Sound

Introduction

In daily life we hear sound everywhere, from various sources like vehicles, humans, televisions, mechanics and so on. Sound is a form of energy which produces a sensation of hearing in our ears. In this chapter we will study how sound is produced, and how is it propagated and how is it reflected etc.

Production of Sound

Sound is produced when an object vibrates. Sound is produced when we speak, when our fingers strike the membrane of a tabla, when signals are fed to the speakers of a radio, television or music system, when brakes are applied suddenly to stop a vehicle, when utensil bang against each other, and so on. In each case the source of sound vibrates.

The following activities demonstrate the production of sound.

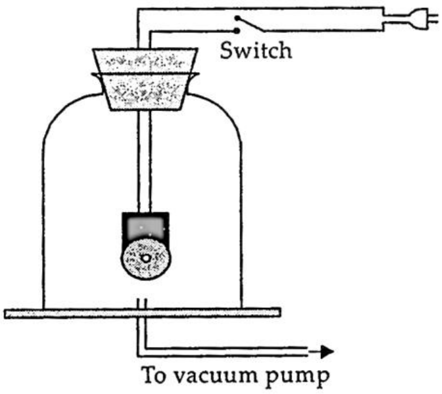
Activity Corner

1. 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.

2. Take a trough and fill it with water up to the brim. Take a tuning fork and set it into vibrations by striking its prongs on a rubber pad. Gently touch the surface of the water with one of the prongs of the vibrating tuning fork. What do you observe? Waves are formed on the water surface.
The water particles vibrate to form these waves.

Sound needs a Medium to Travel

The substance or matter through which sound is transmitted is called a medium. The medium can be a 'solid, a liquid or a gas. When a school bell rings, the solid bell vibrates and produces sound (point of generation). The sound travels through air and finally reaches our ears (listener).
So, sound moves through a medium from the point of generation to the listener.
Let us perform an experiment to prove that sound requires a medium for its propagation.

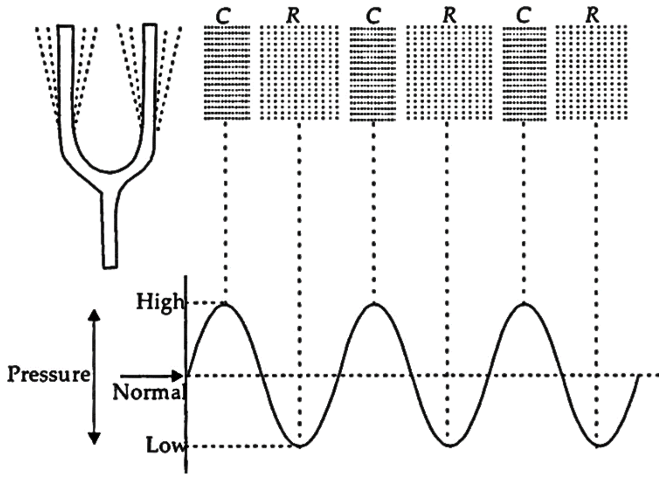


Take an electric bell, a big glass jar and vacuum pump. Hand an electric bell inside a jar connected to a vacuum pump. Switch on the bell and switch on the vacuum pump to take the air molecules out of the jar. The sound becomes feeble and finally you may not hear the sound.
When there was air in the jar sound travelled through it to the wall of the jar. This caused the wall to vibrate and send the sound to you and everyone around it. But when air was removed, sound from the bell could not travel to the wall of the jar.
This shows that sound needs a medium to travel.

The speed of sound depends on the medium through which it travels. It is fastest in solids and slowest in air. The reason behind it is that solids are most dense and therefore, carry sound fastest.

Propagation of Sound

Sound is produced by vibrating objects. The object that vibrates and produces sound is called point of generation.
Let us see how the sound travels from 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 neighboring particles. Hence the number of particles of the medium in the region where the displaced particles strike against the neighboring 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 (R) 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 region of compressions (or high pressures) and rarefactions (or low pressures) as the sound propagation in the medium.



ILLUSTRATION

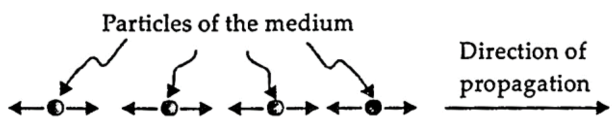
1. How sound is produced in Musical Instruments?

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

Longitudinal Waves

A wave in which the particles of the medium oscillate (vibrate) to and fro about their mean position in the direction of propagation of the wave is called a longitudinal wave.

A longitudinal wave is described in figure.



Longitudinal waves can be produced in any medium, viz., in solids, liquids and in gases.

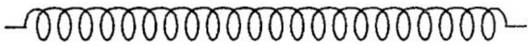
Examples:

(i) ***Sound waves are longitudinal waves.***

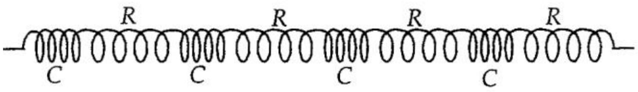
(ii) ***The waves produced in a spring (slinky) by compressing a small portion of it and releasing are longitudinal waves.***

Formation of Longitudinal Waves in a Slinky

The regions where the coils become closer are called compressions (C) and the regions where the coils are further apart are called rarefactions (R). As we already know, sound propagates in the medium as a series of compressions and rarefactions. Now, we can compare the propagation of disturbance in a slinky with the sound propagation in the medium. These waves are called 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. This is exactly how a sound wave propagates, hence sound waves are longitudinal waves.



Normal Slinky

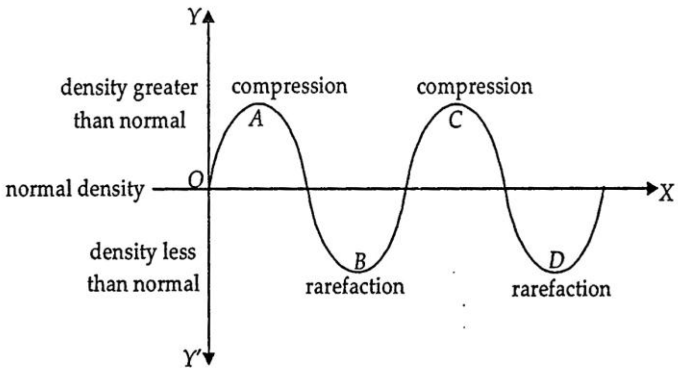


Back and forth Movement

Graphical Representation of Longitudinal Waves

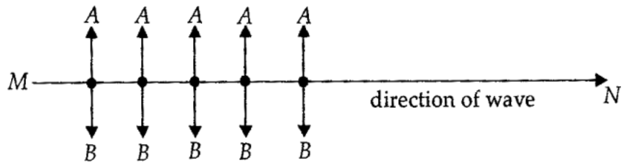
Longitudinal wave is represented by density-distance graph. In figure, the horizontal line OX represents the normal density of air. All the points above this line represent greater density. In a compression of a longitudinal wave, the density of the particles is high. So, here A and C represent compressions. All the points below the line OX represent less density (than normal).

In a rarefaction, the density of the particles is less than that in the normal. So, here B and D represent rarefactions.

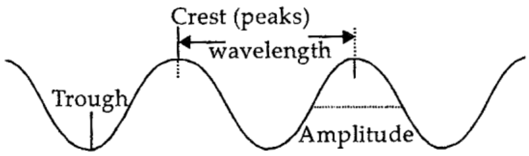


There is also another type of wave/ called a transverse waves. In a transverse wave the particles of the medium oscillate (vibrate) up and down/ i.e., perpendicular to the direction in which the wave is moving is called a transverse wave. A transverse wave is illustrated in figure. In this figure the direction of a wave is shown from M to N in the horizontal plane. The direction of vibrations of the particles of the medium is along AB or we can say/ perpendicular to the direction of the wave, i.e., the particles of the medium vibrate up and down perpendicular to the direction of propagation of the wave.

Particles of the medium vibrating up and down



Characteristics of a Sound Wave



- **Wavelength:** Distance between two consecutive peaks and trough is called wavelength. Wavelength is represented by X (lambda) and its unit is metre.
- **Frequency:** Number of oscillations of sound wave is called its frequency. Number of peak and troughs per unit of time will give frequency. It is represented by I) ^nu) and its unit is Hertz (Hz).
- **Time period:** Time taken by a vibrating particle or a body to complete one vibration or oscillation is known as time period. Its unit is second and is represented by T.
- **Relation between frequency and time period:** The number of waves produced per second is called its frequency.

  $$\upsilon = \frac{1}{T}$$
- **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.
- **Softness or Loudness of Sound:** If the amplitude is smaller then the sound will be softer and if it is larger then sound will be louder. Higher amplitude helps the sound wave to travel fast.
- **Speed of sound:** It is the distance which a compression or a rarefaction travels per unit of time.

  Speed of sound $= \upsilon = \frac{\lambda}{T} = \frac{\text{Wavelength}}{\text{Time}}$

or $v = \lambda \upsilon (\text{because} \frac{1}{T} = \upsilon)$

So, speed = Wavelength x Frequency

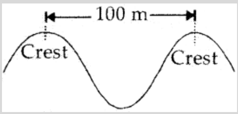
The speed of the sound remains almost the same for all frequencies in a given medium under the same physical condition.

ILLUSTRATION

2. A boat at anchor is rocker by waves whose consecutive crests are 100 m apart. The wave velocity of the moving crests is $20\ m\ s^{-1}$. What is the frequency of rocking of the boat?

Sol.: Given $\lambda = 100\ m,\ \upsilon = 20\ m\ s^{-1}$

Now $\upsilon = u\lambda$



$$\therefore\ \upsilon = \frac{v}{\lambda} = \frac{20}{100} = 0.2 Hz$$

3. Audible ranges of frequencies is 20 Hz to 20, 000 Hz. Find the range of wavelengths corresponding to this frequency. Given, velocity of sound $= 340\ m\ s^{-1}$.

Sol.: We know,

$\upsilon = u\lambda$ or $\lambda = \frac{\upsilon}{u}$

When $\upsilon = 20\ Hz,$

$$\lambda = \frac{340\ m\ s^{-1}}{20 Hz} = \frac{340\ m\ s^{-1}}{20\ s^{-1}} = 17 m$$

When $\upsilon = 20{,}000$ Hz,

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

Thus, range of wavelength = 0.017 m to 17 m.

Speed of Sound in Different Medium

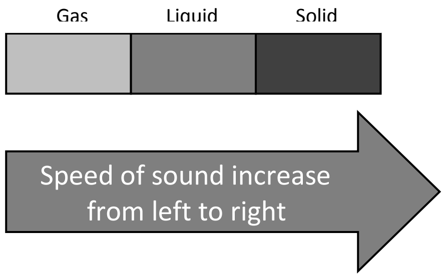
The speed of sound in different media is different. This is because the molecules are packed closer in solids and liquids than in air (or gas). Since molecules undergo vibrations, they do so more efficiently when they are closer together.

- The speed of sound depend upon:

(i) the properties (elasticity and density) of the medium through which it propagates and

(ii) temperature of the medium.

Sound (in general) has greatest speed in case of solids and least in case of gases. For liquids, the speed of sound is intermediate between these two extremes as shown in figure.



In general, speed of sound in solids > speed of sound in liquids > speed of sound in gases.

However, in certain solids, the speed (v) of sound is much less than that even in gases as v (for vulcanized rubber) = 54 m s^{-1} and v (for hydrogen) = 1284 m s^{-1}. The speed of sound in lead (a solid) = 1332 m s^{-1} and in sea water (a liquid) = 1531 m s^{-1}. The speed of sound in methyl alcohol (a liquid) = 1103 m s^{-1}.

The speed of sound increases with increase in temperature of the medium. In air, it increases roughly by 0.61 m s^{-1} with rise of 1°C in temperature. The speed of sound in air at 0°C is 331 m s^{-1} and at 22°C, it is 344 m s^{-1}.

Do You Know

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

- The speed of sound in some gases, liquids and solids are listed in table.

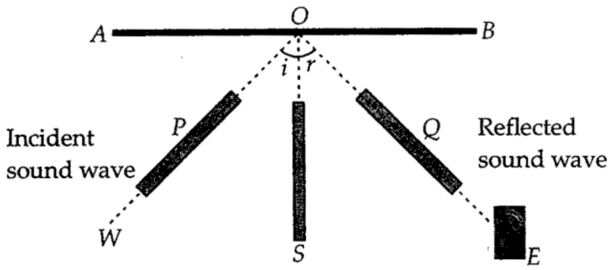
State	Substance	Speed in $m\ s^{-1}$
(a) Gases	1. Hydrogen	1284
	2. Helium	965
	3. Air	346
	4. Oxygen	316
	5. Sulphur dioxide	213
(b) Liquids	1. Water (sea)	1531
	2. Water (distilled)	1498
	3. Ethanol	1207
	4. Methanol	1103
(c) Solids	1. Aluminium	6420
	2. Nickel	6040
	3. Steel	5960
	4. Iron	5950
	5. Brass	4700
	6. Glass (Flint)	3980

Reflection of sound

Like light waves, sound waves also get reflected when fall on the surface of an obstacle. But unlike light waves, sound waves do not necessarily require a polished surface for reflection, i.e., for reflection of sound waves, the surface may be polished or rough. The following simple experiment establishes that reflection of sound follows the same laws as those for reflection of light.

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

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



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

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

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

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

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

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

These laws are as follows.

- **First law.** The angle of reflection (r) is always equal to the angle of incidence (;'), i.e.,
  $\angle r = \angle i$ or $i = r$.
- **Second law.** The incident wave, the reflected wave and the normal (at the point of incidence), all lie in the same plane.

Examples:

(i) Speaking tube or Megaphone: You must have seen in fairs or tourist spots, people using megaphones addressing a group of people. Megaphone is simply a horn-shaped tube. The sound waves are prevented from spreading out by successive reflections and are confined to the air in the tube. For the same reason, loud speakers also have horn-shaped openings.

(ii) The circular runway round the base of a dome is a whispering gallery. If someone whispers at a point close to the wall of the gallery, the sound gets reflected round the wall of the gallery. The sound can be distinctly heard at all points near the wall all around.

(iii) Ear Trumpet or Hearing Aid: It is a device which is used by the persons who are hard of hearing. The sound waves received by the wide end of the trumpet are reflected into a much narrower area, leading it to the ear. This enhances the amplitude of vibrating layer of air inside the ear and helps in improving hearing.

(iv) Stethoscope: It is an instrument used by the doctors for listening sound produced with the body, especially in the heart and lungs. In the stethoscope, the sound produced within the body of a patient is picked up by a sensitive diaphragm and then reaches the doctors ears by multiple reflection.

Echo

The sound returning back towards the source after suffering reflection from a distant obstacle (a wall, a hill, a row of building etc.) is called an echo. When the sound is reflected repeatedly from a number of obstacles, more than one echoes, called multiple echoes are heard. Multiple echoes may be heard one after the other when sound gets repeatedly reflected from distant high rise buildings or hills. The rolling of thunder is an example of multiple echo formation.

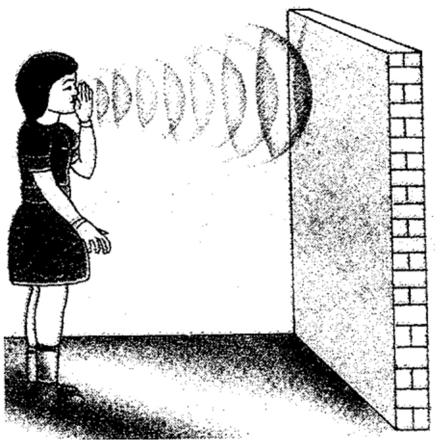
Echo is a very familiar example of reflection of sound waves. The time gap between the two sounds - one direct and the other echo, depends upon the medium through which the sound wave travels.

The two sounds - one direct and the other echo, can be heard distinctly provided the distance between the observer and the reflecting surface is large enough to allow the reflected sound to reach him without interfering with the direct sound. Since the sensation of sound persists for $\frac{1}{10}$ second after it is produced, the echo can be heard distinctly only if it reaches at least $\frac{1}{10}$ second after the original sound is produced.

- **Minimum distance between the observer and the obstacle for echo to be heard**
  Let distance between the observer and the obstacle $= d$
  Speed of sound (in the medium) $= \upsilon$
  Time after which echo is heard $= t$
  Then, $t = \frac{2d}{\upsilon}$ or $d = \frac{\upsilon t}{2}$
  We know
  Speed of sound in air at 20° C = 343 m s^{-1}
  For an echo to be heard distinctly,
  $t \geq 0.1\ s$
  Then $d \geq \frac{343\ m\ s^{-1} \times 0.1\ s}{2}$ or
  $d \geq 17.2\ m$
  Thus, the minimum distance (in air at 20°C) between the observer and the obstacle for the echo to be heard clearly should be 17.2 m.

Conditions for the Formation of Echoes

(i) The minimum distance between the source of sound and the reflector should be at least 17.2 metres (so that the echo is heard distinctly after the original sound is over or dies off).



(ii) The size of the reflector must be large (like tall mountains, hills, walls, etc.) compared to the wavelength of the incident sound (for reflection of sound to take place).
(iii) The intensity or loudness of the sound should be sufficient for the reflected sound reaching the ear to be audible.
Whispering gallery: We can experience extraordinary sound effects in the form of echoes at Gol Gumbaz, Bijapur (Karnataka). Even a whisper at the end is amplified and heard very clearly at different ends. A similar gallery is there at St. Paul's Cathedral in London (U.K.).

ILLUSTRATION

4. A child hears an echo from a cliff 4 seconds after the sound from a powerful cracker is produced. How far away is the cliff from the child? Velocity of sound in air at $20^{o}C$ is $344\ m\ s^{-1}$

Sol.: Let the distance the child and the cliff be d. Then,
Total distance travelled by the sound = 2d
Total time taken by the sound = 4 s
Then, velocity of sound $= \frac{2d}{4s} = \frac{d}{2s}$
$344\ ms^{-1} = \frac{d}{2s}$
This gives, $d = 344\ m\ s^{-1} \times 2\ s = 688\ m$
Thus, the cliff is at a distance of 688 m from the child.

Reverberation

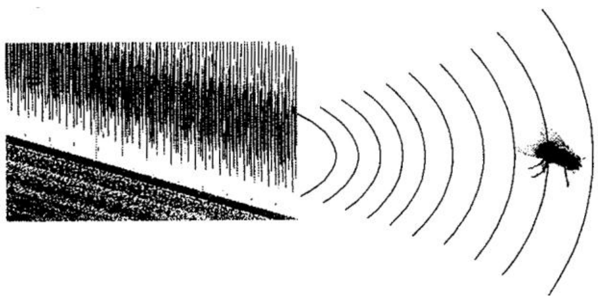
Persistence of sound after its production is stopped, is called reverberation.
When a sound is produced in a big hall, its wave reflect from the walls and travel back and forth. Due to this energy does not reduce and the sound persist.
A short reverberation is desirable in a concert hall (where music is being played) because it gives life to sound. Too much reverberation confuses the programmers and must be reduced to reduce reverberation. The material having sound-absorbing properties is used for making the seats in a big hall or auditorium to reduce reverberations. Panels made of sound-absorbing materials (like compressed fibre board or felt) are put on the walls and ceiling of big halls and auditoriums to reduce reverberations.

Infrasonics or Infrasound

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.
It has been observed that animals behaviour 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.



Properties of Ultrasound Waves

(i) **Ultrasonic waves** can travel easily in solid and liquid but not in gases. This is because the intensity of ultrasonic waves decreases fast with propagation in gases.
(ii) Good directionality: Due to high frequency of ultrasound, its wavelength is small. Therefore, these waves do not bend easily and therefore move along a straight line. It is because of this property that these waves are used for scanning objects and making their image. The imaging phenomenon also, depends on the fact that these waves can travel through opaque objects.

(iii) High power: Due to high frequency, the energy possessed by these waves is high. Therefore, if these waves are focused at a point, a high power is generated at that point which is used in breaking and cutting objects.

Applications of Ultrasound (Ultrasonic Waves)

Ultrasonic waves have number of uses:
(i) Ultrasonic waves are used to establish ship-to-ship communication.

(ii) Ultrasonic waves are used to determine the depth of a sea. It is done with the help of a SONAR.

(iii) 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 cannot be approached directly.

(iv) 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.

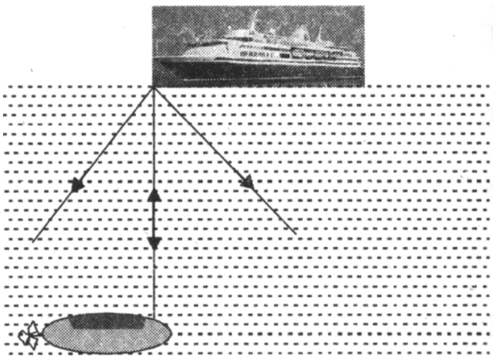
(v) Ultrasonic waves are used for diagonosing the diseases in human body. Different parts of the body like bone, fat muscles and liquid have different reflective properties. Ultrasonic waves are allowed to fall on the portion of the body of a patient to be diagonsed. These waves are reflected back by the different parts (like bones, tissues, liquids and muscles etc.) of that portion o64he body in different manners. The varying echoes are recorded for analyzing that part of the body.
The method used for diagonosing the different part of a human body with the help of the ultrasonic waves is known as ultra sonography.

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

(viii) Ultrasonic waves are also used to analyze the development of an unborn child. Any abnormality in the growth of an unborn child can be detected by observing the picture taken by ultrasound.

SONAR [Sound Navigation and Ranging]

It is a device which is used in the ships to locate rocks, icebergs, submarines, old ships sank
Ultrasonic waves of high frequency are sent from a ship on the surface. These waves travel in a straight line till they hit a body like a shipwreck or submarine from where these waves are reflected back as shown in the figure. The transmitter sending the waves notes the time interval t between sending the signal and receiving it back. If d is the distance of the submarine from the ship, then the total distance travelled by the wave in time interval t is 2d.



Using speed $= \frac{\text{Distance}}{\text{Time}} \Rightarrow \upsilon = \frac{2d}{t}$

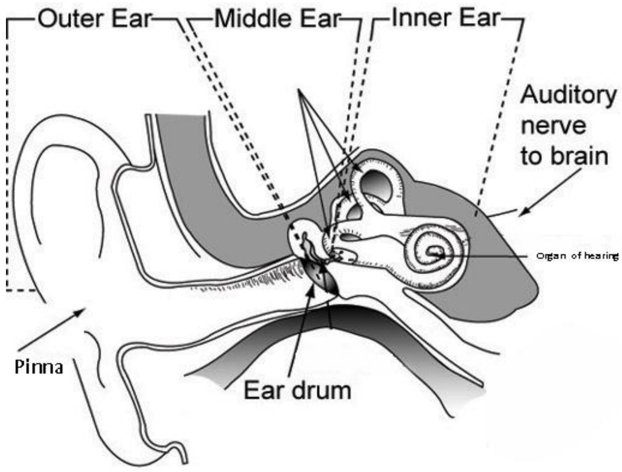
$\therefore \quad d = \frac{1}{2}\left(\frac{\upsilon}{t}\right)$

The velocity v of the ultrasonic wave in water is same as that of audible range in water.

Structure of human Ear

The human ear is a very sensitive device and faintest sound detected by it has a pressure variation of about 2×10^{-5} N/m^2 (corresponding to an amplitude of about 10^{-1} m).
The ear has the following parts:

- **Outer ear:** The part seen outside is known as the pinna. This part collects the sound and sends it to the auditory canal. A tightly stretched membrane called eardrum separates the outer ear from the middle ear.



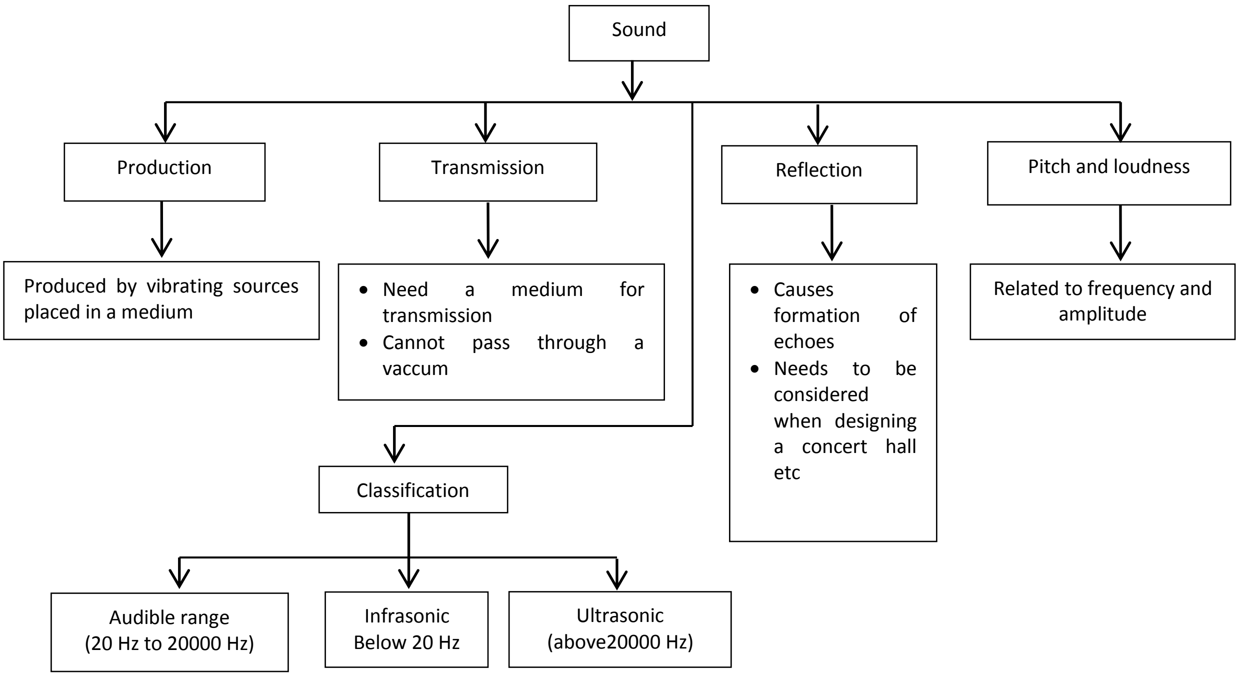
- **Middle ear:** It consists of three small bones, the hammer, the anvil and the stirrup. The amplified vibrations of sound are transmitted through these bones to the cochlea.
- **Inner ear:** The inner ear contains the organs of hearing which perceive sound and send a message to the brain via the **auditory nerve**.

Essential Points

- Sound is a form of energy which produces the sensation of hearing in our ears.
- 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 needs material medium for its propagation.
- Sound cannot travel through vacuum.
- Compression is a region (of a medium) of high pressure or high density.
- Rarefaction is region (of a medium) of low pressure or low density.

- Pitch or shrillness is a characteristic of a sound that depends on the frequency received by a human ear.
- Loudness of a sound is the characteristic of a sound that depends upon the amplitude of the vibrating body producing sound.
- Timber or quality is a characteristic 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.
- The S.I. unit of intensity of sound is $J\,s^{-1}\,m^{-2}$ or $W\,m^{-2}$.
- The relationship between speed of wave, wavelength and frequency is $\upsilon = u\lambda$
- A wave of high frequency in a given medium has small wavelength.
- The speed of an object moving faster than the speed of sound is known as supersonic speed.
- Supersonic jet air craft's 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.
- 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 sound stops to produce sound, then the effect is known as reverberation.
- Reverberation time is the time interval for which the audible sound persists after the production of original sound.
- The audible range of frequency is 20 Hz to 20,000 Hz (or 20 kHz).
- 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 hearing device. It consists of three parts - the external ear, the middle ear and the inner ear.

CONCEPT MAP



SOLVED EXAMPLES

1. The wavelength and frequency, of a sound wave in a certain medium are 20 cm and 1650 Hz respectively. Keeping the medium same, if the wavelength is changed to 16 cm, calculate: (a) the velocity of sound (b) the new frequency of the sound wave.

Sol.: (a) Wavelength (X) = 20 cm = 0.20 m

Frequency (u) = 1650 Hz

$\therefore$ Velocity of sound $(\upsilon) = \upsilon\,\lambda = 1650 \times 0.20 = 330\ m\ s^{-1}$.

(b) Velocity of sound (v) = 330 m s^{-1}

Wavelength $(\lambda) = 16\ cm = 0.16 m$

$\therefore$ Frequency $(\upsilon) = \frac{\upsilon}{\lambda} = \frac{330}{0.16} = 2062.5\ Hz$

2. A construction worker's helmet slips and falls when he is 78.4 m above the ground. He hears the sound of the helmet hitting the ground 4.23 seconds after it slipped. Find the speed of sound in air.

Sol.: Let t be the time taken by the helmet to reach the ground.

We have $h = ut + \frac{1}{2}gt^2$

Here $u = 0,\ h = 78.4\ m,\ g = 9.8\ m/s^2$.

$\therefore\quad 78.4\ m = \frac{1}{2} \times (9.8\ m/s^2) \times t^2$

or $t^2 = \frac{2 \times 78.4\ m}{9.8 m/s^2}$ or $t = 4s$

$\therefore$ the time taken by the helmet to drop to the ground = 4 s

The time taken by sound to travel 78.4 m = (4.23 - 4) s = 0.23 s.

$\therefore$ the speed of sound in air $= \frac{78.4m}{0.23s} = 340.87\ m/s = 341\ m/s$

3. Your friend is listening to a Lata Mangeshkar concert live at New York. The distance between the stage and your friend is 50 m. The same program is also being broadcast live on the All India Radio. You too are listening to the same program at Hydrabad. The distance between Hydrabad and New York is approximately 10,000 km. Who will hear Lata Mangeshkar's voice first, you or your friend?

Sol.: Distance between the stage and your friend = 50 m

Distance between New York and your place $= x = 10,000\ km = 10,000 \times 10^3 = 10^7$ m

We know that/ time $= \frac{\text{distance}}{\text{speed}}$

The waves received by your friend directly from Lata Mangeshkar are sound waves.

Time taken by the waves to reach your friend $= t_{sound}$

$= t_{sound} = \frac{\text{distance between the stage and your friend}}{\text{speed of sound}} = \frac{50}{330} s$ ...(i)

The relay from Newyork reaches Hyderabad through Radio waves which are electromagnetic in nature.

All electromagnetic radiations move at the speed of light. So you are getting the signal at the speed of light which is 106 times faster than sound.

Time taken by the radio waves to reach you at Hydrabad $= t_{light}$

$t_{light} = \frac{dis\tan ce\ between\ New York\ and\ Hydrabad}{speed\ of\ light} = \frac{x}{3 \times 10^8} s$ ...(ii)

$$\frac{t_{sound}}{t_{light}} = \frac{\frac{50}{330}}{\frac{x}{3 \times 10^8}} = \frac{50}{330} \times \frac{3 \times 10^8}{10^7} \approx 4.5$$

$\therefore\quad t_{sound} = 4.5 \times t_{light}$

The time taken by the sound wave is approximately four and a half times more than the time taken by Radio waves. So the Radio Waves are reaching you, four and half times more quickly than the sound waves reach your friend. Hence you will be hearing the voice of Lata Mangeshkar first.

4. A source is producing 1500 sound waves in 3 seconds. If the distance covered by a compression and an adjacent rarefaction be 68 cm, find: (a) frequency, (b) wavelength, and (c) velocity, of the sound wave.

Sol.: **(a) Frequency.** We know that frequency of a wave is the number of waves produced in 1 second.

Here, number of waves produced in 3 seconds = 1500

So, number of waves produced in 1 second $= \frac{1500}{3} = 500$

So, the frequency of this sound wave is 500 hertz.

(b) Wavelength. In a sound wave, the distance covered by a compression and an adjacent rarefaction is equal to its wavelength. This distance has been given to be 68 cm. So, the wavelength (X) of this sound wave is 68 cm.

(c) Velocity. The formula for calculating the velocity of a sound wave is:

$\upsilon = u \times \lambda$

Here, Frequency, $\upsilon = 500\ Hz$

And, wavelength, $\lambda = 68\ cm$

$= \frac{68}{100} m = 0.68\ m$

Putting these values of υ and λ in the above formula, we get;

$\upsilon = 500 \times 0.68 = 340\ \text{m s}^{-1}$

Thus, the velocity (or speed) of the sound wave is 340 m s^{-1}.

5. The wavelength of sound emitted by a source is $1.7\times10^{-2}\,m$. Calculate frequency of sound, if its velocity is 343.4 m s^{-1}.

Sol.: The relationship between velocity, frequency and wavelength of a wave is given by the formula:

$\upsilon = u \times \lambda$

Here, velocity, $\upsilon = 343.4\ ms^{-1}$

Frequency, $\upsilon = ?$

And, Wavelength, $\lambda = 1.7\times10^{-2}\,m$

So, putting these values in the above formula, we get;

$343.4 = \upsilon \times 1.7\times10^{-2}$

$\upsilon = \dfrac{343.4}{1.7\times10^{-2}};\ \upsilon = \dfrac{3434\times10^{2}}{17}$

$\upsilon = 2.02\times10^{4}\ Hz$

Thus, the frequency of sound is 2.02×10^{4} hertz.

6. A man claps his hands near a mountain and hears the echo after 4 seconds. If the speed of sound under these conditions be 330 m s"1, calculate the distance of the mountain from the man.

Sol.: Here the time taken by the sound (of clap) to go from the man to the mountain, and return to the man (as echo) is 4 seconds. So, the time taken by the sound to go from the man to the mountain only will be half of this time, which is $\dfrac{4}{2} = 2$ seconds. Now, knowing the speed of sound in air, we can calculate the distance travelled by sound in 2 seconds. This will give us the distance of the mountain from the man.

We know that, speed $= \dfrac{distance\ travelled}{time\ taken}$

So, $330 = \dfrac{distance\ travelled}{2}$

And, distance travelled $= 330\times2$ metres = 660 metres

Since sound travels a distance of 660 metres in going from the man to the mountain, therefore, the distance of mountain from the man is 660 metres.

7. An engine is approaching a hill at constant speed. When it is at a distance of 0.9 km, it blows a whistle, whose echo is heard by the driver after 5 s. If the speed of sound is 340 m s^{-1}, calculate the speed of the engine.

Sol.: Let υ_e be the speed of the engine distance covered by the engine in $5\ s = 5\upsilon_e$

distance covered by sound in reaching the hill and coming back to the moving driver

$= (900\times2 - 5\upsilon_e)$ $\quad (0.9\ km = 900\,m)$

$1800 - 5\upsilon_e$

According to the given conditions,

$t = \dfrac{(1800 - 5\upsilon_e)}{\upsilon}$

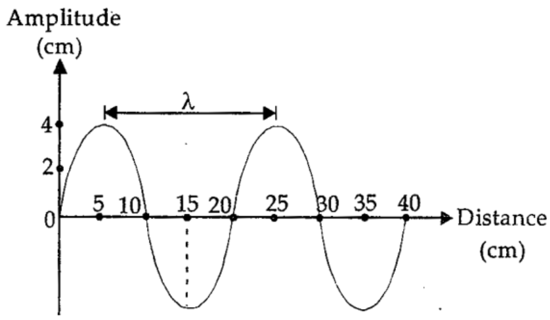
As $t = 5$ s and v (speed of sound) $= 340\ ms^{-1}$.

$5 = \dfrac{1800 - 5\upsilon_e}{340}$ or $1700 = 1800 - 5\upsilon_e$

or $\upsilon_e = 20\ m\ s^{-1}$

8. Figure shows a snap-shot of a wave-form of frequency 50 Hz. For this wave motion, find (a) wavelength (b) amplitude (c) velocity.

Sol.: Here, v = 50 Hz



(a) Wavelength = distance between two consecutive crests

$= \lambda = 25\ cm - 5\ cm = 20\ cm$

(b) Amplitude = 4 cm

(c) Wave velocity,

$\upsilon = u\lambda = 50\times20 = 1000\ cm\ s^{-1} = 10\ m\ s^{-1}$.

9. A sonar device fitted in a submarine receives an echo 4 s later the signal is transmitted towards another submarine 3060 m away. Find the speed of sound in water.

Sol.: Here, s = 3060 m

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

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

$\upsilon = \dfrac{s}{t} = \dfrac{3060}{2s} = 1530\ m\ s^{-1}$

Thus, speed of sound in water = 1530 m s^{-1}.

10. A radio station transmits waves of wavelength 200 m. If the speed of the waves is $3\times10^{8}\ m\ s^{-1}$, find the frequency of the radio station.

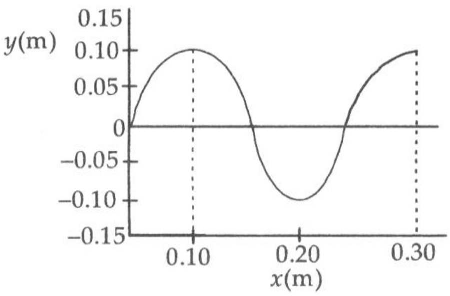
Sol.: Here, Wavelength, $\lambda = 200\ m$

Speed $\upsilon = 3\times10^{8}\ ms^{-1}$

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

$$\upsilon = \frac{u}{\lambda} = \frac{3\times10^{8}\ m\ s^{-1}}{200\ m} = 1.5\times10^{6}\ s^{-1}$$ or $1.5\times10^{6}\ Hz$

11. The diagram shown is a snapshot of a wave on a rope at a given time. The frequency of the wave is 60 Hz.
Find (a) amplitude, (b) wavelength and (c) wave speed



Sol.: Given: I) $\upsilon = 60\ Hz$

(a) Amplitude is the maximum distance from the equilibrium position
From the diagram, A = 0.10 m
(b) Wavelength is the distance between successive crests
From the diagram, $\lambda = 0.20\ m$
(c) $u = \lambda\upsilon = (0.20\ m)\ (60\,Hz) = 12\ m\ s^{-1}$

12. A wave pulse on a string moves a distance of 8 m in 0.05 s.
(a) Find the velocity of the pulse.
(b) What would be the wavelength of the wave on the same string if its frequency is 200 Hz?

Sol.: (a) Velocity of the wave pulse =

$$\upsilon = \frac{\text{distance covered}}{\text{time taken}}$$

$$\upsilon = \frac{8\ m}{0.05 s} = 160\ m\ s^{-1}$$

(b) The periodic wave has the same velocity as that of the wave pulse on the same string.

Wavelength of a wave $\lambda = \frac{u}{\upsilon}$

$$\lambda = \frac{160\ m s^{-1}}{200\,Hz} = 0.8\ m$$

Thus the wavelength of the periodic wave is 0.8 m.

13. 25 waves pass through a point in 5 seconds. If the distance between one crest and the adjacent trough is 0.05 m, calculate
(a) the frequency
(b) the wavelength
(c) wave velocity

Sol.: (a) In 5 seconds, the number of waves produced = 25
$\therefore$ In 1 second, the number of waves produced $= \frac{25}{5} = 5$
$\therefore$ Frequency = 5 Hz
(b) Distance between two consecutive crests = one wavelength $= \lambda$
$\therefore$ Distance between, one crest and the adjacent trough $= \lambda / 2$
Also the distance between one crest and the adjacent trough = CL05 m

$\therefore \quad \frac{\lambda}{2} = 0.05\ m$

Wavelength, $\lambda = 2\times0.05\ m = 0.10\ m$

(c) Wave velocity $\upsilon = u\lambda = 5\times0.10 = 0.5\ \text{m s}^{-1}$

14. AM and FM radio waves are transverse waves that consist of electric and magnetic disturbances. These waves travel at a speed of. $3.00\times10^{8}\ m/s$ A station broadcasts an AM radio wave whose frequency is 1230×10^{3} Hz (1230 kHz on the dial) and an FM radio wave whose frequency is 91.9×10^{6} Hz (91.9 MHz on the dial). Find the distance between adjacent crests in each wave.

Sol.: The distance between adjacent crests is the wavelength λ. Since the speed of each wave is $u = 3.00\times10^{8}\ m\ s^{-1}$ and the frequencies are known, the relation $u = \upsilon\lambda$ can be used to determine the wavelengths.

AM: $\lambda = \frac{u}{\upsilon} = \frac{3.00\times10^{8}\ m s^{-1}}{1230\times10^{3}\ Hz} = 244\ m$

FM: $\lambda = \frac{u}{\upsilon} = \frac{3.00\times10^{8}\ m\ s^{-1}}{91.9\times10^{6}\ Hz} = 3.26 m$

15. A sound wave travels at a speed of $330\ m\ s^{-1}$. If its wavelength is 1.5 cm, what is the frequency of the wave? Will it be audible?

Sol.: Speed of the wave, $u = 339\ m\ s^{-1}$
Length of the wave $\lambda = 1.5\ m = 1.5\times10^{-2}\ m$
Frequency of the wave, $\upsilon = ?$
From relation $u = \upsilon\lambda$

We have, $\upsilon = \frac{u}{\lambda}$

Putting values, we get

$$\upsilon = \frac{339}{1.5\times10^{-2}} = \frac{339}{1.5}\times10^{2}\ s^{-1} = 22600 s^{-1}$$

Frequency $\upsilon = 22600\,Hz$

Not since its frequency is above 20,000 Hz, it will not be audible.

NCERT SECTION

1. How does the sound produced by a vibrating object in a medium reach your ear?

Ans.: When a disturbance is created on an object, it starts vibrating and sets the particles of the medium to vibrate. The particle of the medium is displaced from its mean position and exerts a force on the adjacent particle. As a result, the adjacent particle is disturbed from its mean position and the original particle comes back to rest. This process continues till the disturbance reaches our ear.

2. Explain how sound is produced by your school bell.

Ans.: When the school bell is struck with a hammer, it starts vibrating and as a result of these vibrations, sound waves are produced.

3. Why are sound waves called mechanical waves?

Ans.: Waves which need a material medium for propagation are called mechanical waves. Since sound waves also need a material medium for propagation, these are called mechanical waves.

Sound wave are called mechanical waves or elastic waves as these are produced in a deformable or elastic medium. Unlike electromagnetic waves, sound waves need a medium to sustain them. Mechanical waves are governed by Newton's laws of motion.

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

Ans.: No we'll not be able to hear the sound because sound requires a medium for its propagation. In the moon there is no atmosphere, *i.e.,* there is vacuum.

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

Ans.: (a) Loudness is determined by the amplitude of the sound wave which in turn depends on the force with which the object is made to vibrate.

(b) Pitch of a sound is determined by its frequency. (Apart from this, the pitch of sound also depends upon the relative motion between the source of sound and the listener).

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

Ans.: A guitar has a higher pitch than a car horn, provided the guitar is properly tuned.

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

Ans.: **Wavelength :** The distance between two consecutive compressions (C) or two consecutive rarefactions (R) is called the wavelength, (unit metre).

Frequency : The number of oscillations per unit time is called frequency, unit (Hz). **Time period :** The time taken by two consecutive compressions or rarefactions to cross a fixed point is called the time period.

Amplitude : The magnitude of the maximum disturbance in the medium on either side of the mean value is called the amplitude of the wave.

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

Ans.: The speed is defined as the distance travelled by a wave per unit time.

$$Speed = \frac{distance}{time} = \frac{\lambda}{T}$$

λ is the wavelength, $T \rightarrow$ time period.

$$\upsilon = \upsilon\lambda \because \upsilon = \frac{1}{T}$$

$\therefore$ Speed = wavelength $\times$ frequency

9. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 m s^{-1} in a given medium.

Ans.: Here, frequency of the sound wave, $\upsilon = 220 Hz$ speed of the sound wave, $\upsilon = 440 m s^{-1}$

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

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

Ans.: Here, frequency of the source, $\upsilon = 500 Hz$

time period of the tone, $T = \frac{1}{\upsilon} = \frac{1}{500} s$

The time period between successive compressions from the source is equal to the time period of the tone, *i.e.,* (1/500) s and it has nothing to do with the distance (450 m) of the person from the source provided the sound wave reaches the person.

11. Distinguish between loudness and intensity of sound.

Ans.:

Loudness	Intensity
1. It is not an entirely physical quantity.	**1.** It is not an physical quantity which can be accurately measured.
2. It depends upon (i) sensitivity of the ear and (ii) intensity of sound.	**2.** It does not depend upon the sensitivity of the ear.
3. It has a subjective existence.	**3.** It has an objective existence.

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

Ans.: The speed of sound in air = 346 m s^{-1}. The speed of sound in water = 1531 m s^{-1}. The speed of sound in iron == 5960 m s^{-1}.
$\therefore$The speed of sound in iron is greater and sound travels faster in iron.

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

Ans.: Here, speed of sound, *v* = 342 m s^{-1}
Time taken by echo to return, *t* = 3 s
If *d* is the distance between the source and the reflecting surface, distance covered by sound in time $t = d + d = 2d$ (distance *d* while going to the reflecting surface and distance *d* while returning back) As distance = speed (of sound) x time,

$$2d = 342(ms^{-1}) \times 3(s) = 1026m \text{ or } d = 513m$$

14. Why are the ceilings of concert halls curved?

Ans.: The ceiling of the concert halls are curved to ensure that after reflection from the ceilings, sound reaches all comers of the hall.

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

Ans.: 20 Hz to 20,000 Hz.

16. What is the range of frequencies associated with
(a) Infrasound? (b) Ultrasound?

Ans.: (a) Range of frequencies associated with infrasound : 1 Hz to 20 Hz.
(b) Range of frequencies associated with ultrasound : 2 x 10^4 Hz to 10^{10} Hz.

17. A submarine emits a sonar pulse, which returns from an underwater cliff in 1.02 s. If the speed of sound in salt water is 1531 m s~1, how far away is the cliff?

Ans.: Speed of sound in salt water = 1531 m s^{-1}
Time period = 1.02 sec
Distance travelled 2 x d = speed x time

$$2 \times d = 1531 \times 1.02$$

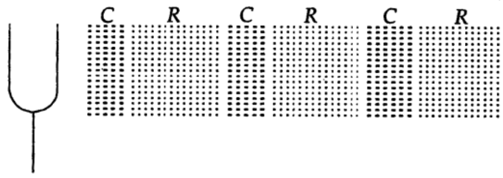
$$\therefore d = \frac{1531 \times 1.02}{2}$$

$$d = 750m$$

17. What is sound and how is it produced?

Ans.: Sound is a form of energy and it is produced due to vibrations of different types of object, *e.g.,* a vibrating tuning fork, a bell, wires in a sitar and a violin etc.

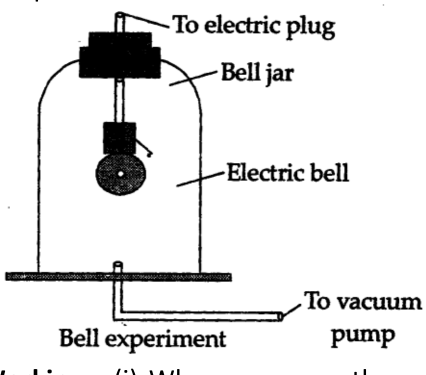
19. Describe with the help of a diagram, how compressions and rarefactions are produced in air near a source of sound.



Ans.: (i) When a vibrating object moves forward, it pushes the air in front of it and compresses the air creating a region of high pressure called compression (Q.
(ii) It starts moving away from the surface of the vibrating object.
(iii) As this occurs the surface moves backward creating a region of low pressure called rarefaction (R).

18. Cite an experiment to show that sound needs a material medium for its propagation.

Ans.: Take an electric bell and an air tight glass bell jar. The electric bell is suspended inside an air tight glass jar which is connected to a vacuum pump.



Bell experiment

Working : (i) When we press the switch, we will be able to hear the bell.
(ii) When the air in the jar is pumped out gradually, the sound becomes feeble although the same amount of current is flowing through the bell.
(iii) When the air is removed completely, we will not be able to hear the sound of the bell.

Conclusion : This experiment shows that sound requires a medium for its propagation.

21. Why is sound wave called a longitudinal wave?

Ans.: A sound wave is called a longitudinal wave as it travels in a medium in the form of compressions and rarefactions where the particles of the medium vibrate in a direction which is parallel to the direction of propagation of the sound wave.

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

Ans.: The quality (or timbre) of sound is that characteristic which enables us to distinguish one sound from me other even when these are of the same pitch and loudness. Each person has its own quality of sound and it is this characteristic which enables us to identify a person from others even without looking at him *(i.e.,* in a dark room).

23. Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen, why?

Ans.: The speed of light (c) is greater than the speed of sound (υ) by a factor of 10^6 as $\frac{c}{v}=\frac{3\times10^8 ms^{-1}}{340 ms^{-1}}=10^6$ Thus, the flash of light is seen earlier than the thunder of sound even though both are produced simultaneously.

24. A person has a hearing range from 20 Hz to 20 kHz. What are the typical wavelengths of sound waves in air corresponding to these two frequencies? Take the speed of sound in air as 344 m s^{-1}.

Ans.: Here, $\upsilon_1 = 20 Hz$ and $\upsilon_2 = 20k Hz = 20\times10^3 Hz$, speed of sound, *v* = 344 m s^{-1}

Clearly, $\lambda_1 = \frac{\upsilon}{\upsilon_1}=\frac{344}{20}=17.2m$ and

$\lambda_2 = \frac{\upsilon}{\upsilon_2}=\frac{344}{20\times10^3}=0.0172 m$

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

Ans.: Speed of sound in air $=(\upsilon_1)=346 ms^{-1}$

Speed of sound in aluminium, $\upsilon_2 = 6420 ms^{-1}$

Let the length of the aluminium rod $= x m$

We know that speed $=\frac{distnace}{time} \therefore time = \frac{distnace}{speed}$

Time taken in air $=\frac{x}{346}\sec(distnce = x m)$

Time taken in aluminium $=\frac{x}{6420}\sec$

Required ratio $=\frac{x}{346}\div\frac{x}{6420}=\frac{x}{346}\times\frac{6420}{x}=18.55$

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

Ans.: Frequency of sound = 100 Hz

Time taken = 1 minute = 60 sec

We know frequency $=\frac{number\ of\ oscillations}{time\ taken}$

$\therefore$ No. of oscillations $=\upsilon\times t = 100\times60 = 6000$ times.

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

Ans.: Yes, sound follows the same laws of reflection as that of light because,

(i) Angle of incidence of sound is always equal to that of angle of reflection of sound waves.

(ii) The direction in which sound is incident, the direction in which it is reflected and normal all lie in the same plane.

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

Ans.: The minimum distance *(d)* for the distinct echo to be heard (say at 22°C) is 17.2 m (as *2d* $=\upsilon t = 344\times0.1 = 34.4m$). On a hotter day, the temperature increases and the speed of sound in air also increases. For example, at 40°C, speed of sound, *i.e. v* 356 m s^{-1} and as such *Id* = 356 x 0.1 = 35.6 m or *d* = 17.8 m. Thus, if the distance of the reflecting surface and the source of sound remains the same *(i.e.,* 17.2 m), no echo is heard on the hotter day as the minimum distance now required is 17.8 m.

29. Give two practical applications of reflection of sound waves.

Ans.: **Ear Trumpet**: It is a sort of machine used by persons who are hard of hearing. The sound energy received by the wide end of the trumpet is connected into a much smaller area at the narrow end by multiple reflections. The narrow end of the trumpet which is inserted in the ear delivers the entire amount of energy falling on the wide end which makes the inaudible sound audible to the user.

Stethoscope : It is a medical instrument used frequently by doctors for making a rough diagnosis of the diseases existing inside the body at places which are either inaccessible or accessible only through major operations.

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

Ans.: Here, height through which the stone falls, *h* = 500 m speed of sound, *v* = 340 m s^{-1}, *g* = 10 m s^{-1} If *t* is the time taken by the stone to fall through *h,* then

$$h=\frac{1}{2}gt^2 or\, t=\sqrt{\frac{2h}{g}}$$

$$t'=\sqrt{\frac{2\times 500}{10}}=10s$$

Further, if f is the time taken by sound (produced as a result of splashing) to travel to the top of the tower,

$$t'=\frac{h}{\upsilon}=\frac{500}{10}=1.47s$$

Time after which the splash is heard at the top of the tower = *t* + f = 10 s + 1.47 s = 11.47s

31. A sound wave travels at a speed of 339 m s~1. If its wavelength is 1.5 cm, what is the frequency of the wave? Will it be audible?

Ans.: Here, speed of sound wave, *v* = 339 m s^{-1} Wavelength of sound wave, $\lambda=1.5cm=1.5\times10^{-2}m$

Frequency of the sound wave, $\upsilon=\frac{\upsilon}{\lambda}=\frac{339}{1.5\times10^{-2}}=22600Hz$ The sound is not audible as its frequency lies beyond the audible range (20 Hz to 20000 Hz).

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

Ans.: The persistence of sound in an auditorium as a result of repeated reflections of sound is called reverberation. To reduce the undesirable effects due to reverberation roofs and walls of the auditorium are generally covered with sound absorbent materials like compressed fiberboard, rough plaster, glass wool etc. The furniture is upholstered and floor is carpeted.

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

Ans.: Loudness of a sound depends on the amplitude of the vibration producing that sound.

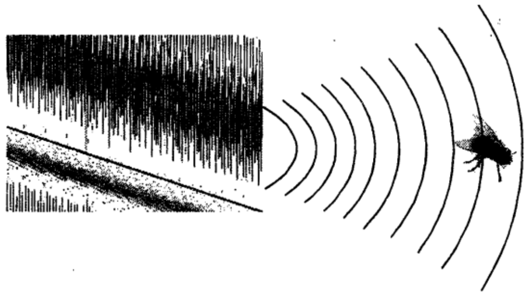
Greater is the amplitude of vibration, louder is the sound produced by it. The amplitude of the sound depends upon the force with which an object is made to vibrate.

The loudness of a sound also depends on the quantity of air that is made to vibrate.

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

Ans.: The ultrasonic waves emitted by the bat are reflected from the prey *(e.g.,* an insect) and are detected by its ears shown in figure. The nature of reflected waves tells the bat :

(i) the location and (ii) the nature of its prey.

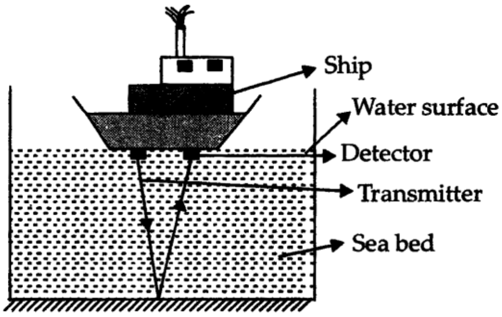


35. How is ultrasound used for cleaning?

Ans.: Ultrasound is used to clean parts located in hard-to-reach places *{i.e.)* spiral tube, odd shaped parks, electronic components etc. Objects to be cleaned are placed in a cleaning solutions and ultrasonic waves are sent into the solutions. Due to the high frequency, the dust particles, grease get detached and drop out. The objects thus get thoroughly cleaned.

36. Explain the working and application of a SONAR.

Ans.: **Working :** SONAR consists of a transmitter and a detector and is installed in a boat or a ship as shown in figure.



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

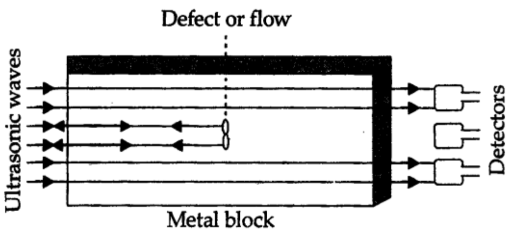
time interval between the transmission and reception of the ultrasound.
Let, depth of the sea == *d*
Speed of sound in sea water $= \upsilon$
Time taken for transmission and reception of signal $= t$
$\therefore$ Time taken to travel a distance, $d = \frac{t}{2}$
$\therefore$ Depth of the sea,
$d = \frac{t}{2} \times \upsilon (\because distnce = speed \times time)$

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

Ans.: Here, time interval between the transmission of the signal and its reception, *t = 5 s*
Distance of the object from the submarine, *d* = 3625 m
If *v* is the speed of sound in water, then
$2d = \upsilon t \, or \, v = \frac{2d}{t} = \frac{2 \times 3625}{5} = 1450 \, m \, s^{-1}$

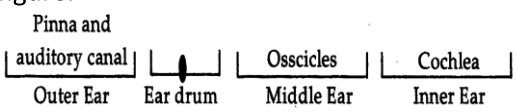
38. Explain how defects in a metal block can be detected using ultrasound.

Ans.: Ultrasounds can be used to detect cracks and flaws in metal blocks. Metallic components are used in the construction of big structures like buildings, bridges, machines and scientific equipments. 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 metallic 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.



39. Explain how the human ear works.

Ans.: The function of the human ear is shown in figure.



(i) The outer ear collects sound wave which are conducted through the auditory canal.
(ii) These waves fall on the ear drum and set it into vibrations.
(iii) The middle ear which is of the size of a small marble and houses ossicles (three bones:
hammer, anvil and stirrup) amplifies these oscillations about 60 times.
(iv)The inner ear which contains cochlea and is filled with a fluid converts these pressure variations into the electrical signals.
(v) These electrical signals are conveyed to the brain via auditory nerve for interpretation.

NCERT EXEMPLAR PROBLEMS-SOLUTIONS

Multiple Choice Questions (MCQs)

1. Note is a sound
(a) of mixture of several frequencies
(b) of mixture of two frequencies only
(c) of a single frequency
(d) always unpleasant to listen

Ans. **(a)** The sound which is produced due to a mixture of several frequencies is called a note and it is pleasant to listen too. An octave consists of eight different note, ranging from 256 Hz to 512 Hz.

2. A key of a mechanical piano struck gently and then struck again but much harder this time. In the second case
(a) sound will be louder but pitch will not be different
(b) sound will be louder and pitch will also be higher
(c) sound will be louder but pitch will be lower
(d) both loudness and pitch will remain unaffected

Ans. **(c)** In the second case, sound will be louder but pitch will be lower, because pitch of sound directly depends on frequency.

3. In SONAR, we use
(a) ultrasonic waves
(b) infrasonic waves
(c) radio waves
(d) audible sound waves

Ans. (a) SONAR is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects.

4. Sound travels in air, if
(a) particles of medium travel from one place to another
(b) there is no moisture in the atmosphere
(c) disturbance moves

(d) both particles as well as disturbance travel from one place to another

Ans. **(c)** Sound travels in air if disturbance moves. As during the propagation of sound waves, particles only vibrates in its own position and disturbances created by the vibration of particle moves from one place to other.

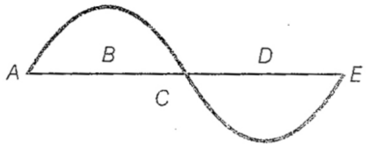
5. When we change feeble sound to loud sound we increase its

(a) frequency (b) amplitude

(c) velocity (d) wavelength

Ans. **(b)** The loudness or softness of a sound is determined basically by its amplitude, so for a loud sound it must have higher amplitude.

6. In the given curve, half the wavelength is



(a) AB (b) BD

(c) DE (d) AE

Ans. **(b)** In this curve, half the wavelength is BD. Because it is half the length of one complete cycle.

7. Earthquake produces which kind of sound before the main shock wave begins

(a) ultrasound (b) infrasound

(c) audible sound (d) None of these

Ans. **(b)** Earthquakes produces low frequency $(i.e., 5 Hz)$ infrasound before the main shock waves begin which possibly alert the animals and they get disturbed.

8. Infrasound can be heard by

(a) dog (b) bat

(c) rhinocerose (d) human beings

Ans. **(c)** Infrasound are the waves whose frequency is less than 20 Hz. Rhinoceroses communicate using infrasound of frequency as low as 5 Hz,

9. Before playing the orchestra in a musical concert, a sitaris t tries to adjust the tension and pluck the string suitably. By doing so, he is adjusting

(a) intensity of sound only

(b) amplitude of sound only

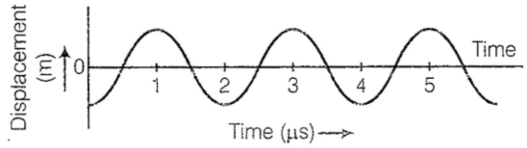
(c) frequency of the sitar string with the frequency of other musical instruments

(d) loudness of sounds

Ans. **(c)** Sitarist is adjusting frequency of the sitar string with the frequency of other musical instruments. Because if it is not done so, the sound will be un pleasant to listen.

SHORT ANSWER TYPE QUESTIONS

10. The given graph shows the displacement versus time relation for a disturbance travelling with velocity of $1500 ms^{-1}$. Calculate the wavelength of the disturbance.



Ans. Given, velocity $(v) = 1500 ms^{-1}$

Time taken in one complete cycle is $2 \mu s$

Time, $t = 2\mu s = 2 \times 10^{-6} s$ $(\because 1\mu s = 10^{-6} s)$

We know that, $v = u\lambda$ $\left(\because v = \frac{1}{T}\right)$

So. $v = \frac{\lambda}{T} \Rightarrow \lambda = vT$

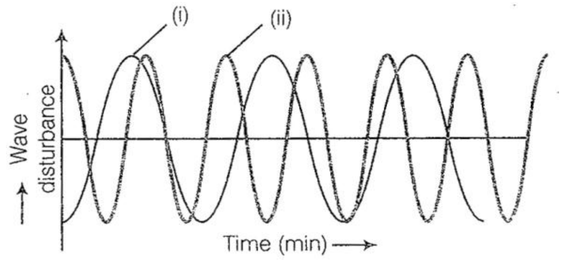
where, $\lambda =$ wavelength, v = frequency

and T= time period

So, $\lambda = 1500 \times 2 \times 10^{-6} = 3000 \times 10^{-6}$

$= 3 \times 10^{+3} \times 10^{-6} = 3 \times 10^{-3} m$

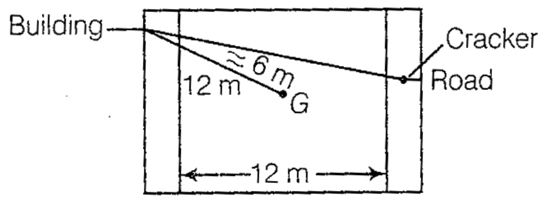
11. Which of the two graphs (i) and (ii) representing the human voice is likely to be the male voice? Give reason for your answer.



Ans. Graph (i) represents the male voice. Since the pitch and frequency of male voice is lower than the pitch of female voice and vibration of graph (ii) represents higher frequency and higher pitch.

12. A girl is sitting in the middle of a park of dimension 12m x 12m. On the left side of it there is a building adjoining the park and on right side of the park, there is a road adjoining the park. A sound is produced on the road by a cracker. Is it possible for the girl to hear the echo of this sound? Explain your answer.

Ans. No, it is not possible (or the girl to hear the echo of this sound, because the distance between girl and obstacle (building) is only 6m approx but echo is heard only if the minimum distance between the observer at the source of sound and the obstacle is 11.3 m.



13. Why do we hear the sound produced by the humming bees while the sound of vibrations of pendulum is not heard?

Ans. The frequency of vibrations of pendulum is below 20 Hz (infrasound). We cannot hear infrasound but humming produce audible sound which can be heard by human beings.

14. If any explosion takes place at the bottom of a lake, what type of shock waves in water will take place?

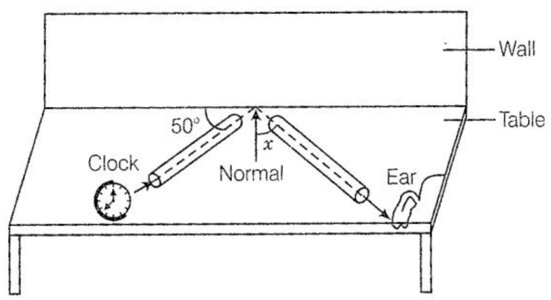
Ans. It any explosion Sakes place at the bottom of a lake. Infrasound type of shock waves in water will take place.

15. Sound produced by a thunderstorm is heard 10 s after the lightning is seen. Calculate the approximate distance of the thunder cloud (Given speed of sound $=340\,ms^{-1}$).

Ans. Given, time(t)= 10 s and speed (v)= 340 m/s We know that, distance = speed x time = 340 x 10 = 3400 m

$$=\frac{3400}{1000}km = 3.4\,km \qquad [\because 1km = 1000m]$$

16. For hearing the loudest ticking sound heard by the ear, find the angle x in the given figure.



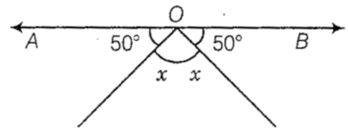
Thinking Process

Firstly, we use the law of reflection, i.e., angle of incidence = angle of reflection and use the property of linear pair axiom, then find the value of x

Ans. We know that, in laws of reflection, the angle of incidence (x) is always equal to the angle of reflection (x), Since, AOB is a straight line.

$\therefore \quad \angle AOB = 180^o$

$\therefore \quad 50^o + x + x + 50^o = 180^o$



($\because$ sum of all angles lies on the same side of aline is 180°)

$$2x + 100^o = 180^o$$
$$2x = 180^o - 100^o$$
$$2x = 80^o$$
$$x = \frac{80^o}{2}$$
$$x = 40^o$$

Hence, the value of x is 40^o.

17. Why is the ceiling and wall behind the stage of good conference halls or concert halls made curved?

Ans. The ceiling of concert halls, conference halls and cinema halls are curved so that sound after reflection reaches all corners of the hall uniformly.

LONG ANSWER TYPE QUESTIONS

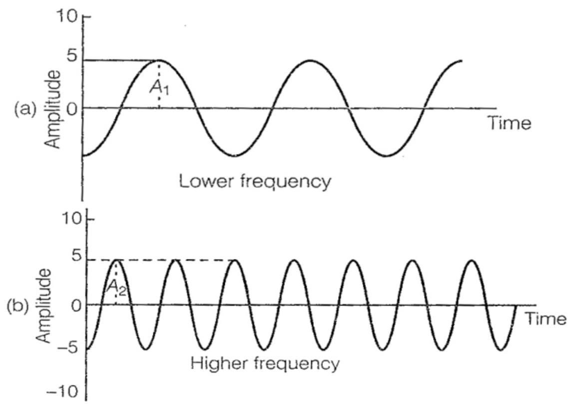
18. Represent graphically by two separate diagrams in each case.

(i) Two sound waves having the same amplitude but different frequencies.

(ii) Two sound waves having the same frequency but different amplitudes.

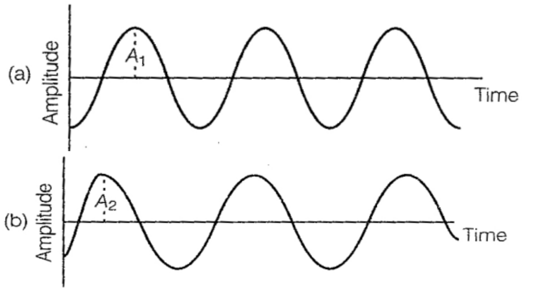
(iii) Two sound waves having different amplitudes and also different wavelengths.

Ans. (i)



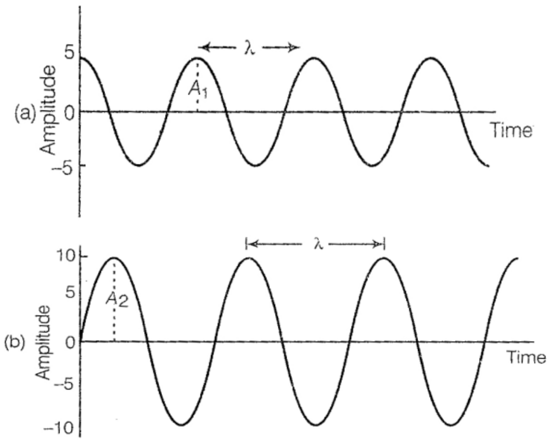
In both cases (a) and (b), same amplitude but different frequencies $(A_1 = A_2)$.

(ii)



In both cases (a) and (b) same frequency and different amplitudes. i.e., $(A_1 \neq A_2)$

(iii)



In both cases (a) and (b), different amplitudes and different wavelengths i.e., $A_1 \neq A_2, \lambda_1 \neq \lambda_2$

19. Establish the relationship between speed of sound, its wavelength and frequency. If velocity of sound in air is 340 ms^{-1}. Calculate
(i) wavelength when frequency is 256 Hz.
(ii) frequency when wavelength is 0.85 m.

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

We know that, $\text{speed (v)} = \dfrac{\text{distance}}{\text{time}} = \dfrac{\lambda}{T}$

Here, λ is the wavelength of the sound wave. It is the distance travelled by the sound wave in one time period (*T*) of the wave

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

We know that, $v = \dfrac{1}{T}$ (where v = frequency)

$$\mathrm{V} = \lambda v$$

i.e., Speed = wavelength x frequency

Given, speed of sound in air v = 340 m/s and frequency v = 256 Hz.

(i) $\therefore$ Speed = wavelength x frequency

$\Rightarrow \quad 340 = \lambda \times 256$

$\Rightarrow \quad \lambda = \dfrac{340}{256} = 133m$

(ii) Again, given wavelength $\lambda = 0.85m$

Then. frequency of sound in air. $v = \dfrac{\text{speed}}{\text{wavelength}}$

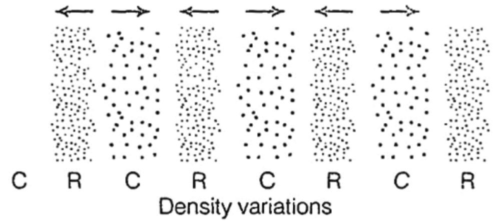
($\because$ speed = wavelength x frequency)

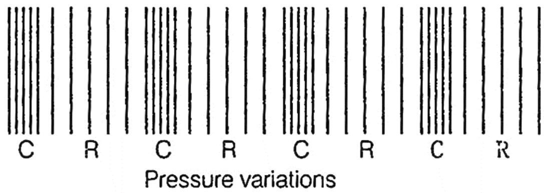
$\Rightarrow \quad v = \dfrac{340}{0.85} = \dfrac{340 \times 100}{85} = 400Hz$

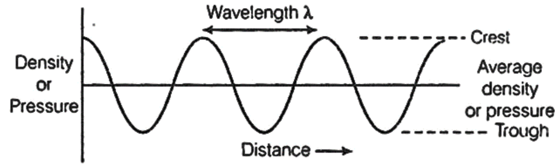
Thus, frequency of sound is 400 Hz.

20. Draw a curve showing density or pressure variations with respect to distance for a disturbance produced by sound. Mark the position of compression and rarefaction on this curve. Also define wavelengths and. time period using this curve.

Ans. We have a curve showing density or pressure variations with respect to distance for a disturbance produced by sound.







Wavelength can be defined as the distance between to successive compresion or rarefaction. It is denoted by λ.

Time taken by the waves to complete one full cycle, so that its particles are in same phase is called time period. It is denoted by T.

EXERCISE

Multiple Choice Questions

1. Which is not the condition for hearing sound?
(a) There must be a vibrating body capable of transferring energy.
(b) There must be a material medium to pick up and propagate energy.
(c) The medium must have a large density.
(d) There must be receiver to receive the energy and interpret it.

2. An instrument commonly used in laboratory to produce a sound of some particular frequency is
(a) sonar (b) electric bell
(c) tuning fork (d) a stretched wire

3. When a sound wave travels in air, the physical quantity which is transferred from one place to the other is
(a) mass (b) force
(c) momentum (d) energy

4. In case of longitudinal waves, the particles of medium vibrate
(a) in the direction of wave propagation opposite to the direction of wave propagation
(c) at right angles to the direction- of wave propagation
(d) none of the above

5. In case of transverse waves the particles of a medium vibrate
(a) in the direction of wave propagation opposite to the direction of wave propagation
(c) at the right angles to the direction of wave propagation
(d) none of the above

6. In the region of compression or rarefaction, in a longitudinal wave the physical quantity which does not change is
(a) pressure (b) mass
(c) density (d)volume

7. A slinky can produce in laboratory
(a) transverse waves only
(b) longitudinal waves only
(c) both (a) and (b)
(d) none of the above

8. The change in density/pressure of a medium from maximum value to minimum value and again to maximum value, due to the propagation of a longitudinal wave is called a complete
(a) oscillation (b) frequency
(c) amplitude (d) none of the above

9. If the frequency of a wave is 25 Hz, the total number of compressions and rarefactions passing through a point in 1 second is
(a) 25 (b) 50
(c) 100 (d) none of the above

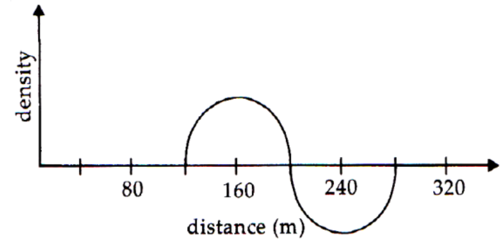
10. A stretched slinky is given a sharp push along its length. A wave travels from one end to another. The wave so produced is
(a) transverse wave (b) longitudinal wave
(b)stationary wave (d) none of the above

11. The sound waves having a frequency more than 20,000 Hz are called
(a) infrasonic waves (b) supersonic waves
(c) ultrasonic waves (d) hypersonic waves

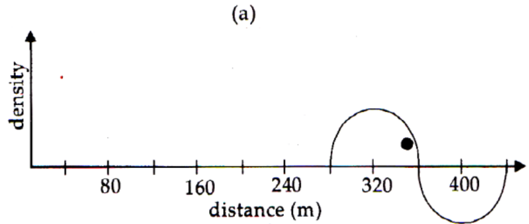
12. A boy sitting in a boat fires a gun. An observer P is at a distance of 50 m from the boat. Another observer Q is a diver, who is 50 m under water.
Both hear the sound of gun
(a) P hears the sound first
(b) Q hears the sound first
(c) Both P and Q hear the sound at the same time
(d) none of the above

13. Calculate the wavelength of radio waves of frequency 109 Hz. The speed of radio waves is $3\times10^{8}\,ms^{-1}$
(a) 60 cm (b) 40 cm
(c) 30 cm (d) 10 cm

14. A wave pulse moving through air causes Change in the density of the air. The variation of density at two different instants are shown in the figure. The figure (a) corresponds to, $t=10\,s$ and figure (b) to $t=10.5\,s$.



(a)



(b)

The speed of the wave pulse is
(a) $520\,ms^{-1}$ (b) $320\,ms^{-1}$
(c) $300\,ms^{-1}$ (d) $200\,ms^{-1}$

15. A wave source produces 20 crests and 20 troughs in 0.2 sec. Find the frequency of the wave.
(a) 200 Hz (b) 500 Hz
(c) 100 Hz (d) 300 Hz

16. If the density of air at a point through which a sound wave is passing is maximum at an instant, the pressure at that point will be
(a) minimum
(b) same as the density of air
(c) equal to the atmospheric pressure
(d) maximum

17. An object moving at a speed greater than that of sound is said to be moving at
(a) ultrasonic speed (b) sonic speed

(c) infrasonic speed (d) supersonic speed

18. Ultrasonic waves are used for detecting objects under water. What technique/device is used for this?
(a) Ultrasonography
(b) Echocardiography
(c) Phakoemulsification
(d) Sonar

19. In which of the three media; air, water and steel does sound travel the fastest?
(a) air (b) water
(c) steel (d) none of these

20. A sound wave has a frequency of 1000 Hz and a wave length of 34 cm. How long will it take to travel 1 km?
(a) 3.20 s (b) 2.94 s
(c) 5.94 s (d) 3.10 s

21. An object is 11 km below sea level. A research vessel sends down a sonar signal to confirm this depth. After how long can it expect to get the echo? (Take the speed of sound in sea water as 1,520 m s^{-1}.)
(a) 15.30 s (b) 14.47 s
(c) 12.20 s (d) 11.13 s

22. Which of the following is an elastic wave?
(a) Sound waves (b) Light waves
(c) X-rays (d) Radio waves

23. A big explosion on the moon cannot be heard on the earth because
(a) the explosion produces high frequency sound waves which are inaudible
(b) sound waves required a material medium for propagation
(c) sound wave are absorbed in the moon's atmosphere
(d) sound waves are absorbed in the earth's atmosphere

24. Two waves having sinusoidal waveforms have different wavelengths and different amplitude.
They will be having
(a) same pitch and different intensity
(b) same quality and different intensity
(c) different quality and different intensity
(d) same quality and different pitch

25. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is $1500 m s^{-1}$ and in air is $300 m s^{-1}$.
The frequency of sound recorded by an observer who is standing in air is
(a) 200 Hz (b) 300 Hz
(c) 120 Hz (d) 600 Hz

26. Each of the properties of sound listed in column A primarily depends on one of the quantities in column B. Choose the matching pairs from two columns.

Column A	**Column B**
Pitch	Waveform
Quality	Frequency
Loudness	Intensity

(a) Fitch-waveform, Quality-frequency, Loudness-intensity
(b) Pitch-frequency, Quality-waveform, Loudness-density
(c) Pitch-intensity, Quality-waveform, Loudness-frequency
(d) Pitch-waveform, Quality-intensity, Loudness-frequency

27. A light pointer fixed to one prong to a tuning fork touches a vertical plate. The fork is set vibrating and the plate is allowed to fall freely. If eight oscillations are counted when the Plate falls through 10 cm, the frequency of the tuning fork is
(a) 360 Hz (b) 280 Hz
(c) 560 Hz (d) 56 Hz

28. A person is listening to a tone of 500 Hz, sitting at a distance of 450 m from the source of sound. The time interval between successive compressions from the source is
(a) 0.2 s (b) 0.02 s
(c) 0.002 s (d) 2.0 s

29. An echo is returned in 3 s. If the speed of sound is $342 m s^{-1}$,then the distance between the source of sound and the reflecting body is
(a) 351 m (b) 513 m
(c) 153 m
(d) none of the above

30. A submarine emits a sonar pulse, which returns from under water cliff in 1.02 s. If the speed of sound in water is $1531 m s^{-1}$, the submarine is at a distance of
(a) 780.8 m from cliff (b) 718.8 m from cliff
(c) 714.8 m from cliff (d) none of the above

31. The minimum hearing range for a normal ear is 20 Hz. The wavelength associated with this range when velocity of sound is $344 m s^{-1}$ is
(a) 16.2 m (b) 17.2 m
(c) 17.4 m (d) 17.3 m

32. A person can hear a sound of maximum frequency 20,000 Hz. If the speed of sound in air is $344 m s^{-1}$, the wavelength is
(a) 0.176 m (b) 0.178 m
(c) 0.0172 m (d) 0.0176 m

33. The wavelength of ripples produced on the surface of water is 0.14m. If the speed of ripples is 42 m s 1, the number of ripples produced per second are

(a) 290 (b) 310

(c) 300 (d) 280

34. The highest frequency produced by a man is 1700 Hz and that of a woman is 2780 Hz. The ratio of wave lengths of sound of man and woman are (speed of sound is $340 m s^{-1}$)

(a) 1 : 0.60 (b) 1 : 0.61

(c) 1 : 0.62 (d) 1 : 0.59

35. The wavelength and frequency of a sound wave in medium A is 20 cm and 1650 Hz. Keeping the medium same, if wavelength is changed to 16 cm, then new frequency is

(a) 2060 Hz (b) 2062.5 Hz

(c) 2061 Hz (d) 2063.0 Hz

36. A boy stands 66.4 m in front of a high wall and then blows a whistle. If speed of sound is $332 m s^{-1}$, the echo is heard after

(a) 0.45 s (b) 0.48 s

(c) 0.40 s (d) 0.46 s

37. A man stands between two cliffs and fires a gun. He hears two successive echoes after 3 s and 5 s. The distance between two cliffs is

(a) 1310 m (b) 1320 m

(c) 1315m (d) 1312m

38. A boat at anchor is rocked by the waves, such that the distance between two consecutive crests is 100 m. If the wave velocity is $20 m s^{-1}$ the frequency of rocking boat is

(a) 2 Hz (b) 1 Hz

(c) 0.5 Hz (d) 0.2 Hz

39. Water waves are

(a) longitudinal (b) transverse

(c) both longitudinal and transverse

(d) neither longitudinal nor transverse

40. Human ear cannot hear those mechanical waves whose frequency lies in the frequency range

(a) less than 100 Hz but greater than 10000 Hz

(b) between 1000 Hz and 5000 Hz

(c) between 500 Hz and 20000 Hz

(d) less than 20 Hz and more than 20000 Hz

41. An echo repeats two syllables. If the velocity of sound is $330 m s^{-1}$, then the distance of The reflecting surface is

(a) 66.0 m (b) 33.0 m

(c) 99.0 m (d) 16.5 m

42. A plane wave of sound travelling in air is incident upon a plane water surface. The angle of incidence is 30°. If the velocity of sound in water is $1400 m s^{-1}$, and the velocity of sound in air is $330 m s^{-1}$, there will be

(a) Reflection only

(b) Refraction only

(c) both reflection and refraction

(d) neither reflection nor refraction

43. Which one of the following properties of sound is affected by change in the air temperature?

(a) frequency (b) amplitude

(c) intensity (d) wavelength

44. In a stationary wave, the particle velocity at the nodal point is

(a) zero

(b) maximum

(c) minimum but non zero

(d) none of the above

45. The distance between any two consecutive nodes or antinodes in a stationary wave of wavelength X is

(a) λ (b) $\lambda / 2$

(c) $\lambda / 4$ (d) $\lambda / 8$

46. If you go on increasing the stretching force on a wire in a guitar, its frequency

(a) increases

(b) decreases

(c) remains unchanged

(d) none of the above

47. A simple pendulum has a metal bob which is negatively charged. If it is allowed to oscillate above a positively charged metallic plate then its time period will

(a) increase (b) decrease

(c) remains the same (d) become zero

48. The velocity of sound in vacuum is

(a) $332 m s^{-1}$ (b) $330 m s^{-1}$

(c) $288 m s^{-1}$ (d) 0

49. Longitudinal wave cannot travel through

(a) vacuum (b) solids

(c) liquids (d) gases

50. A bomb explodes on the moon. How long will it take for the sound to reach the earth?

(a) 10 seconds (b) 1000 seconds

(c) 1 day (d) none of these

51. A pendulum vibrates with a time period of 1 second. The sound produced by it is

(a) supersonic (b) audible

(c) infrasonic (d) ultrasonic

52. Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen. This is because

(a) speed of sound is greater than speed of light

(b) speed of sound is equal to the speed of light
(c) speed of light is much greater than the speed of sound
(d) none of these

53. During night, distant sounds such as that of the traffic and the loudspeakers become louder than during day. This is due to
(a) reflection of sound waves
(b) refraction of sound waves
(c) absence of other sounds
(d) clear perception of hearing

54. A source of wave produces 40 crests and 40 troughs in 0.4 seconds. Find the frequency of the wave?
(a) 100 Hz (b) 50 Hz
(c) 25 Hz (d) 10 Hz

55. A person is listening to sound of 50 Hz sitting at a distance of 450 m from the source of sound. What is the time interval between successive compressions of the sound from the source reaches him?
(a) 0.02 s (b) 0.025 s
(c) 0.0025 s (d) 0.15 s

56. A boat at anchor is rocked by waves whose consecutive crests are 100 m apart. The wave velocity of the moving crests is 20 m/s. What is the frequency of rocking of the boat?
(a) $2s^{-1}$ (b) $0.2\,s^{-1}$
(c) $0.1\,s^{-1}$ (d) $0\,s^{-1}$

57. A longitudinal wave is produced on a toy slinky. The wave travels at a speed of $30cms^{-1}$ and the frequency of the wave is 20 Hz. What is the minimum separation between the consecutive compressions of the slinky?
(a) 1.0 cm (b) 1.5 cm
(c) 2.5 cm (d) 3.0 cm

58. A gun is fired in the air at a distance of 660 m from a person. He hears the sound of the gun after 2 s. What is the speed of sound?
(a) $330ms^{-1}$ (b) $360ms^{-1}$
(c) $370ms^{-1}$ (d) $390ms^{-1}$

59. A child hears an echo from a cliff 4 seconds after the sound from a powerful cracker is produced. How far away is the cliff from the child? Velocity of sound in air at 20°C is $344ms^{-1}$
(a) 688 m (b) 672 m
(c) 660 m (d) 650 m

60. A ship sends on a high frequency sound wave and receives an echo after 1 second. What is the depth of the sea? Speed of sound in water is 1500 m/s.
(a) 700 m (b) 750 m
(c) 800 m (d) 850 m

61. Sound travels at a speed of 334 m s^{-1} in air. this means that
(a) the source of sound moves 334 m in one second
(b) the listener moves 334 m in one second
(c) air moves 334 m in one second
(d) the disturbance in air moves 334 m in one second

62. Non-mechanical wave can travel
(a) in vacuum as well as in a medium
(b) in vacuum but not in a medium
(c) in medium but not in vacuum
(d) neither in a medium nor in vacuum

63. A boat anchor is rocked by waves whose crests are 100 m apart and whose velocity is $25ms^{-1}$. The wave strike the boat once every
(a) 2 s (b) 0.25 s
(c) 3s (d) 4 s

64. A source of frequency 500 Hz emits waves of wavelength 0.2 m. How long does it take the wave to travel 300 m?
(a) 7 s (b) 6 s
(c) 12 s (d) 3 s

65. When sound waves travelling in air enter into water, the following remains constant?
(a) amplitude (b) frequency
(c) wavelength (d) velocity

66. If ultrasonic, infrasonic and audio waves travel through a medium with speed υ_1, υ_2 and υ_3 respectively, then
(a) $\upsilon_1 = \upsilon_2 = \upsilon_3$ (b) $\upsilon_1 > \upsilon_3 > \upsilon_2$
(c) $\upsilon_1 < \upsilon_3 < \upsilon_2$ (d) $\upsilon_3 \le \upsilon_1$ and $\upsilon_1 = \upsilon_3$

67. Ultrasonic waves are produced by
(a) Piezoelectric effect (b) Peltier effect
(c) Doppler effect (d) Coulomb's law

68. The minimum distance between the source of sound and the obstacle for an echo to take place is
(a) 17.2 m (b) 1.72 m
(c) 17 cm (d) 34.4 m

69. The wavelength of a sound wave in air corresponding to a frequency of 20 Hz is
(a) 1.7 m (b) 17 m
(c) 1.7 cm (d) 17 cm

70. The wavelength of sound wave corresponding to a frequency of 20 kHz is
(a) 1.7 cm (b) 17 cm
(c) 1.7 m (d) 17 m

71. Sound waves of wavelength λ travel from a medium in which their speed is υ into a medium in which their speed is 4υ. The wavelength of the sound in the second medium is
(a) λ (b) 2λ c
(c) 4λ (d) 3λ

72. The amplitude of a sound is doubled and the frequency is reduced to one fourth. The intensity of sound at the same point will be
(a) increased by a factor of 2
(b) increased by a factor of 4
(c) decreased by a factor of 2
(d) decreased by a factor of 4

FILL IN THE BLANKS

1. Sound waves are............. waves.
2. .... waves consist of compressions and rarefactions.
3. A wave of short duration is called a.............
4. The frequency of a wave does not depend upon the............. of the medium through which is passes.
5. The SI unit of time period is.............
6. .... is the SI unit of frequency.
7. Sound navigation and ranging is abbreviated as.............
8. Sound waves of frequency less than 20 Hz are .... waves.
9. Wave motion carries............. from one place to another place in a medium.
10. .... travel through air.
11. When you hit a drum you make the skin..........
12. Vibrations of high frequency have a larger............. than vibrations of lower frequency.
13. Reflected sound waves are called.............
14. Larger vibrations have............. amplitude.
15. Jal tarangis an example of............. instruments.
16. Sound travels fastest in............ and slowest in

TRUE OR FALSE

1. During a wave motion, energy is transferred from one point to another.
2. In any medium, the speed of electromagnetic waves is lesser than that of sound waves.
3. A transverse wave consists of crests and troughs.
4. Transverse waves can propagate through any medium.
5. Sound waves require a medium for their propagation.
6. All sound waves are caused by vibrations.
7. In a metal, the sound waves that propagate are always transverse.
8. Wavelength is measured in Hertz.
9. Since sound waves can travel through air, and air can transmit only transverse waves, it follows that sound travels as transverse waves,
10. Light is a longitudinal wave.
11. Wave velocity is equal to particle velocity.
12. Transverse waves cannot propagate in a gas.
13. Wavelength is the distance between two particles of the same medium in the opposite phase.
14. Louder sound travels faster in air than a feeble sound.
15. Frequency of sound is related its pitch.
16. Sound cannot be heard on moon.
17. Pitch of sound is related to amplitude of vibrations.
18. We hear a bomb blast 10 seconds after it happens.
19. Sound waves are transverse waves.
20. Loudness determines the amplitude of vibrations.

Matrix Match Type

In this section each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in Column-I have to be matched with statements (p, a, r, s) in Column-II.

1.

Column-I	**Column-II**
(A) High pitch	(p) Faint sound
(B) Low pitch	(q) Loud sound
(C) Small amplitude	(r) High frequency
(D) Large amplitude	(s) Low frequency

2.

Column-I	**Column -I**
(A) Megaphone	(p) 17.2 m
(B) Minimum distance for echo	(q) 3000 m
(C) Depth of sea if ultrasonic wave come back in 4 sec.	(r) Multiple reflection of sound
(D) Echo heard after 5 sec distance of reflecting surface	(s) 855 m

3.

Column-I	**Column-II**
(A) Elephants	(p) Reflection of

		sound
	(B) Ultrasound	(q) Infrasonic waves
	(C) Sonar	(r) Multiple reflection of sound
	(D) Reverberation	(s) Welding purpose
4.	**Column-I**	**Column-II**
	(A) Slinky when jerked	(p) Longitudinal wave
	(B) Quality of sound	(q) Loudness
	(C) Slinky pushed or pulled	(r) Transverse wave
	(D) Amplitude	(s) Timbre

ASSERTION & REASON QUESTIONS

Directions: In each of the following questions, A statement of Assertion (A) is given followed by a corresponding statement of Reason (R) just below it. Of the statements, mark the correct answer as

(a) If both assertion and reason are true and reason is the correct explanation of assertion
(b) If both assertion and reason are true but Reason is not the correct explanation of assertion
(c) If assertion is true but reason is false
(d) If assertion is false but reason is true.

1. **Assertion:** Two persons on the surface of moon cannot talk to each other.
Reason: There is no atmosphere on moon.

2. **Assertion:** The velocity of sound increases with increases in humidity.
Reason: Velocity of sound does not depends upon the medium.

3. **Assertion:** Compression and rarefaction involve changes in density and pressure.
Reason: When particles are compressed, density of medium increases and when they are rarefied, density of medium decreases.

4. **Assertion:** Transverse waves travel through air in an organ pipe.
Reason: Air possesses only volume elasticity.

5. **Assertion:** The velocity of sound in hydrogen gas is less than the velocity of sound in oxygen gas.
Reason: The density of oxygen is more than the density of hydrogen.

6. **Assertion:** Sound would travel faster on a hot summer day than on a cold winter day.
Reason: Velocity of sound is directly proportional to the square of its absolute temperature.

7. **Assertion:** Waves produced in a cylinder containing a liquid by moving its piston back and forth are longitudinal waves.
Reason: In longitudinal waves, the particle of the medium oscillate parallel to the direction of propagation of the wave.

8. **Assertion:** A vibrating tuning fork sounds louder when its stem is pressed against a desk top.
Reason: When a wave reaches another denser medium, part of the wave is reflected.

9. **Assertion:** Waves produced by a motor boat sailing in water are both longitudinal and transverse waves.
Reason: The longitudinal and transverse waves cannot be produced simultaneously.

10. **Assertion :** The speed of sound in solids is maximum though their density is large.
Reason: The coefficient of elasticity of solid is large.

11. **Assertion:** To hear distinct beats, difference in frequencies of two sources should be less than 10.
Reason: More the number of beats per sec more difficult to hear them.

12. **Assertion:** The velocity of sound changes as we go up in the atmosphere.
Reason : Pressure decreases as we go up in the atmosphere.

PASSAGE

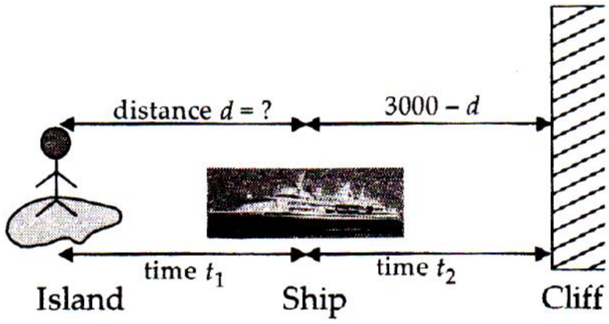
PASSAGE 1: Words are either in single syllables or a combination of syllables. A single syllable takes about $\frac{1}{5}$ m of a second to utter. The least distance necessary for hearing the echo of a word with two syllables is two times of a single syllable, for a trisyllabic word it is three times and so on.

1. The minimum distance to hear the echo of a single syllable word clearly should be
(a) 33.2 m (b) 33.4 m
(c) 33.6 m (d) 33.8 m

2. The number of syllable in the word Saritha
(a) 1 (b) 2
(c) 3 (d) 4

3. The least distance to hear on echo of the word Seema
(a) 33.2 m (b) 66.4 m
(c) 68.4 m (d) 72 m

PASSAGE 2: The survivor of a shipwrech lands on an island which is 3000 m from a vertical cliff as shown in figure. He sees a ship anchored between the island and the cliff. A blast from the ship's horn is heard twice with a time lapse of 4 s.



1. The distance of the ship from the island is
(a) 2300 m (b) 6000 m
(c) 3200 m (d) 2340 m

2. The time taken by sound from ship to reach cliff is
(a) 2340 s (b) 4680 s
(c) 3420 s (d) 6480 s

3. The time taken for first horn blast to reach survivor is
(a) 7.09 s (b) 5.09 s
(c) 6.09 s (d) 4.09 s

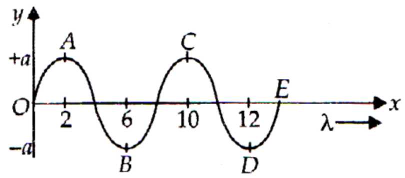
PASSAGE 3: The intensity of a sound is the sound energy flowing through a unit area in one sound. The more the intensity of sound, the more its loudness.

1. The unit of intensity of sound is
(a) $W\,m^2$ (b) $W\,m^{-2}$
(c) $W\,m^{-1}$ (d) $W\,m^1$

2. Which among the following is false m case of intensity of sound
(a) $I \propto a^2$ (b) $I \propto \upsilon^2$
(c) $I \propto r^2$ (d) $I \propto \lambda^2$

3. The maximum displacement of air particles between the faintest and maximum intensity of sound is
(a) 0.001 cm (b) 0.01 cm
(c) 0.1 cm (d) 1.0 cm

PASSAGE 4: For the wave shown below, the time period is 0.8 s.



1. The wavelength of wave is
(a) 12 m (b) 8 m
(c) 16 m (d) 4 m

2. The tune taken by wave from 0 to E is
(a) 0.16 S (b) 0.8 s
(c) 1.0 s (d) 0.24 s

3. The velocity of the wave is
(a) $4 m s^{-1}$ (b) $8 m s^{-1}$
(c) $10 m s^{-1}$ (d) $12 m s^{-1}$

PASSAGE 5: An Unidentified Flying Object (UFO) lands on a planet at a point 5 kilometres from an active volcano. There is a volcanic explosion. The time interval between the flash of light from the volcanic explosion and the sound of eruption was registered as 100 sec. The time period of wave is 2s.

1. The speed of sound on the planet is
(a) 25 m s^{-1} (b) 50 m s^{-1}
(c) 75 m s^{-1} (d) 100 m s^{-1}

2. The wavelength of the wave is
(a) 100 m (b) 200 m
(c) 300 m (d) 400 m

3. Frequency of the wave is
(a) 0.001 Hz (b) 0.01 Hz
(c) 0.1 Hz (d) 1.0 Hz

SUBJECTIVE PROBLEMS

VERY SHORT ANSWER TYPE QUESTIONS

1. How does a high pitch sound differ from a low pitch sound?
2. Name the waves used to break small stones formed in the kidneys into fine grains.
3. What is a sonic boom?
4. Can you produce sound without utilizing energy?
5. By how much does the speed of sound Increase with rise of temperature?
6. What is the basic principle which SONAR
7. Define the characteristic timber or quality of a sound.
8. A gun is fired at a distance. Why is the sound heard after the flash is seen.
9. What is a note?
10. What happens to the medium through which sound travels?
11. What do you understand by the pitch of the sound?
12. Why cannot we hear an echo in a small room?
13. What is a mechanical wave?
14. By what amount, the speed of sound in air increases with 1°C rise in temperature of the air?
15. Have you ever wondered why we hear sound of the horn of an approaching car before the car reaches us?

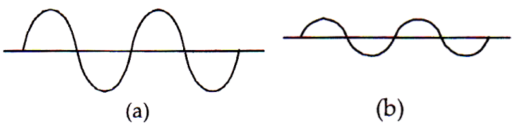
SHORT ANSWER TYPE QUESTIONS

1. The sound of distant horses can be heard by applying the ear to the ground whereas it is inaudible if the ear is held a little distance above the ground. Explain.

2. The sound of an explosion on the surface of a lake is heard by a boatman 100 m away and by a diver 100 m below the point of explosion.
(a) Who will hear the sound of explosion first?
(b) If sound takes time t s to reach the boatman, how much time (approximately) will it take to reach the diver?

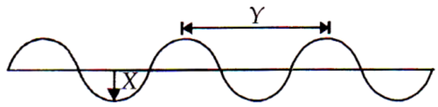
3. A large auditorium has a curved back. Explain.

4. Two waves are shown below. Which of the two corresponds to lower decibel level?



5. What is the difference between an echo and a reverberation?

6. A sound wave travelling in a medium is represented as shown in the figure:

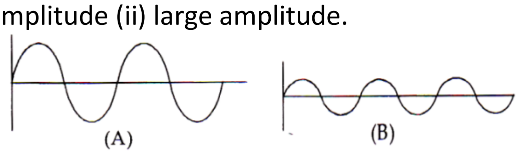


(a) Which letter represents the amplitude of the sound wave?
(b) Which letter represents the wavelength of wave?
(c) What is the frequency of the source of sound if the vibrating source of sound makes 360 oscillations in 2 minutes.

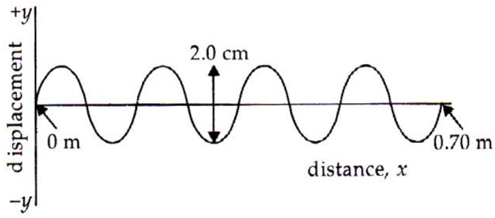
7. Sound of explosions taking place on other planets are not heard by a person on the earth. Explain, why?

8. Where is reverberation desirable and where is this to be avoided?

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



10. A snapshot is taken of a periodic wave travelling on a string as shown below. What is the amplitude and wavelength of the wave?



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

12. When we nibble at a rusk, we hear a noise that is simply defining. But for some reason, our neighbor makes hardly any noise though he is doing the same. Why?

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

14. Waves of higher frequencies are used for cleaning hard-to-reach places. These are also used to detect and find the distance of object under water.
(a) Name these waves.
(b) What is the frequency of these waves?
(c) Mention one more use of these waves.

15. An observer notes that there is a 6 second interval between seeing a flash of lightning and hearing the clap of thunder. How far away is the storm?

LONG ANSWER TYPE QUESTIONS

1. What is SONAR? How is it used to detect an underwater object and measure its distance?

2. A man stationed between two parallel cliffs fires a gun. He hears the first echo after 1.5s and the next after $2.5s$ What is die Distance between the cliffs and when does he hear the third echo? Take the speed of sound in air as $340\,ms^{-1}$.

3. A man fires gun towards a hill and hears its echo after 5 s. He then moves 340 m towards the hill and fires his gun again. This time he hears the echo after 3 s. Calculate the speed of sound.

4. A stone is dropped into a well, 44.1 metres deep. The sound of the splash is heard 3.13 seconds after the stone is dropped. Find the velocity of sound in air.

5. Audible frequencies have a range 40 hertz to 30,000 hertz. Express this range in terms of
(i) period T
(ii) wavelength X in air, and
(iii) angular frequency,
Given velocity of sound in air is $350\,ms^{-1}$

6. If the frequency of a tuning fork is 400, find how far the sound travels when the fork makes 30 vibrations. Given velocity of sound in air is 320 metres sec.

7. What is an echo? How is it formed?

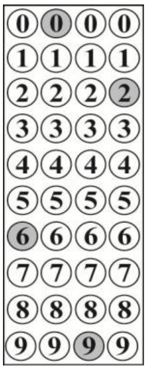
8. It was observed that at a receiving station at Ahmadabad, the longitudinal waves and transverse waves produced during the Gujarat earthquake arrived at speeds of $x\ m/s$ and $y\ m/s$ respectively. The two waves are received at an interval of t seconds. Find the distance between the receiving station and Bhuj where the epicenter of the earthquake was located $(x > y)$

9. A man fires a shot and hears an echo from a cliff after 2 s. He walks 85 m towards the cliff and the echo of second shot is now heard after 1.4 s. What is the velocity of sound and how far was the man from the cliff when he first heard the echo?

10. What is the maximum time taken by the particle in an ultrasonic wave to go from one extreme to another during its oscillation.

INTEGER ANSWER TYPE

This section contains 5 questions.
The answer to each of the questions is a single digit integer, ranging from 0 to 9 If the correct answers to question numbers X, Y, Z and W (say) are 6, 0, 9 and 2 respectively, then the correct darkening of bubbles will look like the following.



1. A light pointer fixed to one prong of a tuning fork touches a vertical plate. The fork is set vibrating at a frequency of 56 Hz and allowed to free fall. How many complete oscillations (to the nearest integer) are counted when plate falls at 10 cm?

2. Find the wavelength of a sound wave whose. frequency is 220 Hz and speed is $440\,ms^{-1}$ in a given a medium.

3. A person has a hearing range from 20 Hz to 20 kHz. What are the typical wavelengths of sound waves in air corresponding to these two frequencies? Take the speed of sound in air as $340\,ms^{-1}$.

4. A sound wave has a frequency 1000 Hz and wavelength 34 cm. How long will it take to move through 1 km?

5. An observer standing at the sea coast observes 54 waves reaching the coast per minute. If the wavelength of a wave is 10 m, find the wave velocity.

ANSWER – KEY

Multiple Choice Questions

1. C	**2.** C	**3.** D	**4.** A	**5.** C	**6.** B	**7.** C
8. A	**9.** B	**10.** B	**11.** C	**12.** B	**13.** C	**14.** B
15. C	**16.** D	**17.** D	**18.** D	**19.** C	**20.** B	**21.** B
22. A	**23.** B	**24.** A	**25.** D	**26.** B	**27.** D	**28.** C
29. B	**30.** A	**31.** B	**32.** C	**33.** C	**34.** B	**35.** B
36. C	**37.** B	**38.** D	**39.** C	**40.** D	**41.** A	**42.** A
43. D	**44.** A	**45.** B	**46.** A	**47.** B	**48.** D	**49.** A
50. D	**51.** C	**52.** C	**53.** B	**54.** A	**55.** A	**56.** B
57. B	**58.** A	**59.** A	**60.** B	**61.** D	**62.** A	**63.** D
64. D	**65.** B	**66.** A	**67.** A	**68.** A	**69.** B	**70.** A
71. C	**72.** D					

Fill in the Blanks

1. Mechanical	**2.** Longitudinal
3. Pulse	**4.** Nature
5. Second	**6.** Hz
7. SONAR	**8.** Infrasonic
9. Energy	**10.** Sound
11. Vibrate	**12.** Pitch
13. Longitudinal	**14.** Larger
15. Percussion	**16.** Solid, air

True or False

1. True	**2.** False
3. True	**4.** False
5. True	**6.** True
7. False	**8.** False
9. False	**10.** False
11. False	**12.** False
13. False	**14.** False
15. True	**16.** True
17. False	**18.** True
19. False	**20.** True

Matrix Match Type

1. A→r; B→s; C→p; D→q
2. A→r; B→p; C→q; D→s
3. A→q; B→s; C→p; D→r
4. A→r; B→s; C→p; D→q

Assertion and Reason Type

1. A	**2.** C	**3.** A	**4.** D	**5.** D	**6.** C	**7.** B
8. C	**9.** C	**10.** A	**11.** B	**12.** B		

Passage Comprehension

Passage : 1

1. A	**2.** C	**3.** C

Passage : 2

1. D	**2.** B	**3.** A

Passage : 3

1. B	**2.** D	**3.** A

Passage : 4

1. B	**2.** A	**3.** C

Passage : 5

1. B	**2.** A	**3.** B

Integer Answer Type

1. 8	**2.** 2	**3.** 2	**4.** 3	**5.** 9