A SOUND WAVE AND RELATED TERMS



• Compression(C): Theseare the regions of high pressure and density where the particles are crowded and are represented by the upper portion or peak of the curve called crest.

• Rare-factions(R): Theseare 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 or valleys.

• Amplitude: The magnitude of the maximum disturbance in the medium on either side of the mean value is called the amplitude of the wave. It is usually represented by the letter A. For sound its unit will be that of density or pressure.

• Oscillation: It is the change in density (or pressure) from maximum value to the minimum value and again to the maximum value.

• Frequency: The number of oscillations of a wave per unit time is the frequency of the sound wave. It is usually represented by v (Greek letter, nu). Its SI unit is hertz (symbol, Hz).

1. Larger the amplitude of vibration, louder is the sound.

2. Higher the frequency of vibration, the higher is the pitch, and shriller is the sound.

• Time Period: The time taken by two consecutive compressions or rare-factions to cross a fixed point is called the time period of the wave. It is represented by the symbol T. Its SI unit is second (s).

Time Period = 1/ Frequency

• Wavelength: It is the distance between two consecutive compressions or two consecutive rare-factions. The wavelength is usually represented by λ (Greek letter lambda). Its SI unit is metre (m)

• The speed of sound: It is defined as the distance which a point on a wave, such as a compression or a rarefaction, travels per unit time.

Speed = wavelength × frequency

Range of Hearing of sound: The audible range of sound for human beings extends from about 20 Hz to 20000 Hz (one Hz = one cycle/s).

1. Sounds of frequencies below 20 Hz are called infrasonic sound or infra sound. Rhinoceroses communicate using infrasound of frequency as low as 5 Hz. Whales and elephants produce sound in the infrasound range.

2. Frequencies higher than 20 kHz are called ultrasonic sound or ultrasound. Ultrasound is produced by dolphins, bats and porpoises.

➤ULTRASOUND

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

Applications

• 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.

• Ultrasound is generally used to clean parts located in hard-to-reach places,for example, spiral tube, odd shaped parts, electronic components etc.

• Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called 'echocardiography'.

• Ultrasound scanner is an instrument which uses ultrasonic waves for getting images of internal organs of the human body. It helps the doctor to detect abnormalities, such as stones in the gall bladder and kidney or tumours in different organs. The technique is called 'ultrasonography'.

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

➤SONAR

• The acronym SONAR stands for Sound Navigation And Ranging.

• Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects.

• Sonar consists of a transmitter and a detector and is installed in a boat or a ship. The transmitter produces and transmits ultrasonic waves.

• These waves travel through water and after striking the object on the seabed, get reflected back and 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 in water and the time interval between transmission and reception of the ultrasound.

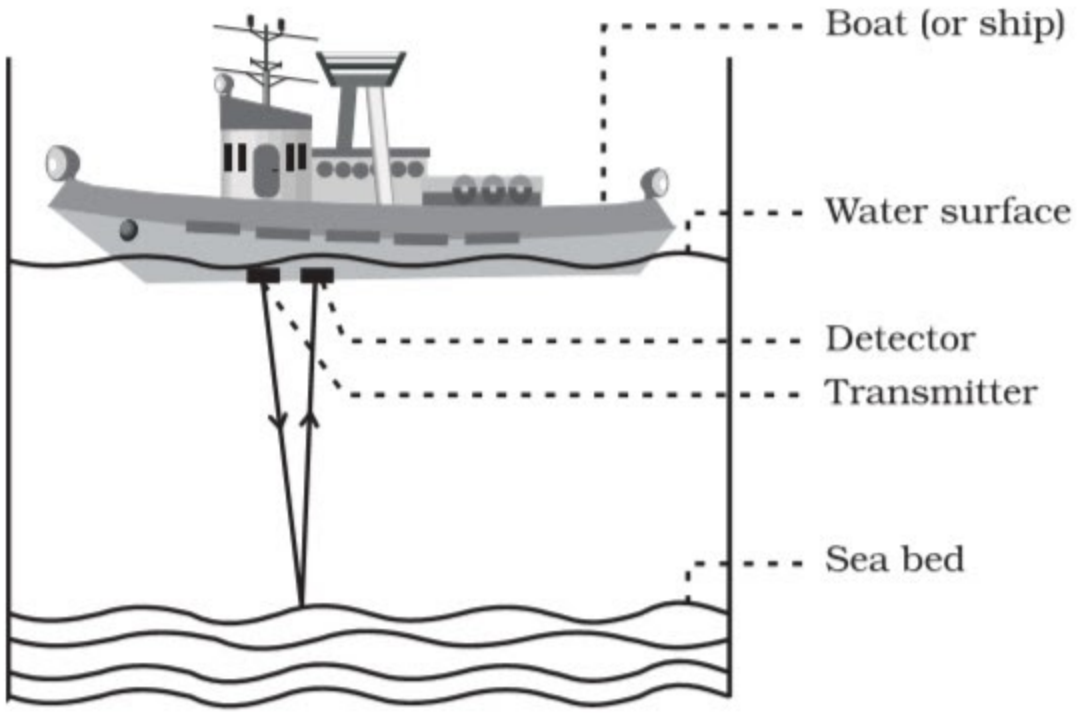


Fig.12.17: *Ultrasound sent by the transmitter and received by the detector.*

Let the time interval between transmission and reception of ultrasound signal be t and the speed of sound through seawater be v.

The total distance, 2d travelled by the ultrasound is then,

2d = v × t,

The above method is called echo ranging.

The sonar technique is used to determine the depth of the sea and to locate underwater hills, valleys, submarine, icebergs, sunken ship etc.

➤SUPERSONIC SOUND

Again if the speed of any substance, specially of an air-craft, be more than the speed of sound in air, then the speed of the substance is called supersonic speed.

➤INFRASONIC SOUND

Sounds of frequencies below 20 Hz are called infrasonic sound or infrasound.

Example:

Rhinoceroses communicate using infrasound of frequency as low as 5 Hz. Whales and elephants produce sound in the infrasound range. It is observed that some animals get disturbed before earthquakes. Earthquakes produce low-frequency infrasound before the main shock waves begin which possibly alert the animals.

➤ULTRASONIC SOUND

Frequencies higher than 20 kHz are called ultrasonic sound or ultrasound.

Example:

Ultrasound is produced by dolphins, bats and porpoises.

Applications:

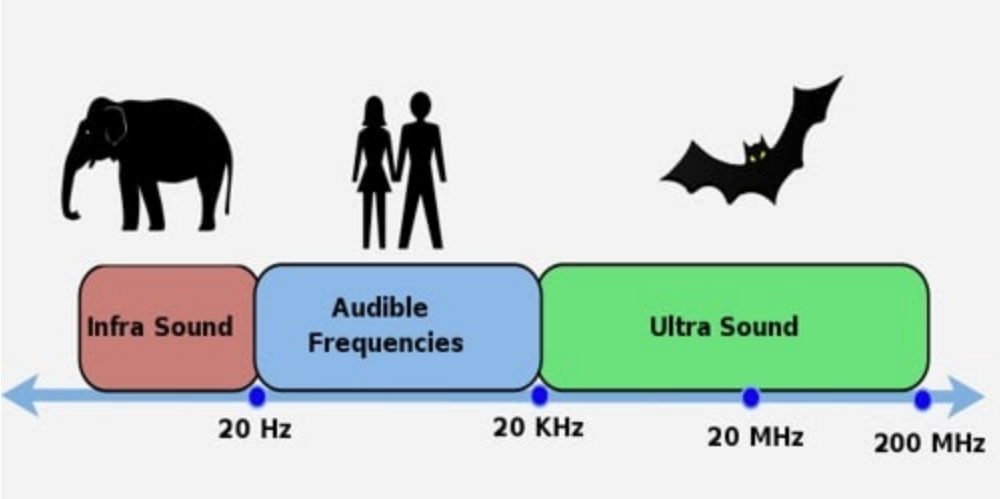
• Ultrasounds can be used to detect cracks and flaws in metal blocks.

• 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.

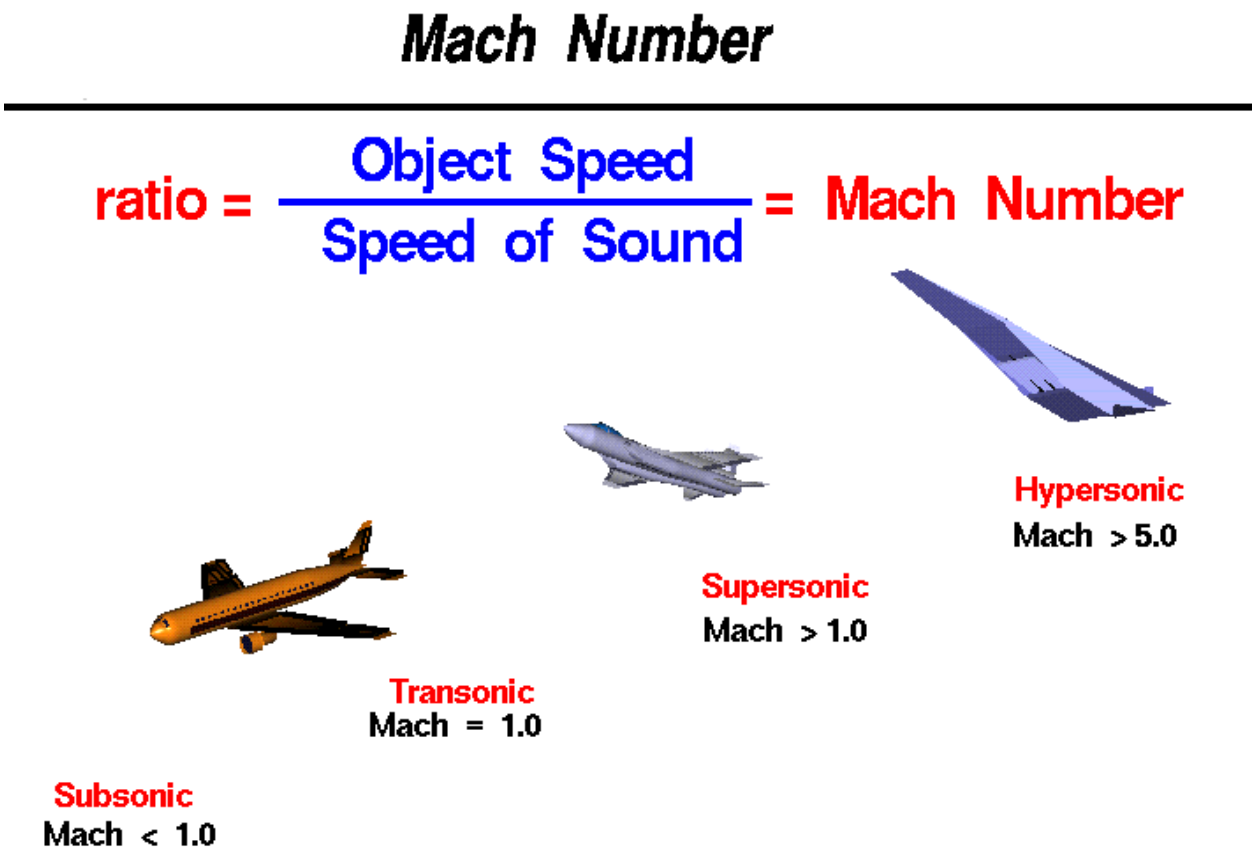
• Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called 'echocardiography'.

• 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. In this technique the ultrasonic waves travel through the tissues of the body and get reflected from a region where there is a change of tissue density. These waves are then converted into electrical signals that are used to generate images of the organ. These images are then displayed on a monitor or printed on a film. This technique is called 'ultrasonography'.

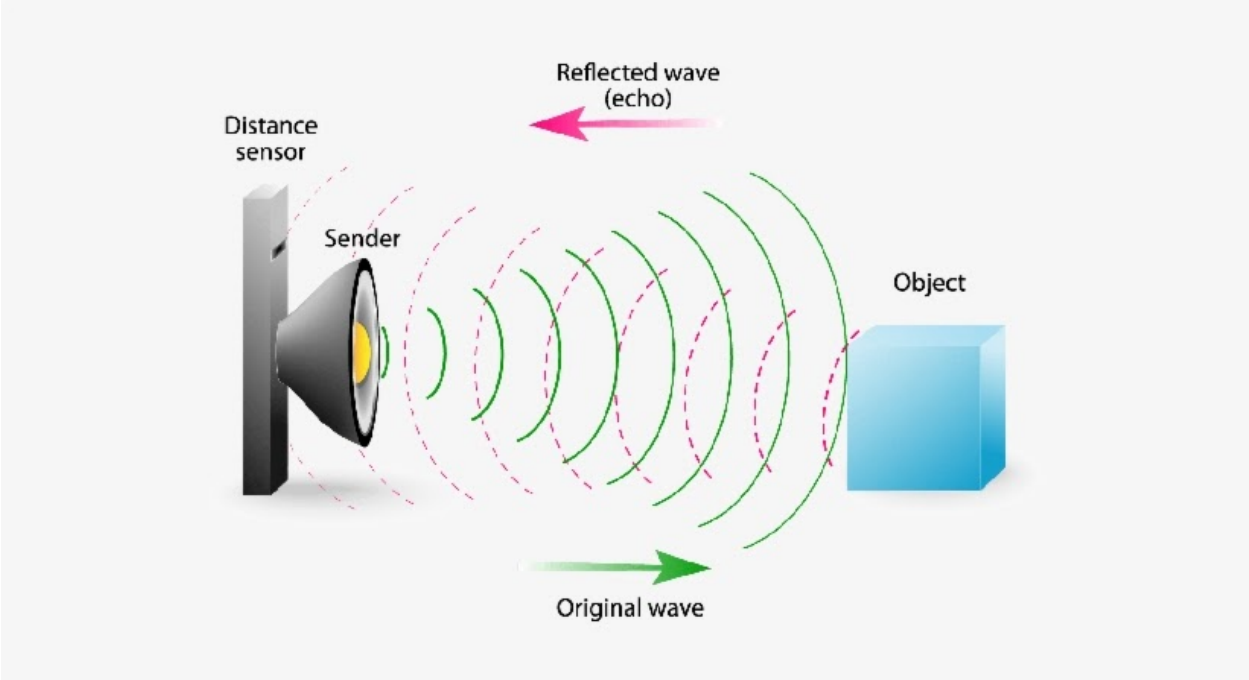


➤MACH NUMBER

• The ratio of the speed of a body and that of sound in air is, however, called the Mach number of the body. If the Mach number of a body is more than 1 , it is clear that the body has supersonic speed.



➤REFLECTION OF SOUND (ECHO)



• t is a reflection of sound that arrives at the listener with a delay after the direct sound.

• The sensation of sound persists in our brain for about 0.1 second.

• To hear a distinct echo, the time interval between the original sound and the reflected one must be at least 0.1 second.

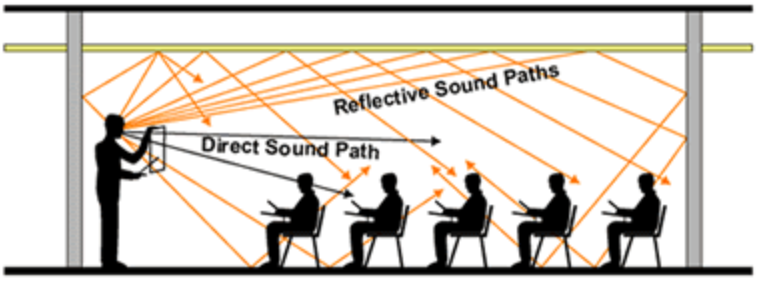
• For hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be 17.2 m. This distance will change with the temperature of air. Echoes may be heard more than once due to successive or multiple reflections.

➤REVERBERATION

REVERBERATION

The time it takes for reflected sound to die down by 60 decibels from the cessation of the original sound signal (measured in seconds).

- Reflected sound tends to "build up" to a level louder than direct sound. Reflected sounds **MASK** direct sound.
- Late arriving reflections tend to **SMEAR** the direct sound signal.



The phenomenon of prolongation of sound due to successive reflections of sound from surrounding objects is called reverberation.

Example:

In stethoscopes the sound of the patient's heartbeat reaches the doctor's ears by multiple reflection of sound.

➤AUDIBLE RANGE

The audible range of sound for human beings extends from about 20 Hz to 20000 Hz (one Hz = one cycle/s). Children under the age of five and some animals, such as dogs can hear up to 25 kHz (1 kHz = 1000 Hz).