Sound

Nature of sound and its propagation in various media, speed of sound, range of hearing in humans; ultrasound; reflection of sound; echo and sonar, structure of the human ear (auditory aspect only).

Throughout the day, we listen the various types of sounds like our father's voice, our mother's voice, our teacher's voice, chirping of birds, ringing of a school bell, a telephone ringing, a guitar being played, a sire, a jet engine roaring in the sky, buzzing of a mosquito, a gun shot etc. These sounds stimulate the auditory nerve in the human ear and the brain interprets the sound. Now let us define sound.

Sound is as form of energy which produces the sensation of hearing in our ears.

Now, we shall discuss the production of sound and transmission of sound through a medium.

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PRODUCTION OF SOUND

Perform the following activities to produce sound.

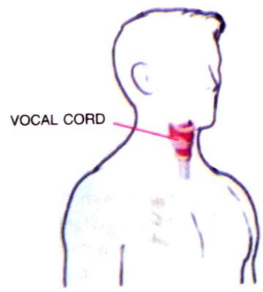
VIBRATING TUNING FORK

Activity

Take a plastic scale or ruler from your geometry box. Hold it flat on your desk or table with about half its length protruding (stick out from the surface) over the edge. Now bend it down and release it. It will move up and down rapidly (i.e., it will vibrate) and produce the sound at the same time. The sound will last as long as the vibration (i.e, rapid up and down motion) of the scale continues.

Activity

Take a tunning fork. Hold it from its stem and strike it with a rubber pad or hammer. You will observe that the prongs of the tuning fork vibrate and at the same time sound is produced.

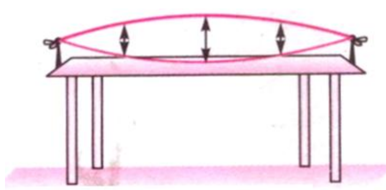


Activity

Place your finger lightly on your throat near the vocal cords as shown in figure 2. Now say "Ah" for few seconds. You will feel the vibration in your finger as long as you say "Ah"

Activity

Tie a thin metallic string rigidly at the two ends of a table as shown in figure 3. Now, pluck the string from the middle and release it. The string begins to vibrate up and down and at the same time, sound is heard.



Conclusion: From these activities, we come to the conclusion that the sound is produced by the vibrating objects or bodies.

PRODUCTION OF SOUND IN MUSICAL INSTRUMENTS

When a drum is beaten, then the skin of drum vibrates and sound is produced. When the string of a guitar are plucked and released, they vibrate and produce sound. When air is blown into the flute, pipe, clarinet, saxophone etc., it vibrates in the tube of the instrument and hence sound is produced. Sound is also produced when the birds flap their wings during the flight.

WHAT IS A WAVE?

When a pebble is thrown in a pond of still water, we observe that **ripples** known as **waves** move outward on the surface of water as shown in a figure 4.

MUSICAL INSTRUMENTS

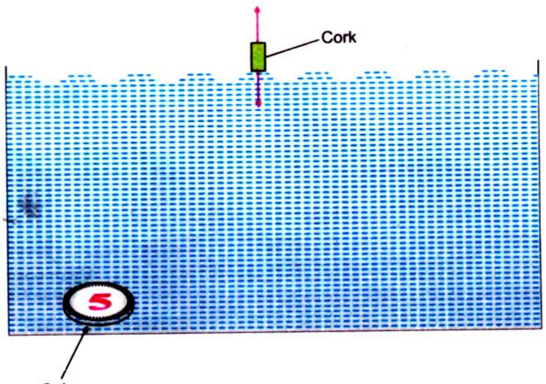
. WATER RIPPLES

When a pebble hits the surface of water, it sinks in water but disturbs the particles of water where it hits the surface of water. So the particles of water begin to vibrate about their mean positions. These vibrating particles collide with the neighbouring particles and make them to vibrate. This process continues and the disturbance travels through the water due to the repeated periodic motion of the particles of water about their mean position. **The movement of the disturbance through a medium due to the repeated periodic motion of the particles of the medium about their mean position is known as a wave.**

WAVE TRANSFERS ENERGY AND NOT THE MATTER.

To understand the fact that wave transfers energy and not the matter, perform the following activity.

Throw a coin in a container filled with water, you will find that the ripples move outward on the surface of water as shown in figure 5. Place a wooden cork on the surface of water. This cork begins to move up and down as the ripple or wave reach the cork. As soon as the ripple passes by, the cork again comes to rest. This indicates that the matter is not transported as the wave moves through the medium. When still water is disturbed, the particles of water begins to vibrate about their mean position at the point of disturbance. These particles collide with their neighbouring particles and impart some of their energy to these neighbouring particles start vibrating about their mean positions. Now these particles transfer their energy to the next particles which in turn begin to vibrate. This process continues and the energy is transferred from one particle to other particles of the medium (here, water). Thus, waves transfer energy from one position to another position of the medium and not the matter.



MECHANICAL WAVE

A mechanical wave is a periodic disturbance which requires material medium (i.e. should, liquid or gas) for its propagation.

In other words, waves that are characterized by the motion of particles of a medium are called mechanical waves.

Examples of mechanical waves

(i) Sound waves in air

(ii) Water waves

(iii) Waves produced due to the earthquake (known as seismic waves)

(iv) Waves produced by supersonic jet planes (known as shock waves)

(v) Waves produced in a stretched string.

(vi) Waves produced in a slinky or long spring.

Types of waves

Waves are of two types:

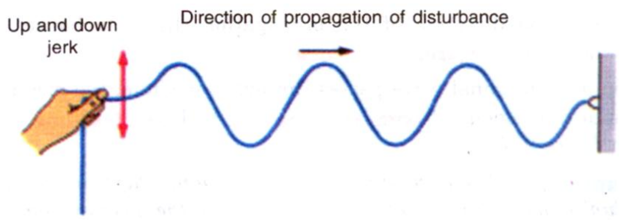
(i) Transverse Wave (ii) Longitudinal Wave

TRANSVERSE WAVE

If the particles of a medium vibrate or oscillate about their mean positions at right angles to the direction of propagation (i.e. advancement) of the disturbance then the wave is called transverse wave.

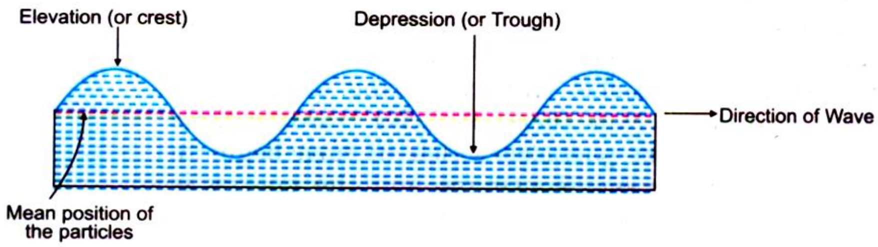
Activity

Fix one end of a thin rope and give up and down jerk to the free end of the rope. The rope oscillates or vibrates up and down as shown in figure 6. The disturbance travels form the free end to the fixed and but the rope vibrates up and down. This wave is known as transverse wave.



TRANSVERSE WAVE

A transverse wave traveling on the surface of water is shown in figure.



When transverse wave travels through the medium, the shape of the medium changes. At some positions, the particles of the medium rise (or elevate) above their mean positions and at some positions, the particles of the medium go down (or depressed) below their mean positions.

The point on the elevation of the medium whose distance from the mean position is maximum is known as ***crest*** *(C). On the other hand, the point on the depression of the medium whose distance from the mean position is maximum is known as* ***trough****(T). Thus, crests and troughs are formed when a transverse wave travels through a medium (Figure).*

WAVELENGTH (Or Length of A Wave)

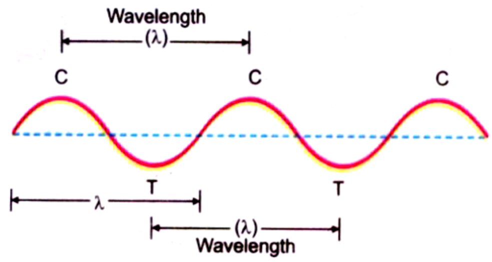
The distance between two successive crests or between two successive troughs is known as the wavelength of a transverse wave.

Or

The distance between two successive particles of the medium which are in phase is called wavelength of the wave. It is denoted by λ **(lambda).**

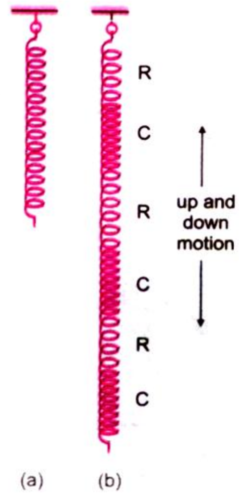
LONGITUDINAL WAVE

If the particles of a medium vibrate or oscillate to and fro about their mean positions along the direction of propagation of the disturbance then the wave is called longitudinal wave.



Activity

Take a slinky or a long spring which can be easily compressed and extended as shown in figure 9 (a). Fix one end of the slinky with a rigid support. Now push the free end of the slinky in the downward direction and release it. It is observed that the slinky begins to move up and down (i.e., "to and fro") as shown in figure. The disturbance travels form the free end to the fixed end and the parts of the slinky vibrate along the direction of the propagation the disturbance. This wave is known as **longitudinal wave.**



When a longitudinal wave passes through a medium, the medium is divided into the regions of **compressions (C)** and **rarefactions (R)** as shown in figure.

Compression. The part or region of a medium, where the density of the medium is maximum or where the particles of the medium come very close to each other is known as compression. It is denoted by C.

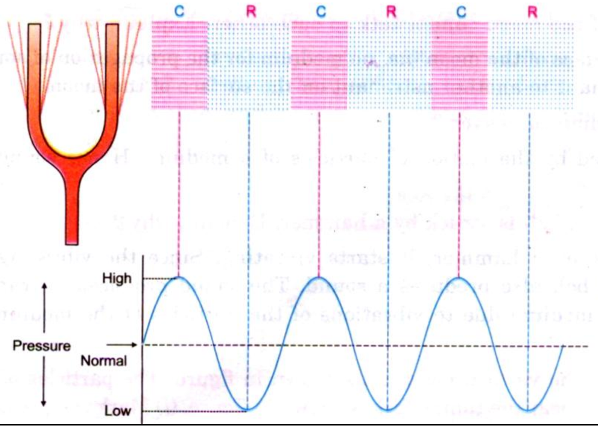
Rarefaction. The part or region of a medium, where the density of the medium is minimum or where the particles of the medium are far apart from each other is known as rearefaction. It is denoted by R.

PROPAGATION OF SOUND

A vibrating body produces sound. Now we shall study, how the sound travels from one one place to another place.

When a body vibrates, then the particles of the medium (say air) around the vibrating body are set into vibrations. The particles of the medium which are very close to the vibrating body are pushed away from the body. These particles of the medium strike against the neighbouring particles. Hence the number of particles of the medium in the region where the displaced particles strike against the neighbouring particles is large. This region is known as compression (C). Since pressure is directly proportional to the number of particles, so the **compression is a region of high pressure or high density.** When the vibrating body moves backward, a region of emptiness known as rarefaction ® or a region of low pressure or low density is created. The displaced particles of the medium rebound into the region of low pressure or rarefaction. At the same time, compression is followed outwards. Therefore, when a body vibrates to produce sound, compressions and rarefactions follow one another as the sound waves travel through the medium away from the vibrating body. When a sound wave travels through a medium, the particles of the medium simply vibrate about their rest positions and they do not move from one place to another place in the medium.

Figure represents the regions of compressions (or high pressures) and rarefactions (or low pressures) as the sound propagates in the medium.

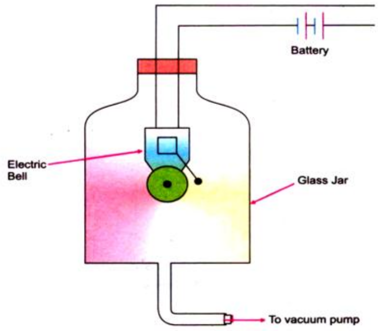


Note:- The variation of the pressure in the medium with distance as shown in figure 10 is known as the waveform produced by the propagation of sound in the medium

SOUND NEEDS A MEDIUM TO TRAVEL

We have learnt that sound travels form one place to another place when the energy is transferred from one particle to another particle of a medium like air or gas, liquid, solid etc. It means, sound needs a material medium for its propagation. In other words, sound cannot travel through vacuum.

DEMONSTRATION TO SHOW THAT SOUND WAVES CANNOT TRAVEL THROUGH VACUUM.



Put an electric bell inside a closed glass jar connected with a vacuum pump. Initially, air from the jar is not taken out. Connect the electric bell with a battery. It rings and the sound produced is heard by us.

Now start evacuating the air form a glass jar using a vacuum pump, we will hear less and less sound. i.e, the **loudness** of the sound decreases. When there is no air in the glass jar, we do not hear sound. This activity illustrates that sound waves require material medium (in this case air) for its propagation.

SOUND WAVES ARE LONGITUDINAL WAVES

When a sound wave travels through the material medium, then compressions and rarefactions follow one another as shown in figure 10. The particles of the medium through which a sound wave travels vibrate to and fro about their mean positions parallel to the direction of propagation of the sound wave. Since the wave is known as longitudinal wave, if the particles of the medium vibrate to and froabout their mean positions parallel to the direction of propagation of the wave, therefore, the sound waves are longitudinal waves.

CHARACTERISTICS OF A SOUND WAVE (OR QUANTITIES TO DESCRIBE A SOUND WAVE)

When a sound wave travels through a material medium, then the density or pressure of the medium changes continuously from maximum value to minimum value and vice-versa. Thus, the sound wave propagating in a medium can be represented as shown in figure.

HEINRICH- HERTZ
(UNIT OF FREQUENCY WAS NAMED IN HIS HONOUR)

Now, we shall discuss the characteristics or quantities to describe a sound wave.

(i) Amplitude. The maximum displacement of a vibrating body or particle from its rest position (i.e., mean position) is called amplitude. In S.I., unit of amplitude is **metre (m).**

(ii) Wavelength (or length of a wave). The distance between two successive regions of high pressure or high density (or compressions) or the distance between two successive regions of low pressure or low density (or rarefactions) is known as wavelength of a sound wave. It is denoted by λ (read as lambda)

In S.I. unit of wavelength is **metre (m)**

(iii) Frequency. The number of oscillations or vibrations made by a vibrating body or particles of a medium in one second is known as the frequency of a wave. It is denoted by v (read as Neu). In S.I., unit of frequency is **hertz** (Hz).

I hertz = one oscillation completed by a vibrating body or a vibrating particle in one second.

Time period. Time taken by a vibrating particle or a body to complete one vibration or oscillation is known as time period. It is denoted by T.

In S.I. unit of time period is **second(s).**

RELATION BETWEEN FREQUENCY AND TIME PERIOD

Let T = time period of a vibrating body

Then number of oscillations completed in T second = T

$\therefore$ Number of oscillations completed in 1 second = $\frac{1}{T}$

But number of oscillations completed in 1 second = frequency (v)

$$v = \frac{1}{T}$$

Thus, frequency = $\frac{1}{Time\ \ perio}$

Numerical Problem. The frequency of a source of sound is 200 Hz. Calculate the number of times, the source of sound vibrates in 60 seconds.

Solution. Here, frequency, $v = 200\,Hz$

It means, the source of sound vibrates 200 times in one second.

i.e., The number of times, the source of sound vibrates in 1 second = 200

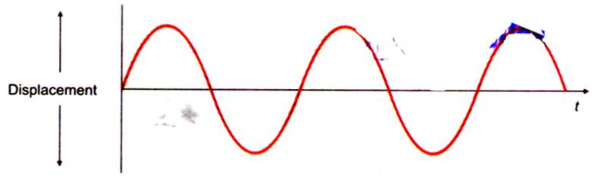
$\therefore$ The number of times, the source of sound vibrates in 60 seconds = 200×60 = 12,000.

(iv) Pitch or **Shrillness.** Pitch is the characteristic (i.e., typical feature) of a sound that depends on the frequency received by a human ear.

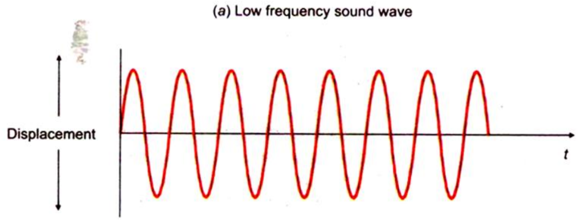
A sound wave of high frequency has high pitch and a sound wave of low frequency has a low pitch.

You must have noticed that the voice of a women has higher pitch than the voice of a man. Thus, the frequency of women's voice is higher than the frequency of man's voice.

A sound wave of low pitch (i.e. low frequency) is represented by figure 13 (a) and a sound wave of high pitch (i.e. high frequency) is represented by figure 13 (b)



(a) Low frequency sound wave



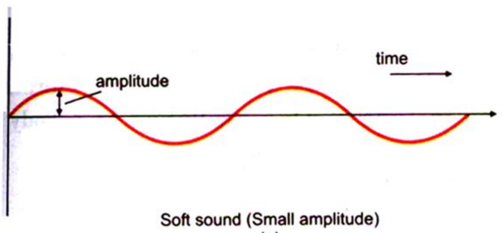
(b) High frequency sound wave

(v) Loudness. Loudness of a sound depends on the amplitude of the vibrating body producing the sound.

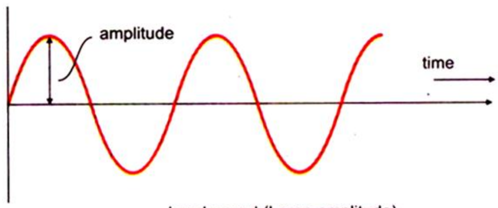
A sound produced by a body vibrating with large amplitude is a loud sound. On the other hand, a sound produced by a body vibrating with small amplitude is a feeble or soft sound. Loud sound and soft or feeble sound are represented as shown in figure I & II respectively.

Loudness is a subjective quantity. It depends on the sensitivity or the response of our ears. A loud sound to a person may be a feeble sound for another person who is hard of hearing.

(vi) Timbre or quality. Quality or timbre is a characteristic (i.e,



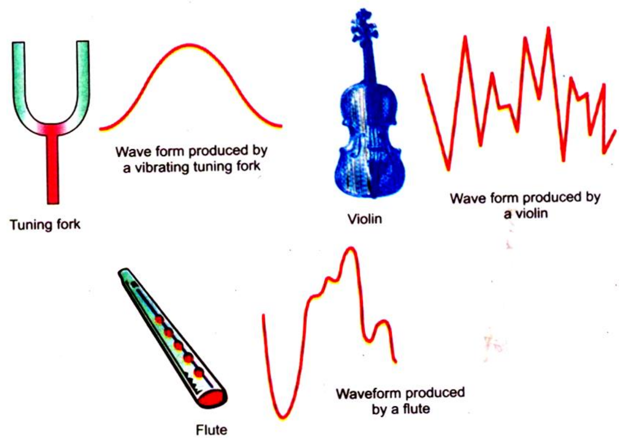
Soft sound (Small amplitude)
(a)



Loud sound (Large amplitude)
(b)

A typical feature) of a sound which enables us to distinguish between the sounds of same loudness and pitch.

This characteristics of sound helps us to recognize our friend from his voice without seeing him.



The quality of two sounds of same loudness and pitch produced by two different sources are distinguishable because of different waveforms produced by them. The waveforms produced by a vibrating tuning fork, violin and flute (Bansuri) are shown in figure.

(vii) **Intensity.** Intensity of a sound is defined as the sound energy transferred per unti time through a unit area placed perpendicular to the direction of the propagation of sound.

That is, intensity of sound

$$= \frac{Sound\ energy}{Time \times Area}$$

Intensity of a sound is **an objective physical quantity.** It does not depend on the response of our ears.

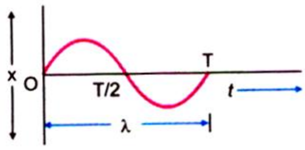
In S.I., unit of intensity of sound is $joule\ s^{-1}\,m^{-2}$ or $watt\ m^{-2}$ $\quad (\because 1J\ s^{-1} = 1W)$

DIFFERENCES BETWEEN LOUDNESS AND INTENSITY OF SOUND

S.No.	Loudness	Intensity of a sound
1.	Loundness is a subjective quantity. It depends upon the sensitivity of the human ear. A sound may be loud for a person but the same sound may be feeble for another person who is hard of hearing even when both are sitting at the same place.	Intensity of a sound is an objective physical quantity. It does not depend on the sensitivity of a human ear.
2.	Loudness cannot be measured as a physical quantity because it is just sensation which can be felt only.	Intensity of a sound can be measured as a physical quantity.

Relation between wave speed, frequency and wavelength

Let the time period of a vibrating body be t. It means, the vibrating body completes one oscillation in time T. One oscillation of a body is represented by a wave of wavelength λ as shown in figure 16.



Now, Wave speed = $\dfrac{Distance\ travelled\ by\ the\ wave}{Time\ taken}$

Here, distance traveled by the wave = wavelength (λ)

and time taken = T

$\therefore$ wave speed, $\upsilon = \dfrac{\lambda}{T} = \lambda \times \dfrac{1}{T}$

But, $\dfrac{1}{T} = \nu$ (frequency of wave)

$\therefore \ \upsilon = \lambda \nu$ ....(i)

Thus, **speed of wave = wavelength × frequency**

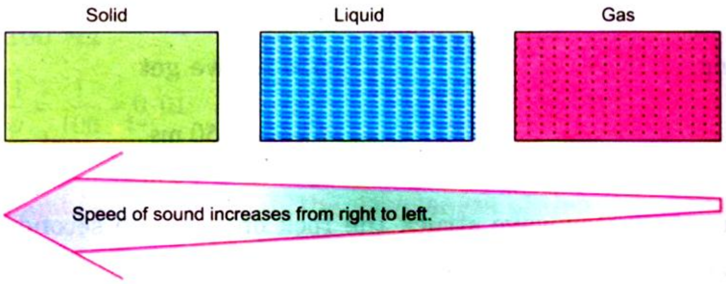
Note: The speed of a mechanical wave (i.e., sound wave) is constant in a given medium. If sound of large frequency is produced by a vibrating body, then the wavelength of this sound wave will be small, so that speed = wavelength × frequency is constant.

The speed of a sound wave differs only when the sound goes from one medium to another medium.

SPEED OF SOUND IN DIFFERENT MEDIA

Sound travels with different speeds in different media like solid, liquid and gases. This is because, sound travels in a medium due to the transfer of energy from one particle to another particle of the medium. Since the particles of the solid are very close to each other so the transfer of energy from one particle to another particle takes place in less time (i.e. faster). Hence, speed of sound in solids is large. In case of liquids, the distance between the particles is large as compared to the distance of the particles in solids. So, the transfer of energy among liquid particles is slower than in solids. Hence, speed of sound in liquids is less than the speed in liquids. In case of gases, the particle, are far away from each other as compared in case of solids and liquids. Hence, the transfer of energy from one particle to another particle of a gas is quite slow. Hence, the speed of sound in gases is less than the speed in liquids and solids.

Conclusion. Speed of sound in solids is greater than the speed of sound in liquids and the speed of sound in liquids is greater than the speed of sound in gases.



Note: The speed of sound in air increases by $61\,cm\,s^{-1}$ or $0.61\,m\,s^{-1}$ with every 1^0C increase in temperature. For example, if speed of sound in air at 0^0C is $330\,ms^{-1}$, then its speed at 25^0C will be about $345\,ms^{-1}$

EFFECT OF TEMPERATURE ON THE SPEED OF SOUND

The speed of sound in a medium depends on the temperature of the medium. As the temperature of the medium increases, the particles of the medium collide more frequently and hence the disturbance spread faster. In other words, sound travels faster as the temperature of the medium increases. On the other hand, sound travels slower as the temperature of the medium decreases.

Note:- Speed of sound does not depend on the pressure of the medium if temperature of the medium remains constant.

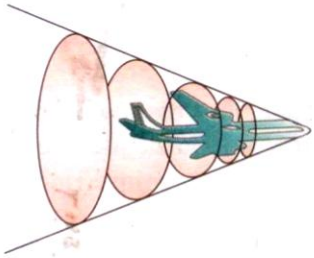
Speed of sound in some media at 20^0C is given below in the table.

Medium	***Speed (in ms^{-1})***
Solids	
Lead	*1960*
Iron (Steel)	*5940*
Aluminium	*6420*
Copper	*5000*
Brass	*4700*
Nickel	*5850*
Liquids	
Water (fresh)	*1480*
Water (Sea)	*1530*
Alcohol (ethyl)	*1150*
Caster (oil)	*1540*
Mercury	*1450*
Glycerin	*1980*
Gases	
Air	*344*
Helium	*999*
Hydrogen	*1330*

SHOCK WAVES-SONIC BOOM

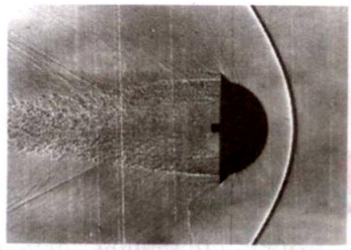
The speed of any object moving faster than the speed of sound is known as supersonic speed.

When an object say a bullet fired from a gun or a supersonic jet aircraft moves through the air with supersonic speed, then the sound waves produced by them are piled up in the form of a cone-shaped wave known as shock wave of highly compressed air. The shock wave carries a huge amount of energy. The shock waves produced a loud sound called sonic boom as it travels through the air.



(A) SHOCK WAVE PRODUCED BY A SUPERSONIC JET AIRCRAFT

When a shock wave produced by a supersonic jet aircraft strikes a building, the glass window panes even break. This is because, the large energy carried by the shock wave forces the glass window panes to vibrate violently. As a result of these vibration, the glass window panes may break.



(B) SHOCK WAVE PRODUCED BY A BULLET

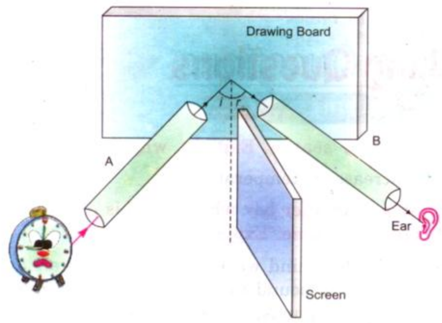
REFELECTION OF SOUND

When a sound wave traveling in a medium bounces back to the same medium after striking the second medium, reflection of sound wave is said to take place. The reflection of sound wave is similar to the bouncing back of a rubber ball after striking a wall or the surface of a floor.

Just like light, sound is reflected by the solid and liquid surfaces. The reflection of sound obeys the laws of reflection.

The laws of reflection of sound are follows:

(i) Incident angle = Reflected angle and (ii), The incident direction of sound, reflected direction of sound and the normal to the point of incidence all lie in the same plane.



The reflection of a sound can be demonstrated as follows:

Take drawing board and fix it in the vertical position on the table. Put two metallic or card board tubes A and B as shown in figure. These tubes make some angle with each other. Put a clock near one end of the tube A and a solid screen (say a drawing board) between the two tubes so that the sound of clock (i.e., tick-tick) may not be heard directly by the ear placed in front of the second tube. The sound (like tick-tick) waves after reflecting from the drawing board enter the second tube and are heard by the ear placed in front of the second tube.

Go on adjusting the position of the second tube B till the loudness of the sound heard through the second tube becomes maximum. At this stage, the incident angle $\angle =$reflected angle $\angle r$, which is the law of reflection.

ECHO

If we clap our hands while standing at some distance from a high and huge wall or a hill, we hear the clapping of our hands again after some short interval of time. The sound of clap heard by us is known as echo. Echo is produced due to the reflection of sound.

Conditions for the production of an echo

1. Time gap between the original sound and the reflected sound.

We can hear the two sounds separately if the time gap between these two sounds is more than 1/10 s or 0.1s. The time interval equal to 0.1s is known as **persistance of hearing.** This means, the impression of any sound heard by us remains for 0.1s in our brain. If any other sound enters our ears before 0.1s, then the second sound will not be heard by us. Thus, the echo will be heard if the original sound reflected by an obstacle reaches our ears after 0.1s

2. Distance between the source of sound and obstacle.

The speed of sound in air is $344\,ms^{-1}$. The distance traveled by the sound in 0.1s = speed × time = 34.4 $ms^{-1} \times 0.1s = 34.4m$. So, echo will be heard if the miniumum obstance between the source of sound and the obstacle = $\dfrac{34.4\,m}{2} = 17.2 = 17m$

Thus, the echo is heard only if the minimum distance between the source of sound and the obstacle is 17m.

3. Nature of the obstacle

For the formation of an echo, the reflecting surface or the obstacle must be rigid such as a building, hill or a cliff.

4. Size of the obstacle.

Echoes can be produced if the size of the obstacle reflecting the sound is quite large.

REVERBERATION

In big rooms and halls, echoes (due to multiple reflection of sound) follow so closely behind the original sound that the original sound appears to be prolonged even when the source of sound stops producing sound. This effect of the sound is known as **reverberation.**

A certain amount of reverberation of may improve the quality of sound. However, excessive reverberation is sometimes undesirable as it interferes with the original sound and hence makes the speech or music indistinct. For example, excessive reverberation makes the speech of a person indistinct. Moreover, rock music also becomes less pleasing with excessive reverberation. But excessive reverberation is desirable in case of orchestral and choral music.

Reverberation Time. Reverberation time is defined as the time interval during which the audible sound persists after the production of original sound is called reverberation time. For an architect, reverberation time of the auditorium (or hall) is the main concern.

The reverberation time of an auditorium used for speeches should be short.

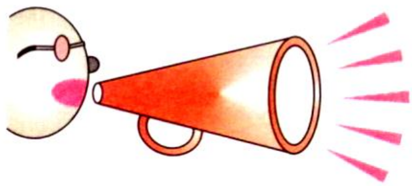
HOW TO DECREASE THE REVERBERATION TIME?

The reverberation time can be decreased by using sound absorbing materials in the auditorium. For example, the ceiling of the auditorium is made by the soft and textured material. The windows of the auditorium are covered with heavy curtains. The special tiles known as acoustic tiles are used for the flooring seats are arranged in the hall. Some plants in pots are also arranged in the hall to reduce the reverberation time.

USES OF REFLECTION OF SOUND

1. Megaphone. Megaphone is a device used to address public meetings. It is a horn-shaped. When we speak through megaphone, sound waves are reflected by the megaphone. These reflected sound waves are directed towards the people without much spreading.

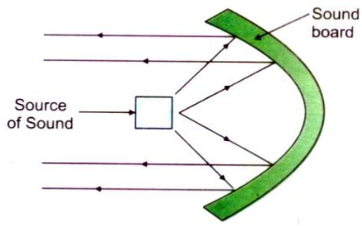
2. Hearing Aid. Hearing aid is used by a person who is hard of hearing. The sound waves falling on hearing aid are concentrated into made to fall on the diaphragm of the ear. Thus, diaphragm of the ear vibrates with large amplitude. Hence, the hearing power of the person is improved.



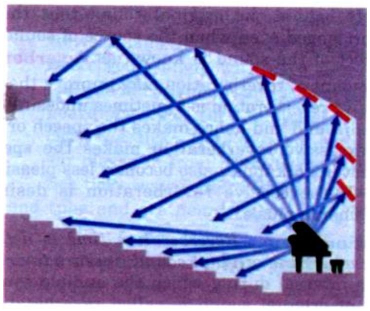
3. Sound boards. Sound boards are curved surfaces (concave) which are used in a big hall to direct the sound waves towards the people sitting in a hall. The speaker is placed at the focus of the sound board as shown in figure .

Sound waves from the speaker are reflected by the sound board and these reflected waves are directed towards the people.

4. Stethoscope. Stethoscope is a device used by doctors to listen the sound produced by heart and lungs. The sound produced by heart beat and lungs of a patient reaches the ears of a doctor due to multiple reflection of sound.



5. Ceilings of concert hall are curved. The ceilings of concert halls and auditoriums are made curved. This is done so that the sound reaches all the parts of the hall after reflecting from the ceiling are made up of sound absorbent materials to reduce the reverberation.



RANGE OF HEARING (I.E., AUDIBLE RANGE)

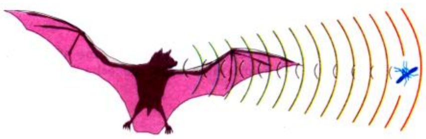
All vibrating bodies produce waves. Each wave has its own frequency. The frequency of a wave is equal to the frequency of the vibrating body producing sound. When a woman speaks, the waves produced by the vocal cords in her throat have different frequency than the frequency frequency of the waves produced by the vocal cords of a man. Can human ears hear all the frequencies produced by the vibrating bodies? The answer is No. In fact, normal human ears can hear only those waves whose frequency lies between 20 Hz and 20,000 Hz. **The sound waves having frequency between 20 Hz and 20,000 Hz are known as sound waves. Thus, the audible range of frequency is 20 Hz to 20,000 Hz.**

The waves having frequency less than 20 Hz and greater than 20,000 Hz cannot be heard by human ear. Thus, a vibrating body does not produce sound waves whose frequency is either less than 20 Hz or more than 20,000 Hz.

INFRASONICS OR INTRASOUND

The waves of frequency less than 20 Hz are known as infrasonic waves.

The infrasonic waves are produced by large vibrating bodies. For example, infrasonic waves are produced by the vibration of the earth's surface during the earthquake. Some animals like elephants, rhinoceroses and whales etc. also produce infrasonic waves. These waves are not audible to a human ear.



If has been observed that animals behavior becomes unusual just before the tremor is felt. This is because the animals has the ability to detect infrasonic waves produced at the time of tremor.

ULTRASONICS OR ULTRASOUND

The waves of frequency greater than 20,000 Hz are known as ultrasonic waves or ultrasound. These waves are not audible to a human ear but they can be heard by animals and birds.

Bats can produce ultrasonic waves by flapping their wings. They can also detect these waves. The ultrasonic waves produced by the bats after reflection from the obstacles like buildings guide them to remain away from the obstacles during their flights. Hence, they can fly during night without hitting the obstacles. Bats also catch their prey during night with the help of ultrasonic waves. The ultrasonic waves produced by a bat spread out. Hence, the bat can easily locate its prey.

Dolphins also produce ultrasonic waves. They can also detect the ultrasonic waves. They catch their prey like a fish due to their ability to detect the ultrasonic waves reaching them after reflecting from a fish.

APPLICATIONS OF ULTRASOUND (Ultrasonic Waves)

Ultrasonic waves have number of uses:

1. Ultrasonic waves are used to establish **ship to ship communication.**

2. Ultrasonic waves are used to **determine the depth of a sea.** It is done with the help of a SONAR.

3. Ultrasonic waves are used **for cleaning the hidden parts of an instrument.** The instrument or device whose hidden parts are to be cleaned is dipped in a liquid. The ultrasonic waves are passed through this liquid. These waves forces the dirt or any other impurity out from the parts of the instrument which can not be approached directly.

4. Ultrasonic waves are used for **welding plastic.** Two plastic surfaces are pressed against each other. Then ultrasonic waves are allowed to fall at a point where plastic surfaces are in contact. These waves produces heat energy. This heat energy binds the two plastic surfaces together.

5. Ultrasonic waves are used **diagonosing the diseases** in human body. Different parts of the body like bone, fat, muscles and liquid have different reflective properties. Ultrasonic waves are allowed to fall on the protion of the body of a patient to be diagnosed. These waves are reflected back by the different parts (like bones, tissues, liquids and muscles etc.) of that portion of the body in different manners. The varying echoes are recorded for analyzing that part of the body.

The method used for diagonising the different part of a human body with the help of the ultrasonic waves is known as **ultrasonography.**

6. Ultrasonic waves are used to **kill bacteria in liquids.** Thus, the liquids like milk can be preserved for a longer period of time.

7. Ultrasonic waves are used **to find faults and cracks in metals.** Ultrasonic waves are thrown on a metal under investigation. The beam of ultrasonic waves reflected by the metal is investigation. The beam of ultrasonic waves reflected by the metal is investigated. The intensity of the ultrasonic waves reflected from the fault or a crack is different from the intensity of the waves reflected from the other part of metal. Thus, the position of the fault or a crack in the metal can be easily located. In fact, the picture of the metal produced by the reflection of ultrasonic waves is taken on the screen or the monitor. By analyzing this picture, the position of the crack or fault in the metal is detected.

8. Ultrasonic waves are also used **to analyse the development of an unborn child.** Any abnormality in the growth of an unborn child can be detected by the observing the picture taken by ultrasound.

SONAR

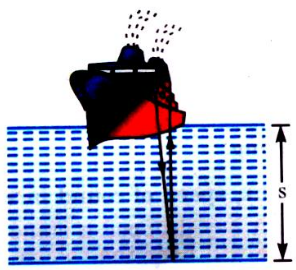
SONAR stands for Sound Navigation Ranging.

It is a device which is used in the ships to locate rocks in a sea, icebergs, submarines, old ships sank in sea etc. It is also used to measure the depth of a sea.

Principle. It is based on the principle of the reflection of sound wave (i.e., echo)

DETERMINATION OF THE DEPTH OF A SEA USING SONAR

A beam of ultrasonic waves from the transmitter of a SONAR fitted on the ship is sent towards the bottom of the sea. This beam is reflected back from the bottom of the sea and is received by the receiver of the SONAR on the ship.



The time taken by the ultrasonic waves to go from the ship to the bottom of the sea and then back to the ship is noted. Let it be ‘t’ seconds. Therefore, the time taken by the ultrasonic waves to go from the ship to the bottom of the sea is $\left(\frac{t}{2}\right)$ seconds.

Using the following formula S = $\upsilon\left(\frac{t}{2}\right)$, we can find the depth of the sea.

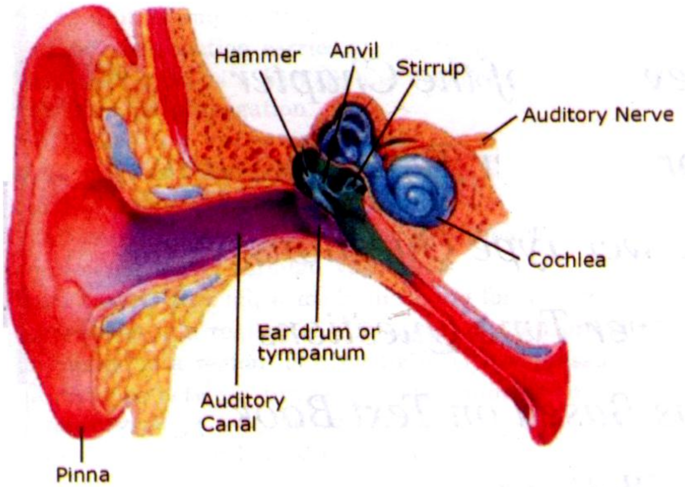
Here, $\upsilon =$ speed of ultrasonic wave in water

$S =$ depth of the sea

STRUCTURE OF HUMAN EAR (Hearing device)

The human ear is divided into three parts- the external ear, the middle ear nd the inner ear. We shall discuss only the auditory aspect of the ear and not its detailed structure.

The external ear which we see is known as **Pinna.** This part collects the sound and sends it to the auditory canal.



The sound in the form of compressions (high pressure) and rarefaction (low pressure) reaches the **ear drum** or **tympanum.** When the compressions and rarefactions strike the ear drum, the ear drum begins to vibrate. These vibrations are transmitted across the middle ear by the **three oscicles** (the hammer, the anvil and the stirrup). The vibrations produced by the eardrum and amplified (i.e., their amplitude is increased) by the hammer, anvil and the stirrup. The amplified vibrations are then transmitted to the **cochlea.** Cochlea is a coiled and fluid filled tube having the sense organ of hearing. The movement of the fluid in the cochlea due to the vibrations stimulates the auditory nerve. The impression (in the form of electrical signals) is carried by the auditory nerve to the brain. This impression is interpreted as sound by the brain.

EXAMINATION CORNER

Quick Revision of the Chapter

- Sound is a form of energy which produces the sensation of hearing in our ears.
- A motion of a body which repeats itself regular interval of time is known as periodic motion.
- The to and fro motion of a body about a fixed point after regular intervals of time is known as oscillatory motion.
- Time taken by an oscillating body to complete on vibration is known as time period(T)
- Number of oscillations made by a vibrating body in one second is known as frequency $(v\ or\ f)$.
- $T=\frac{1}{v}$
- Unit of v is s^{-1} or Hz
- The maximum displacement of a vibrating body or particle of medium from its mean position is known as amplitude
- In S.I. unit of amplitude is metre (**m**)
- Wave or wave motion carries energy from one place to another place of the medium.
- Mechanical wave is a periodic disturbance which requires material medium (i.e., solid, liquid or gas) for its propagation.
- Sound wave is a mechanical wave.
- Sound wave is longitudinal in nature.
- Sound is produced by vibrating bodies
- Sound needs material medium for its propagation.
- Sound cannot travel through vacuum.
- Sound travels through a medium in the form of compressions and rarefactions.
- Compression is a region (of a medium) of high pressure or high density.
- Rarefaction is a region (of a medium) of low pressure or low density.
- The distance between two successive compressions or two successive rarefactions is known as the wavelength of a sound wave.
- In S.I. unit of wavelength is metre (m)
- **Pitch or shrillness** is a characteristic of a sound that depends on the frequency received by a human ear.
- High pitch sound has high frequency
- Low pitch sound has low frequency.
- **Loudness** of a sound is the characteristic of a sound that depends upon the amplitude of the vibrating body producing sound.
- **Loudness** is a sound is the characteristic of a sound that depends upon the amplitude of the vibrating body producing sound.
- **Loudness** is a subjective quantity and depends on the sensitivity of the human ear.
- A loud sound for a person may be feeble sound for another person.
- **Timber or quality** is a characteristics of sound that enables us to distinguish between two sounds of same pitch and same loudness.
- **Intensity of a sound** is defined as the sound energy transferred per unit time per unit area placed perpendicular to the direction of sound.
- Intensity of sound is an objective physical quantity and can be measured.
- In S.I. unit of intensity of sound is $Jm^{-1}\ m^{-2}$ or Wm^{-2}
- The relationship between speed of wave, wavelength and frequency is
- $\upsilon=v\lambda$
- A wave of high frequency in a given medium has small wavelength.
- A wave of low frequency in a given medium has long wavelength.
- Speed of sound is different in different media.
- Sound travels faster in solids than in liquids.
- Sound travels faster in liquids than in gases.
- Speed of sound increase with the increase in temperature of the medium.
- For every 1^0C rise in temperature of air, the increase in the speed of sound is $0.61ms^{-1}$

- Supersonic jet air craft and a bullet fired from a gas produced a **shock wave.**
- Shock wave carries a huge amount of energy and it produces a loud sound called sonic boom.
- **Echo** is repetition of sound due to the reflection of original sound by a large and hard obstacle.
- When echoes due to multiple reflection of sound follow so closely behind the original sound that the original sound appears to be prolonged even when the source of source stops to produced sound, then the effect is known as reverberation.
- **Reverberation time** is the time interval during which the audible sound persists after the production of original sound.
- The **audible range of requency** is 20 Hz to 20,000 Hz (or 20 kHz).
- Infrasonic waves are the waves of frequencies less than 20 Hz.
- Ultrasonic waves (or ultrasound) are the waves of frequencies greater than $20,000\,Hz$ (or $20\,kHz$)
- Infrasonic waves are the waves of frequencies less than 20 Hz.
- Ultrasonic waves (or ultrasound) are the waves of frequencies greater than 20,000 Hz (or 20 kHz).
- Human ears cannot hear infrasonic and ultrasonic waves but animals and birds can hear these waves.
- Human ear is a hearing device. It consist of three parts- the external ear, the middle ear and the inner ear.

VERY SHORT ANSWER TYPE QUESTIONS

1. What is sound?

Ans. Sound is form of energy which produces the sensation of hearing in our ears.

2. What is a mechanical wave?

Ans. A wave which requires material medium for its propagation is called mechanical wave.

3. What is a traverse wave?

Ans. If the particles of the medium vibrate about their mean positions at right angles to the direction of propagation of the disturbance, then the wave is called transverse wave.

4. What is a longitudinal wave?

Ans. If the particles of a medium vibrate or oscillate to and fro about their mean positions along the direction of propagation of the disturbance then the wave is called longitudinal wave.

5. How a sound is produced?

Ans. Vibrating bodies produce sound.

6. What do you understand by the term "compression" and "rarefaction"?

Ans. A region of high pressure of a medium when wave travels through it is called compression. A region of low pressure of a medium when wave travels through it is called rarefaction.

7. What happens to the medium thorugh which sound travels?

Ans. A medium is divide into the regions of high press or high pressure or high density and regions of low pressure or

low density.

8. What do you understand by the wavelength of a sound wave?

Ans. Distance between two successive compression or successive rarefactions is called wavelength of a sound wave.

9. What do you understand by the frequency of a sound wave?

Ans. The number of vibrations or oscillations made by a vibrating body in one in one second is called the frequency of a sound wave.

10. Name the physical quantity which determines the pitch of a sound.

Ans. Frequency of a sound wave.

11. Name the physical quantity which determines the loudness of a sound.

Ans. Amplitude of the vibrating body.

12. **What do you understand by the pitch of a sound?**

Ans. Pitch of a sound is the characteristic of sound that depends on the frequency received by a human ear.

13. **What do you understand by the loudness of a sound?**

Ans. Amplitude of the vibrating body determines the loudness of the sound. Large is the amplitude of vibration, large is

the loudness of the sound produced.

14. **Define the characteristic "timbre" or "quality" of a sound.**

Ans. The wave form produced by a vibrating body determines the timber or guality of sound.

15. **Which characteristic of a sound helps you to identify your friend by his voice while sitting with others in a dark room?**

Ans. Timbre or quality of sound.

16. **What do you mean by the intensity of sound?**

Ans. Sound energy per unit time per unit area is known as the intensity of sound.

17. **Write the S.I. unit of intensity of sound.**

Ans. $Js^{-1} m^2$ or Wm^{-2}.

18. **Out of which of the following media, the speed of sound is maximum: solid, liquid, gas.**

Ans. The Speed of sound is maximum in solid medium.

19. **Sound travels faster as the temperature of the medium increases. Why?**

Ans. Speed of sound increases with increase in temperature.

20. **By what amount, the speed of sound in air increases with 1^0C rise in temperature of the air?**

Ans. $0.61 ms^{-1}$ or $61 cm\ s^{-1}$

21. **What do you understand by supersonic speed?**

Ans. The speed of an object moving faster than the speed of sound is known as supersonic speed.

22. **What is a shock wave?**

Ans. The sound waves produced by an object moving with a speed greater than the speed of sound are known as shock waves.

23. **What do you understand by Sonic boom?**

Ans. A loud sound produced by shock waves is known as sonic boom.

24. **What do you understand by the reflection of sound?**

Ans. The bouncing back of a sound wave after striking a solid surface is called reflection of sound.

25. **What is an echo?**

Ans. Echo is a repetition of sound due to the reflection of original sound by a large and hard obstacle.

26. **What should be the minimum distance between the source of sound and the obstacle to hear an echo?**

Ans. 17 metres

27. **What do you understand by the reverberation?**

Ans. The phenomenon of prolongation of original sound even after the source of sound stops producing sound is called reberberation.

28. **What is reverberation time?**

Ans. The time interval during which original sound appears to prolong.

29. **What is the audible range?**

Ans. Audible range is 20 Hz to 20,000 Hz

30. **What are infrasonic waves?**

Ans. The waves of frequency less than 20 Hz are called infrasonic waves.

31. **What are ultrasonic waves?**

Ans. The waves of frequency greater than 20,000 Hz are called ultrasonic waves.

32. **What type of waves are produced by bats?**

Ans. Ultrasonic waves

33. **What does SONAR stand for?**

Ans. SONAR stands for Sound Navigation and Ranging.

34. **What is the basic principle which SONAR works?**

Ans. SONAR works on the principle of reflection.

SHORT ANSWER TYPE QUESTIONS

1. **Explain how the sound propagates through a medium.**

Ans. Refer Article booklet

2. **Sound cannot ravel through vacuum. How will you demonstrate this fact?**

Ans. Refer Article booklet

3. **Sound waves are called mechanical waves. Why?**

Ans. Since sound wave are characterized by the motion of the particles of a medium, therefore, sound waves are mechanical waves.

4. **Why, sound wave are longitudinal waves?**

Ans. Refer Article booklet

5. **What are the differences between loudness and intensity of sound?**

Ans. Refer Article booklet

6. **Sounds of same loudness and pitch but produced by different musical instruments like a violin and flute and distinguishable. Explain, why?**

Ans. This is due to the quality or timbre of sound waves.

7. **Show that $\upsilon = v\lambda$, where symbols have usual meanings.**

Ans. Refer Article booklet

8. **Why is the speed of sound greater in solides than in gases?**

Ans. This is because particle of solids are closer than the particles of gases.

9. **The glass windows may break when a shock wave produced by supersonic jet aircraft strikes the building. Explain, why?**

Ans. This is because the large energy carried by shock wave forces the windown pans to vibrate violently.

10. **Explain, how can you demonstrate the reflection of sound.**

Ans. Refer Article booklet

11. **How, the hearing power of a person can be improved by the hearing aid?**

Ans. Refer Article booklet

12. **What is an echo? State the conditions required to hear an echo.**

Ans. Refer Article booklet

13. **What is reverberation time? How can one reduce the reverberation time of an auditorium?**

Ans. Refer Article booklet

14. **Bats cannot see but even then they can catch their prey during night. Explain, why?**

Ans. Refer Article booklet

15. **Bats cannot see but even than they can catch their prey during night. Explain, why?**

Ans. Refer Article booklet

16. **State two uses of ultrasonic or ultrasound.**

Ans. Refer Article booklet

17. **How is ultrasound used for cleaning?**

Ans. Refer Article booklet

18. **Explain, how defects in a metallic block can be detected using ultrasound.**

Ans. Refer Article booklet

LONG ANSWER TYPE QUESTIONS

1. **Describe with the help of a diagram, how compressions and rarefactions are produced in air near a source of sound.**

Ans. Refer Articles booklet

2. **What is reflection of sound? State laws of reflection of sound?**

Ans. Refer Article booklet

3. **What is reverberation? How can it be reduced?**

Ans. Refer Article booklet

4. **Give five practical applications of reflection of sound.**

Ans. Refer Article booklet

5. **Give five practical applications of ultrasonic waves.**

Ans. Refer Article booklet

6. **Explain the working and application of a sonar.**

Ans. Refer Article booklet

7. **Explain by drawing a diagram, how the human ear work.**

Ans. Refer Article booklet

QUESTIONS (BASED ON TEXT BOOK)

In Text Questions

1. **Explain how sound is produced by your school bell.**

Ans. When school bell is struck by a hammer, it starts vibrating. Since the vibrating bodies produce sound, so the vibrating school bell produces the sound.

2. **Why are sound waves called mechanical waves?**

Ans. Refer Short Answer Question 3.

3. **Suppose you and your friend are on the moon. Will you be able to hear any sound produced by your friend?**

Ans. Sound waves need material medium like air to move from one place to another place. Since there is no air on the moon, so sound cannot travel from one place to another place. Hence, we cannot hear sound on the moon.

4. **Which wave property determines (a) loudness, (b) pitch?**

Ans. (a) Amplitude of the wave determines loudness. (b) Frequency of the wave determines pitch.

5. Guess which sound has a higher pitch: guitar or car horn?

Ans. Guitar, because frequency of sound produced by guitar is higher than the produced by car horn.

6. What are wavelength, frequency, time period and amplitude of a sound wave?

Ans. For wave length and Frequency. Refer Very Short Answer Questions 8,9.

Time period. Time taken by a vibrating body to complete one oscillation.

Amplitude. The maximum displacement of a vibrating body from its rest position or mean position.

7. How are the wavelength and frequency of a sound wave related to its speed?

Ans. $\upsilon = v\lambda$

8. Calculate the wavelength of a sound wave whose frequency is 200 Hz and speed is $440\, m/s$ in a given medium.

Ans. Here, $v = 220\, Hz$

$\upsilon = 440\, m/s$

$\lambda = ?$

Using, $\upsilon = v\lambda$, we get

$$\lambda = \frac{\upsilon}{v} = \frac{440}{220} = 2m$$

9. A person is listening to a tone of 500 Hz sitting at a distance of 450 m from the source of sound. What is the time interval between successive compressions from the source?

Ans. $$T = \frac{1}{v} = \frac{1}{500} = 2 \times 10^{-3} s = 2\, ms$$

10. Distinguish between loudness and intensity of sound.

Ans. Refer Article booklet

11. In which of the three media, air, water or iron, does sound travel the fastest at a particular temperature?

Ans. Sound travels the fastest iron.

12. An echo returned in 3s. What is the distance of the reflecting surface from the source, given that the speed of sound is 342 ms^{-1}?

Ans. Time taken by sound to travel from the source to the reflecting surface, $t = \frac{3}{2} = 1.5$ s

Speed, $\upsilon = 342\ ms^{-1}$

$\therefore$ Distance of reflecting surface from the source,

$S = \upsilon t = 342 \times 1.5 = \mathbf{513m}$

13. Why are the ceilings of concert?

Ans. So that the sound after reflection from the ceiling reaches all the corners of the hall.

14. What is the audible range of the average human ear?

Ans. 20 Hz to 20,000 Hz

15. What is the range of frequencies associated with:

(a) infra sound? (b) ultra sound?

Ans. (a) Frequencies less than 20 Hz. (b) Frequencies greater than 20,000 Hz.

16. A submarine emits a sonar pulse, which returns from an underwater cliff in 1.02s. If the speed of sound in salt water is 1531 m/s, how far away is the cliff?

Ans. Time taken by the pulse to go from submarine to the cliff, $t = \frac{1.02}{2} = 0.51s$

Speed of sound, $\upsilon = 1531 m/s$ $\therefore$ Distance of cliff form the submarine,

$S = \upsilon t = 1531 \times 0.51 = 780.81m$

CHAPTER AND EXERCIESE

1. What is sound and how is it produced?

Ans. Sound is a form of energy which produces the sensation of hearing in our ears. Sound is produced by forcing an object to vibrte. In other words, sound is produced by a vibrating object.

2. Why is sound wave called longitudinal wave?

Ans. Refer Article booklet

3. Which characteristic of the sound helps you to identify your friend by his voice while sitting with others in a dark room?

Ans. Rever Very Short Answer Questions 15

4. Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen. Why?

Ans. Refer Higher Order Thinking Question 3 after Article booklet

5. A person has a hearing range of 20 Hz to 20 kHz. What are the typical wavelength of sound waves in air corresponding to these two frequencies? Take the speed of sound in air as $344 ms^{-1}$.

Ans. We know, $\upsilon = \nu\lambda$ Or $\lambda = \frac{\upsilon}{\nu}$

Here, $\upsilon = 344\ ms^{-1}$

(i) When, $\nu = 20 Hz$ $\therefore$ $\lambda = \frac{344}{20} = 17.2 m$

(ii) When, $\nu = 20 kHz = 20,000 Hz$ $\therefore$ $\lambda = \frac{344}{20,000} = 0.0172 m$

6. Two children are at opposite ends of an aluminum rod. One strikes the end of the rod with a stone. Find the ratio of times taken by the sound waves in air and in the aluminum to reach the second child.

Ans. Let l = length of the rod

Time taken by sound to travel distance, l in aluminum rod, $t_1 = \frac{Distance}{Speed\ of\ sound\ in\ the\ rod}$

Or $t_1 = \frac{1}{\upsilon_r}$ .....(i)

Time taken by sound to travel distance, l in air, $t_2 = \frac{l}{\upsilon_a}$ ....(ii)

$\therefore \frac{t_2}{t_1} = \frac{l}{\upsilon_a} \times \frac{\upsilon_r}{l} = \frac{\upsilon_r}{\upsilon_a}$

Now, $\upsilon_r = 6420\ m s^{-1}$ (speed in aluminium)

$\upsilon_a = 346 m s^{-1}$ (speed in air)

$\therefore \frac{t_2}{t_1} = \frac{6420}{346} = 18.55$

7. The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute?

Ans. Frequency of source = 100 Hz

$\therefore$ Number of times the source of sound vibrates in 1s = 100

$\therefore$ Number of times the source vibrates in a minute or 60s = 100 $\times$ 60 = 6000

8. Does sound follow the same laws of reflection as light does? Explain.

Ans. Yes, sound waves are reflected just like light wave.

9. When a sound is reflected from a distance object, an echo is produced. Let the distance of the reflecting surface and the source of sound production remains the same. Do you hear echo sound on a hotter day?

Ans. Let $d =$ distance between the reflecting surface and the source of sound

$\upsilon =$ speed of sound in air.

$\therefore$ the echo will be heard after time, $t = \frac{2d}{\upsilon}$

On a hotter day, speed of sound increases with increase in temperature. Hence, the time after which echo is heard decreases. If the time taken by the reflected sound is less than 0.1s after the production of original sound, then echo is not heard. However, if this time is greater than 0.1s, then echo will be heard.

10. Give two partical application of reflection of sound waves.

Ans. (i) Megaphone (ii) Hearing aid.

11. A stone is dropped from the top of a tower 500m high into a pond of water at the base of the tower. When is the splash heard at the top? Given g = $10 ms^{-2}$ and speed of sound = $340\ ms^{-1}$

Ans. Time, after which splash is heard = time taken by the stone to reach the surface of water in a pond + time taken by the sound of splash to reach the top of tower.

(i) Here, $u = 0$, $S = 500 m$, $g = 10\ ms^{-2}$

Using, $S = ut + \frac{1}{2}gt^2$, we get

$500 = 0 + \frac{1}{2} \times 10t^2 = 5t^2$ Or $t^2 = 100$ or $t = 10s$

Thus, time taken by the sound to reach the top of tower = 1.47 s

$\therefore$ Time, after which splash is heard $= 10s + 1.47s \quad = 11.47\,s$

12. A sound wave travels at a speed of $399\,ms^{-1}$. If its wavelength is 1.5m, what is the frequency of the wave? Will it be audible?

Ans. Here, $\upsilon = 399\ m\ s^{-1}$ $\lambda = 1.5cm = 0.015m$ $v = ?$

Using, $\upsilon = v\lambda$, we get $v = \frac{\upsilon}{\lambda} = \frac{399}{0.015}$ $= 26,000\ Hz$

Since audible range of frequencies is 20 Hz to 20,000 Hz. Hence, the given frequency will not be audible.

13. What is reverberation? How can it be reduced?

Ans. For reverberation, Refer Very Short Answer Question 27

Reverberation can be reduced by covering the roof and walls of hall by sound absorbing materials.

14. What is loudness of sound? What factors does it depend on?

Ans. Loudness of a sound is a subjective quantity which causes unpleasant effect on our ear.

Loudness depends upon the amplitude of the vibrating body and the sensitivity of human ear.

15. Explain how bats use ultrasound to catch a prey.

Ans. Refer Article booklet

16. A sonar device on a submarine sends out a signal and receives and echo 5s later. Calculate the speed of sound in water if the distance of the object from the submarine is 3625 m

Ans. Time taken by the signal to go from submarine to the object, $t = \frac{5}{2} = 2.5s$

Distance between submarine and object, S = 3625 m

Using, $S = \upsilon t$, we get

$$\upsilon = \frac{S}{t} = \frac{3625m}{2.5s} = 1450\,ms^{-1}$$

MULTIPLE CHOICE QUESTIONS

Choose the correct option:

1. Wave motion transfers

(a) matter (b) momentum (c) energy (d) all of these.

2. Which of the following waves is a mechanical wave?

(a) light wave (b) sound wave (c) X-rays (d) ultra-violet ray.

3. Distance between two successive compressions

(a) $\frac{\lambda}{4}$ (b) $\frac{\lambda}{2}$ (c) λ (d) 2λ

4. Distance between a compression and the adjoining rarefaction is

(a) $\frac{\lambda}{4}$ (b) $\frac{\lambda}{2}$ (c) λ (d) 2λ

5. Relation between frequency (v) and time period (T) is

(a) $v = T$ (b) $v = T^2$ (c) $\frac{v}{T^2} = 1$ (d) $vT = 1$

6. The unit of amplitude of a vibrating particle is

(a) second (b) hertz (c) ms^{-1} (d) m

7. The unit of frequency is

(a) second (b) hertz (c) m (d) km

8. $1kHz$ is equal to

(a) 10 Hz (b) 100 Hz (c) 1000 Hz (d) 10,000

9. Sound wave can travel

(a) only in solid (b) only in liquid (c) only in gas (d) in all (solid, liquid, gas).

10. Sound wave is

(a) transverse in nature (b) longitudinal in nature

(c) both transverse and longitudinal in nature. (d) none of these

11. Compression is a region of

(a) low pressure (b) normal pressure (c) high pressure (d) no pressure.

12. Pitch of a sound depends upon

(a) amplitude (b) frequency (c) speed of sound (d) pressure of the medium.

13. Relation between speed of sound, wavelength and frequency is

(a) $\upsilon = \frac{v}{\lambda}$ (b) $v = \frac{\lambda}{v}$ (c) $uv = \lambda$ (d) $\upsilon = v\lambda$

14. A sound wave of large frequency is traveling in air. Then the wavelength of this sound wave will be

(a) small (b) large (c) infinite (d) none of these

15. The speed of sound is maximum in

(a) air (b) hydrogen (c) water (d) iron

16. The speed of sound in air

(a) decreases with the increase in temperature (b) increase with the increase in temperature

(c) remains the same with the increase in temperature

(d) remains the same with the decrease in temperature.

17. The speed of sound in air at constant temperature

(a) decreases with increase in pressure (b) increase with increase in pressure

(c) remains the same with the increase in pressure (d) none of these

18. The speed of an object moving faster than the speed of sound in air is known as

(a) infrasonic (b) ultrasonic (c) supersonic (d) none of these

19. When the temperature of air increases by $1^0 C$, the increase in speed of sound in air

(a) $0.061 ms^{-1}$ (b) $0.0061 ms^{-1}$ (c) $0.61 cms^{-1}$ (d) $0.61 ms^{-1}$

20. The minimum distance between the source of sound and the rigid obstacle to produce an echo should be

(a) $17\, km$ (b) $17\, cm$ (c) $17\, mm$ (d) $17\, m$

21. A sonar echo takes 4.4 s to return from a submarine. If the speed of sound in water is $1500\, ms^{-1}$, then the distance of submarine from the sonar is

(a) $1500\, m$ (b) $3000\, m$ (c) $3300\, m$ (d) $3600\, m$

22. During summer, an echo is heard

(a) sooner than during winter (b) later than during winter

(c) after same time as in winter (d) rarely.

23. Audible frequency range is

(a) 20 Hz to 2 kHz (b) 20 Hz to 20 kHz (c) 20 Hz to 200 kHz (d) 20 Hz to 20000 kHz

Answers

1.(c) **2.**(b) **3.**(c) **4.**(b) **5.**(d) **6.**(d) **7**.(b) **8**.(c) **9.**(d) **10.**(b) **11.**(c) **12.**(b)
13.(d) **14.**(a) **15.**(d) **16.**(b) **17.**(c) **18.**(c) **19.**(d) **20.**(d) **21.**(c) **22**.(a) **23.**(b)

Hints to (Typical MCQs)

21. Distance = speed × time

= 1500× (4.4/2)

= **3300 m**

Higher Order Thinking Questions

1. **Sound of explosions taking place on other planets and the moon are not heard by a person on the earth. Explain, why?**

Ans. Sound needs material medium for its propagation from one place to another place. In other words, sound cannot travel through vacuum. Since there is no material medium on the moon as moon has no atmosphere, so the sound of explosions taking place on other planets and the moon cannot reach the earth.

2. **Two astronauts on the surface of the moon cannot talk to each other. Explain, Why?**

Ans. Since there is no air on the surface of the moon (i.e., no medium for the propagation of sound), so the sound cannot travel form one astronaut to another astronaut on the surface of the moon.

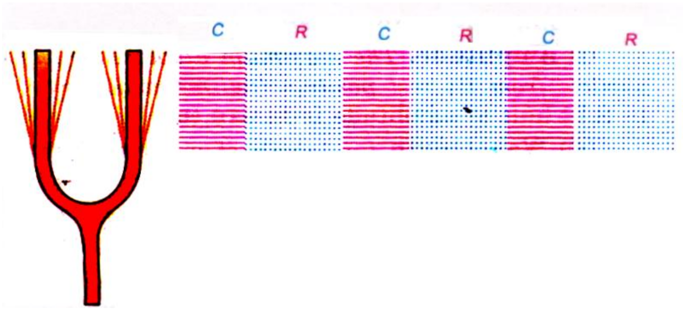
3. **Why sound waves are called mechanical waves?**

Ans. Sound waves are characterized by the motion of particles of a medium. Hence sound waves are called mechanical waves.

4. **Sound is produced, when the school bell is struck by a hammer. Explain, why?**

Ans. When a school bell is struck by a hammer, it starts vibrating. Since the vibrating bodies produce sound, so the vibrating school bell also produces a sound. The sound produced is transferred from one place to another place of the medium due to vibrations of the the particles of the medium about their means positions.

5. A vibrating tuning fork is held in the vertical position as showin in figure. The particles of the air vibrate to and fro and the pattern of the air near the tuning fork is shown in figure. (i) Mark compressions (C) and rarefactions (R) in the air in the given pattern. (ii) Name the regions of high pressure (or high density) and low pressure (or low density) of the air.



(ii) Compressions are the regions of high pressure or high density of air. Rarefactions are the regions of low pressure or low density of the air.

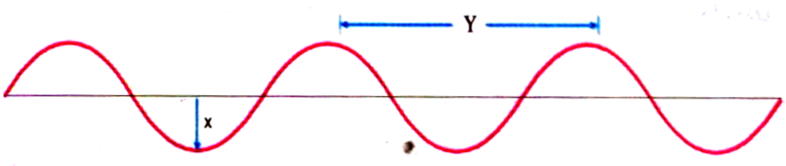
1. A loud sound can be heard at a large distance but a feeble or soft sound cannot be heart at a large distance. Explain, why?

Ans. Sound is a form of energy which is transferred from one place to another place. As sound energy is directly proportional to the square of the amplitude of a vibrating body, so loud has large energy, whereas soft sound has small energy. As the sound travels through a medium, sound with small energy is absorbed after traveling a small distance in the medium. Therefore, loud sound can be heard at a large distance but feeble sound cannot be heard at a large distance.

2. A sound wave traveling in a medium is represented as shown in figure. (i) Which letter represents the amplitude of the sound wave?

(ii) Which letter represents the wavelength of the wave?

(iii) What is the frequency of the source of sound if the vibrating source of sound makes 360 oscillations in 2 minutes.



Ans. (i) Letter X represents the amplitude of the sound wave.

(ii) Letter Y represents the wavelength of the sound wave.

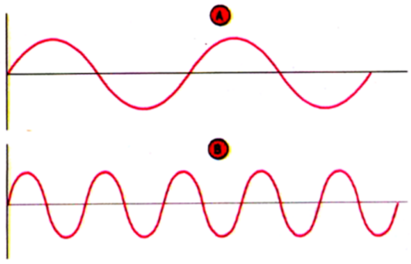
(iii) Number of oscillations made in 2 minutes (120 s) =360

$\therefore$ Numer of oscillations made in 1 second

$$= \frac{360}{120s} = 3s^{-1} \quad \text{or} \quad 3\,Hz$$

Hence, frequency of the source of sound = 3 Hz

3. **Two sound waves A and B are shown in the figure. Name the sound wave of (i) high frequency (ii) low frequency.**



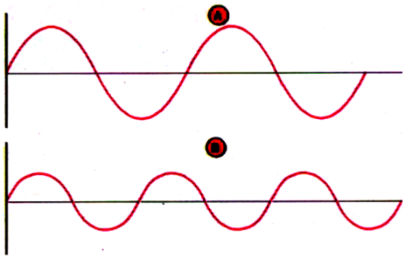
Ans. (i) Wave B has high frequency as it repeats itself after smaller intervals of time.

(ii) Wave A has low frequency as it repeats it self after longer intervals of time.

4. **Two sound waves A and B are shown in figure. Name the sound wave having (i) small amplitude (ii) large amplitude.**

Ans. (i) Sound wave B has small amplitude

(ii) Sound wave A has large amplitude.



5. **Sound travels faster in summer season that in winter season. Explain, why?**

Ans. This is because, speed of sound increase with increase in temperature.

6. **A body strikes one end of a long iron pipe with a stone. Another boy who keeps his ear close to the other end of the pipe heard two sounds in a short interval of time. Explain, why?**

Ans. When a body strikes an iron, sound is produced. The sound waves travel through air and the pipe. Since speed of sound in iron is greater than the speed of sound in air, so the sound travels faster through iron pipe than air. Hence, another boy hears two sounds, one traveling through iron pipe and the other traveling through the air.

7. **On a rainy day, flash of light and thunder are produced at the same time. Why is flash of light seen a**

few seconds earlier than hearing the thunder?

Ans. The velocity of light is much greater than the velocity of sound. That is why, flash of light is seen earlier than

hearing the thunder.

8. **Can you hear an echo if you shout in front of a huge curtain at a distance of 18m?**

Ans. No. Echo can be heard if the obstacle reflecting the sound is rigid. Since curtain is not able to reflect the appreciable amount of sound, so echo cannot be heard.

9. **An echo is heard on a day when temperature is about $22^0 C$. Will the echo be heard sooner or later if the temperature falls to $4^0 C$?**

Ans. Time after which an echo is heard is given by $t = \frac{Distance}{Speed\ of\ sound\ in\ air}$

Since, speed of sound in air decreases with the decrease in temperature, so the time after which the echo will be heard increases. Hence, the echo will be heard later than the echo heard when temperature was 22^0C.

10. An echo is heard on a day when temperature is about 22^0C. Will the echo be heard sooner or later if the temperature increases to 40^0C?

Ans. Time after which an echo is heard is given by $t = \frac{Distance}{Speed\ of\ sound\ in\ air}$

Since, speed of sound in air increases with the increase in temperature, so the time after which the echo will be heard decreases. Hence, echo will be heard sooner than the echo heard when temperature was 22^0C.

11. Why multiple echoes are heard in an auditorium?

Ans. Multiple (means many) echoes are heard in an auditorium due to the multiple reflections of sound.

12. The reverberation time of a hall used for speeches should be very short. Explain why?

Ans. If the reverberation time of a hall is long, then the multiple echoes will interfere with the original sound.

Hence nothing will be heard distinctly. For this reason, the reverberation time of the hall should be very short.

13. Echoes are not heard in a small room. Explain why?

Ans. Echo can be heard if the minimum distance between the source of sound and the obscure is 17 m. that is why, echoes are not heard in a small room.

MODEL NUMERICAL PROBLEMS

Formula used: $\upsilon = \nu\lambda$

Units: υ is measured in ms^{-1}, ν in Hz and λ in **m**

1. A bat can hear sound of frequency 100 kHz. Find the wavelength of the sound wave in air corresponding to this frequency. Given, speed of sound in air = $344\,ms^{-1}$

Sol. Here, $\nu = 100\,kHz = 100\times10^3\,Hz = 10^5\,Hz$

$\upsilon = 344\,ms^{-1}$ Using, $\upsilon = \nu\lambda$, we get

$\lambda = \frac{\upsilon}{\nu} = \frac{344\ ms^{-1}}{10^5\,Hz(s^{-1})}$ $= 344\times10^{-5}m$

$= 3.44\times10^{-3}m = 3.44\,mm$

2. A boy heard a sound of frequency 100 Hzat a distance of 500m from the source of sound. What is the time period of oscillating particles of the medium?

Sol. Here, $\nu = 100\,Hz$

Using, $T = \frac{1}{v} = \frac{1}{100} = 0.01s$

Thus, time period = $0.01s$

3. The water waves are produced at a frequency of 40 Hz. If the wavelength of these waves is 2.5 cm, calculate the speed of the waves.

Sol. Here, Frequency, $v = 40\,Hz\,(or\ s^{-1})$

Wavelength, $\lambda = 2.5\ cm = 0.025\ m$

Using, $\upsilon = v\lambda$, we get

$\upsilon = 40\,s^{-1} \times 0.025\,m = 1ms^{-1}$

4. A radio station transmits wave of wavelength 200 m. If the speed of the waves is $3 \times 108\,ms^{-1}$, find the frequency of the radio station.

Sol. Here, Wavelength, $\lambda = 200m$

Speed $\upsilon = 3 \times 10^8\ ms^{-1}$

Using, $\upsilon = v\lambda$, we get

$v = \frac{\upsilon}{\lambda} = \frac{3 \times 10^8 ms^{-1}}{200m} = 1.5 \times 10^6\ s^{-1}$ `or $1.5 \times 10^6\ Hz$

5. Calculate the time taken by a sound wave of frequency 1000 Hz and wavelength 50 cm to travel a distance of 500 m.

Sol. Here, $v = 1000\,Hz;$ $\lambda = 50\,cm = 0.5\,m$

$S = 500\,m$

Step 1. Using, $\upsilon = v\lambda$, we get

$\upsilon = 1000\,Hz \times 0.5\,m = 500\,ms^{-1}$ $(\because 1Hz = 1s^{-1})$

Thus, speed of sound wave, $\upsilon = 500\,ms^{-1}$

Step2 Using, $S = \upsilon t,$ we get

$t = \frac{S}{\upsilon} = \frac{500m}{500\,ms^{-1}} = 1s$

Thus, the given sound wave takes is to travel a distance of 500m

6. Audible range of requencies is 20 Hz to 20,000 Hz. Find the range of wavelengths corresponding to this frequency. Given, velocity of sound = $340\,ms^{-1}$

Sol. We know, $\upsilon = v\lambda$ or $\lambda = \frac{\upsilon}{v}$

When $v = 20\,Hz,$ $v = 20\,Hz,$ $\lambda = \frac{340\,ms^{-1}}{20,000\,s^{-1}} = 0.017\,m$

Thus, range of wavelength = $0.717\,m$ to $17m$

7. A rock at the bank of a cost is struck by water waves. Find the frequency of the waves striking the rock, if the distance between two consecutive crests or troughs is 50 metre. Given, velocity of water wave = $50\,ms^{-1}$.

Sol. Here, $\upsilon = 50\, ms^{-1}$

$\lambda = 50\, m$

Using, $\upsilon = \nu\lambda$, we get

$$\nu = \frac{\upsilon}{\lambda} = \frac{50\, ms^{-1}}{50\, m} = 1s^{-1} = 1Hz$$

Thus, the water wave struck the rock one is one second

8. A long spring whose one end is rigidly fixed is stretched from the other end then left. Longitudinal waves of frequency 10 Hz are produced. If the velocity of the wave is $25\, ms^{-1}$, find the distance between two consecutive compression in the spring.

Sol. Here, $\nu = 10\, Hz$

$\upsilon = 25\, ms^{-1}$

Using, $\upsilon = \nu\lambda$, we get

$$\lambda = \frac{\upsilon}{\nu} = \frac{25}{10} = 2.5\, m$$

$\therefore$ The distance between two consecutive compressions = wavelength = 2.5m

9. A sound wave transmitted from the ship wave reflected from the sea bed and heard after 4 second. Find the depth of the sea, if velocity of sound in water is $1500\, ms^{-1}$

Sol. Here, $\upsilon = 1500\, ms^{-1}$

Time taken by the wave to go from ship of the bed of the sea, $t = \frac{4}{2}s$ = 2s

Using, $S = \upsilon t,$ we get $S = 1500\, ms^{-1} \times 2s = 3000\, m = \mathbf{3}\, Km$

10. A man shouts inside a deep well and hears the echo after 0.4 second after shouting. If the speed of sound is $340\, ms^{-1}$, find the depth of the water level in the well.

Sol. Here, speed of sound, $\upsilon = 340\, ms^{-1}$

Time taken by the sound to go from the mouth of the well to the water level in the well and back to the mouth of the well = 0.4s

$\therefore$ Time taken by the sound to go from the mouth of the well to the water level in the well.

$$t = \frac{0.4}{2}s = 0.2s$$

Using, $S = \upsilon \times t,$ we get $S = 340\, ms^{-1} \times 0.2\, s = 68\, m$

Thus, depth of water level is **68 m**

11. A boy blew a whistle while standing in front of a cliff. He heard the echo after 2s. Find the distance of the cliff from the boy if velocity of sound in air is $332\, ms^{-1}$.

Sol. Here, $\upsilon = 332\, ms^{-1}$

Time taken by signal to go from sonar to another submarine, t = $\left(\frac{4}{2}\right)s = 2s$

Using $S = \upsilon t,$ We get $\upsilon = \frac{S}{t} = \frac{3060\,m}{2s} = 1530\,ms^{-1}$

Thus, speed of sound in water = 1530 ms^{-1}

12. A boy dropped a stone in well 45 m deep. If speed of sound is $340\ ms^{-1}$, then after how much time, he will hear the splash? Take, g = $10\,ms^{-2}$

Sol. Time, after which the boy will hear the splash = time taken by the stone to reach the surface of water in the well + time taken by the sound of splash to reach the mouth of the well.

(i) Here, $S = 45\,m,$ u =0, $g = 10\,ms^{-2}$

Time taken by the stone to reach the surface of water can be calculated by using

$S = ut + \frac{1}{2}gt^2$ $\therefore\ 45 = 0 + \frac{1}{2}\times 10t^2$ or $t^2 = 9$ or $t = 3s$

(ii) Time taken by sound to reach the mouth of the well can be calculate using

$S = \upsilon t$ $\therefore 45 = 340t$ or $t = \frac{45}{340} = 0.13\,s$

$\therefore$ The splash will be heard after the time = $3s + 0.13s = 3.13s$

UNSOLVED NUMERICAL (try your self)

1. A boy standing 100m from a tall building claps his hands and hears an echo 0.6 later. Find the speed of sound in air.

Ans. $333.3\,ms^{-1}$

2. A boy standing at some distance from a cliff claps his hands and heard an echo 0.8 later. What is the distance of the cliff from the boy, if speed is $340\,ms^{-1}$?

Ans. 136 m

3. The frequency of a body is 20 Hz. If the velocity of the waves produced is $340\,ms^{-1}$, find the wavelength of the waves.

Ans. 17 m

4. The frequency of a wave is 40 Hz and its wavelength is 8m. Find the velocity of the wave.

Ans. $320\,ms^{-1}$

5. The time period of a vibrating body is $0.1s$. The waves produced by the body moves with a speed of $340\,ms^{-1}$. Find the wavelength of the wave.

Ans. 34m