Sound

What is sound and how is it produced?

Solution:

Sound is a form of energy and it is produced by vibrating bodies.

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

Solution:

When an object, like a tuning fork, is set into vibrations, its prongs vibrate to and fro. These vibrations cause the layers of air surrounding the fork to vibrate. When the layers of air are pushed by the prongs, say, towards right, the layers are compressed, and thus a compression is formed. If the prongs of the fork move towards left in the process of vibration, the layers of air are now pulled towards left, creating a rarefaction.

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

Solution:

An electric bell is suspended in a bell jar by means of support wires that pass through the cork lid as shown. The bell jar has an outlet, which is connected to a vacuum pump. The connecting wires for the bell jar also pass through the cork lid. Once the circuit is switched on, the bell rings and we can hear the sound. Now, we pump out air from the bell jar with the help of vacuum pump. As air in the jar is pumped out, we observed a gradual decrease in the loudness of the bell sound and finally it becomes inaudible. Earlier to pumping out of air from the bell, there is air medium in the bell that transmits bell sound. Once air in the jar is evacuated, the sound is not transmitted. This proves that sound requires a medium for its propagation.

Why sound wave is called a longitudinal wave?

Solution:

Sound waves in air comprise of compressions and rarefactions. These compressions and rarefactions vibrate in a direction parallel to the direction of wave propagation, which is the fundamental property of a longitudinal wave. Hence, sound waves in air are longitudinal waves.

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

Solution:

Frequency is the characteristic feature of sound. The voice of every person has its own frequency, which does not match with that of other voices. Hence, we can identify the persons by hearing their voices even when we cannot see them in the dark.

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

Solution:

The speed of sound is much less than that of light. Hence, it takes a few seconds to hear the thunder after the flash is seen, even though both of them are actually produced simultaneously.

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}.

Solution:

Given,

Hearing range of the person is 20Hz - 20 KHz

Velocity of sound in air is 344 ms^{-1}.

We know that,

$v = n\lambda$,

Where

n = frequency

λ = Wave length.

For frequency n = 20 Hz, the corresponding wavelength, $\lambda = v/n = \frac{344}{20} = 17.2$ m

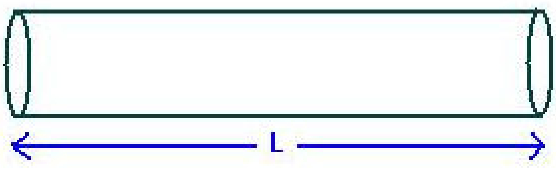
For frequency n = 20 KHz, the corresponding wavelength, $\lambda = v/n = \frac{344}{20}$ KHz

$= \frac{344}{20000} = 0.0172$

Therefore, the wave lengths corresponding to 20Hz - 20KHz are17.2m and 0.0172m respectively.

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.

Solution:



Given,

Speed of sound in aluminium, V_{al} = 6420 m/s

Speed of sound in air, V_{air} = 346 m/s

Let the length of aluminium rod be L metres.

Let t1 and t2 be the time taken by the sound to travel through aluminium rod and air respectively.

We Know that,

Distance = Speed × time

=> Time= $\frac{Distance}{Speed}$

Distance travelled by sound = Length of the rod

Distance travelled by sound = L

Hence, t1 = $\frac{L}{6420}$.... (1)

t2 = $\frac{L}{346}$...... (2)

Ratio of times taken by sound wave in air to aluminium rod to reach other end

= $(\frac{L}{346}) / (\frac{L}{6420})$

= (/346) × (6420/)

= 6420/346 = 18.55

Thus, the required ratio is 18.55.

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

Solution:

Frequency of the source of sound, n = 100Hz

Frequency is the number of vibrations made in a second.

The number of vibrations made by the source of sound in 1 minute =100 × 60s = 6000 vibrations

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

Solution:

Light and sound are different forms of energy, each of which has a characteristic feature. Light gives the sensation of vision, and sound gives the sensation of hearing. Hence, these two forms of energy follow the laws of reflection.

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?

Solution:

The speed of sound in air increases with an increase in its temperature. Thus, the speed of sound is higher on a hotter day, when compared to its value on a colder day. The minimum distance to hear an echo from a distant object depends on the speed of sound in air. The minimum distance to hear an echo from a distant object depends on the speed of sound in air. This is because a time gap of 0.1 second between any two sounds is required for our ears to distinguish them. When a person produces sound, he hears it and the reflected sound. If'd' is the minimum distance between the person producing the sound and the reflector, 'v' is the speed of sound, then d = v/20. If the speed of sound increases, this increases the value of minimum distance. Hence, the chances of hearing an echo on a hotter day, without increasing the distance between the source and reflector, are less. If the required minimum distance to hear an echo is more than the existing distance, you cannot hear the echo.

Give two practical applications of reflection of sound waves.

Solution:

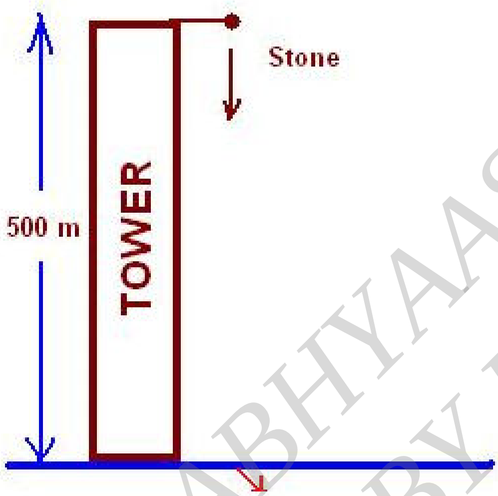
Applications of reflection of sound waves:

1. Megaphones or loudhailers, horns, musical instruments such as trumpets are designed to send sound in a particular direction without spreading it in all directions. In these instruments, a tube followed by a conical opening reflects the sound successively to guide most of the sound waves from the source.

2. In stethoscopes, the sound of the patient's heartbeat reaches the doctor's ears by multiple reflections throughout the pipe of the stethoscope of sound.

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-2 and speed of sound = 340 m s^{-1}.

Solution:



Given,

Height of the tower, h = 500m

Acceleration due to gravity, g = 10 ms-1

Initial velocity of the stone, u = 0 m/s

And

Let the time taken by the stone to reach the base of the tower (Water) be t1 s.

Displacement of stone, s = h = 500 m

We know that,

s = ut + ½ at2

Where

s = displacement

u = initial velocity

a = acceleration and t = time taken.

500 = (0)t + ½ (10)t2

=> 5t2 = 500

=> t2 = 100

=> t = √100 = 10 s

For splash sound, a = 0 m/s2

Distance travelled by sound to reach top of the tower, s = 500 m

The speed of the sound in air, v = 340 m/sec

Let the time taken by splash sound to reach the top of the tower be t2 s

Thus, h = vt2 => t2 = h/v = 500/340 = 1.47 s

Total time taken by the splash sound to reach top of the tower (after the stone is dropped) t = t1 + t2

= 10 + 1.47 = 11.47 sec.

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?

Solution:

Speed of the sound wave, v = 339 ms-1

Its wave length, λ = 1.5 cm = 0.015m

We know that v = nλ Where

n = frequency

v = velocity and

λ = Wavelength

Frequency, n = v/λ = 339/0.015 = 22600 Hz

Audible range of hearing is 20Hz to 20000 Hz

The given sound wave is INAUDIBLE.

What is reverberation? How can it be reduced?

Solution:

The persistence of hearing the sound in a closed enclosure due to multiple reflections taking place in the enclosure is called reverberation. It can be reduced by installing suitable sound-absorbing material in the enclosure and constructing such enclosures with proper designs.

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

Solution:

Loudness is the strength of the sound that makes it audible for a normal ear that does not have any defect. The loudness of sound depends on its amplitude. More the amplitude of sound more is its loudness.

Explain how bats use ultrasound to catch a prey.

Solution:

Bats produce ultrasounds and are capable of detecting their reflections. By sensing the time taken for the sound to reflect from the prey, they estimate their distance from the prey and advance forward to catch it.

How is ultrasound used for cleaning?

Solution:

The objects to clean are placed in a solution, and ultrasound is passed through the solution. Ultrasound has high energy due to its high frequency, and this helps in detaching dust particles from the object to be cleaned. Thus, the object gets cleaned.

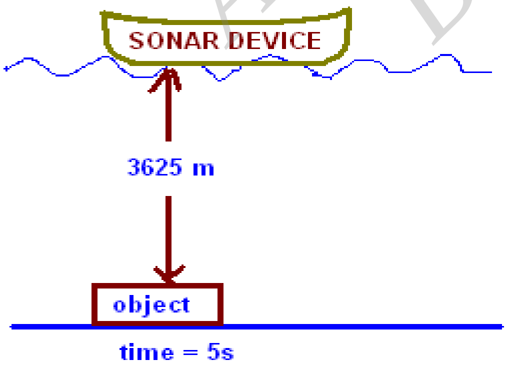
Explain the working and application of sonar.

Solution:

Sonar uses the principle of reflection of sound. Generally, sonar is employed in ships to detect the depth of seabed and locate submarines. Solar sends waves of ultrasound into the water and detects their echo. The time between transmission and reception of the ultrasound is noted. As the speed of ultrasound in water is known, the depth of the sea bed or the distance of an object from a vessel can be calculated.

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.

Solution:



Given,

Distance of the Object from the submarine, d = 3625 m

Time taken by the signal to reach the SONAR device, t = 5 sec

The distance travelled by the signal is double the distance of sound from the submarine = 2d

Let the speed of the sound in water be v.

Then, $v = 2d/t = 2\times\frac{3625}{5}5 = 1450$ m/s.

Speed of the sound in water is 1450 m/s.

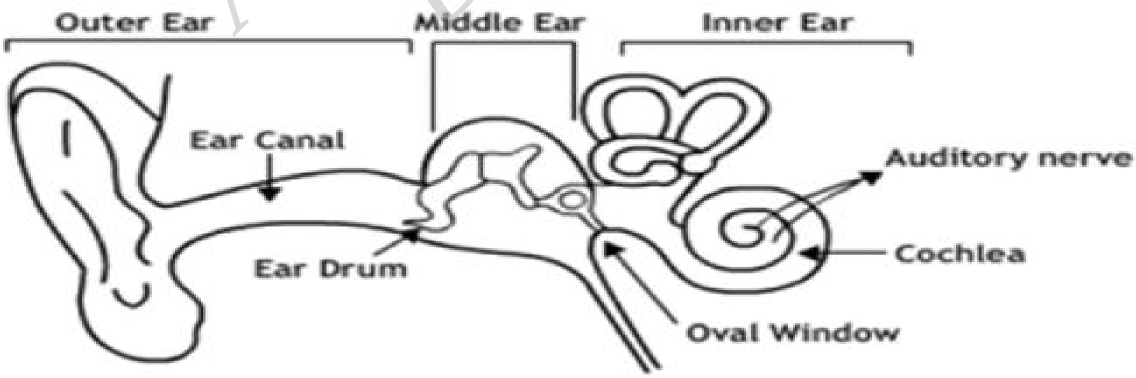
Explain how defects in a metal block can be detected using ultrasound.

Solution:

Defects in metal blocks occur due to cracks in them. Cracks have air in them. The speed of sound in metal is greater than that in air. Thus, air acts as a rarer medium for sound waves. Whenever ultrasound is transmitted through a metal block that has defects, these waves get reflected in encountering such cracks. Therefore, these waves are not detected at the detector placed on the other side of the block, opposite to as that of the transmitter. This indicates that is a defect in the block.

Explain how the human ear works.

Solution:



The main three parts of the ear are the outer ear, the middle ear and the inner ear.

The outer ear is called 'pinna'. It collects the sound from the surroundings. The collected sound passes through the2 auditory or the ear canal. At the end of the auditory canal there is a thin membrane called the ear drum or tympanic membrane. When a compression of the medium reaches the eardrum the pressure on the outside of the membrane increases and forces the eardrum inward. Similarly, the eardrum moves outward when a rarefaction reaches it. In this way the eardrum vibrates.

The vibrations are amplified several times by the three bones (the hammer, anvil and stirrup) in the middle ear. The middle ear transmits the amplified pressure variations received from the sound wave to the inner ear.

The inner ear, the pressure variations are turned into electrical signals by the cochlea. These electrical signals are sent to the brain via the auditory nerve and the brain interprets them as sound.