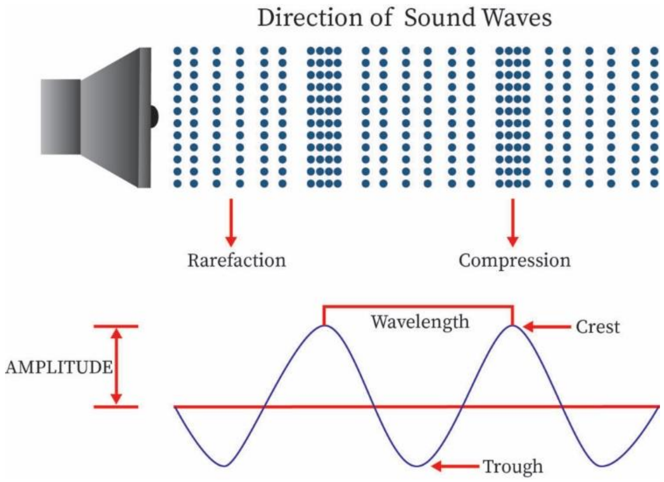
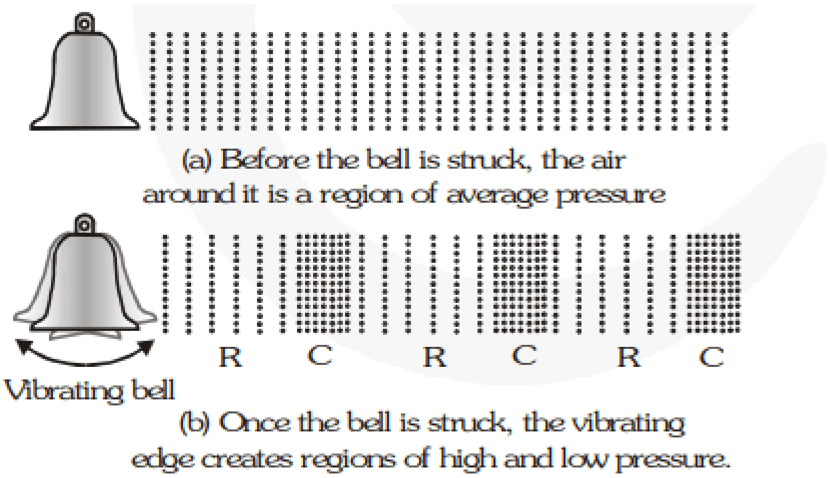
Exercise 1:



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

Answer: When an object vibrates, it causes the neighbouring particles in the medium to vibrate successively. These vibrations are further passed to adjacent particles. Like ways these vibrations are passed from particle to particle and reach our ears.

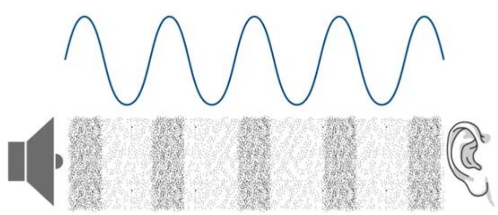
Exercise 2:



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

Answer: When the school bell rings, the neighbouring particles in air are forced to vibrate simultaneously. This disturbance leads to the formation of a sound wave and when the bell moves forward, it pushes the air in front of it. This creates a region of high pressures known as **compression.** When the bell moves backwards, a region of low pressure known as **rarefaction** is created. In this way **the bell continues to move forward and backward which produces a series of compressions and rarefactions**. This leads to the sound of a bell when it propagates through air.

2. Why are sound waves called mechanical waves?



Answer: When sound waves propagate through a medium it causes the neighbouring particles to vibrate. Sound waves propagate due to interaction of particles in the medium due to a series of compressions and rarefactions. Hence, these waves are called mechanical waves.

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

Answer: Sound waves are mechanical waves and hence need a medium to propagate. As the moon is devoid of any atmosphere, we cannot hear any sound on the moon.

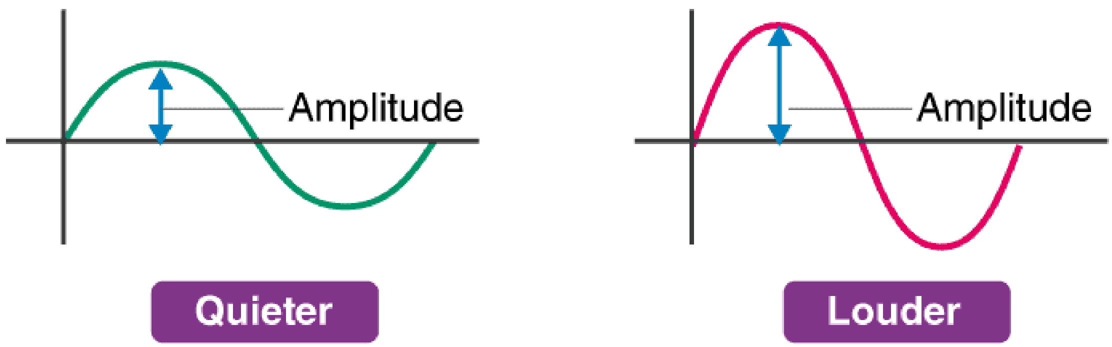
Exercise 3:

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

Answer:

(a) The loudness of a sound depends on its amplitude. Higher the amplitude, the louder the sound.

(b) The pitch of a sound depends on its frequency. Higher the frequency, higher the pitch of sound.



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

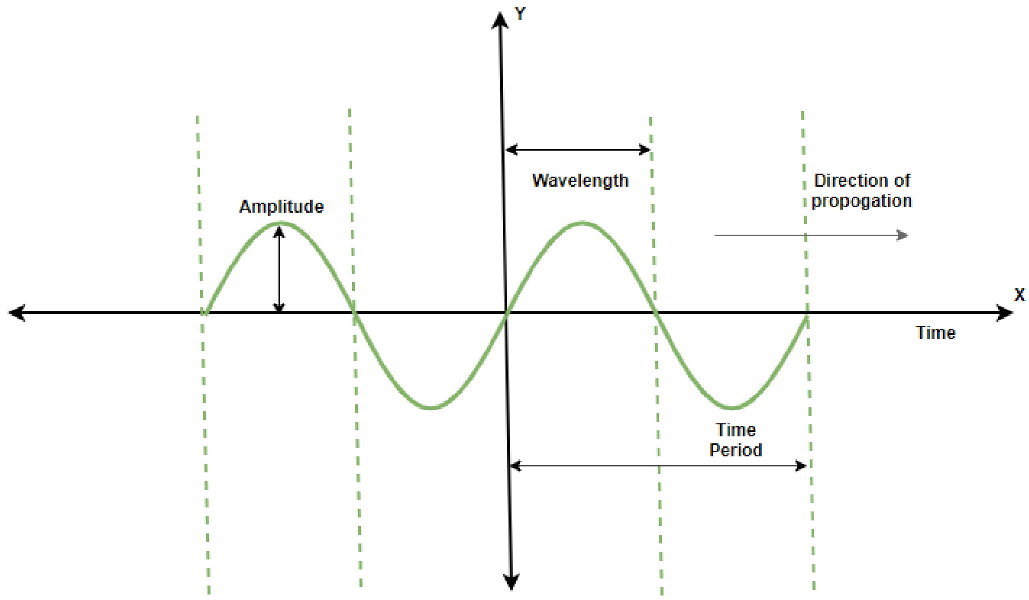
Answer: In the case of guitar, the frequency of vibration produced is greater when compared to a car horn. Pitch of the sound depends on the frequency. Higher the frequency, the higher the pitch. So the guitar produces a higher pitched sound than a car horn.

Exercise 4:

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

Answer: Following are the definitions given below:

- Wavelength: Wavelength is defined as the distance between two consecutive compressions or two consecutive rarefactions. Its SI unit is metre (m).
- Frequency: Frequency of a sound wave is defined as the number of complete oscillations per second. It is measured in hertz (Hz).
- Time period: Time period of a sound wave is defined as the time taken by a sound wave to complete one cycle. Its SI unit is seconds (s).
- Amplitude: The amplitude of a sound wave is defined as the maximum extent of a vibration, measured from the position of equilibrium.



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

Answer: Speed, wavelength, and frequency of a sound wave are related by the equation given below:

Speed (v) = Wavelength (λ) × Frequency (υ)

$\therefore v = \lambda \times \upsilon$

3. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 m/s in a given medium.

Ans: In the above question it is given that:

Frequency of the sound wave is

u = 220 Hz

Speed of the sound wave is

V = 440 m/s

For a sound wave,

Speed (v) = Wavelength (λ) × Frequency (υ)

$\therefore$ wavelength (λ) = $\frac{Speed\ of\ sound (v)}{Frequency\ of\ sound\ (u)}$

$\therefore \lambda = \frac{v}{u}$

$\therefore \lambda = \frac{440}{220} = 2m$

Therefore, the wavelength of the sound wave is 2 m.

4. 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?

Answer: in the above question it is given that:

Frequency = 500Hz

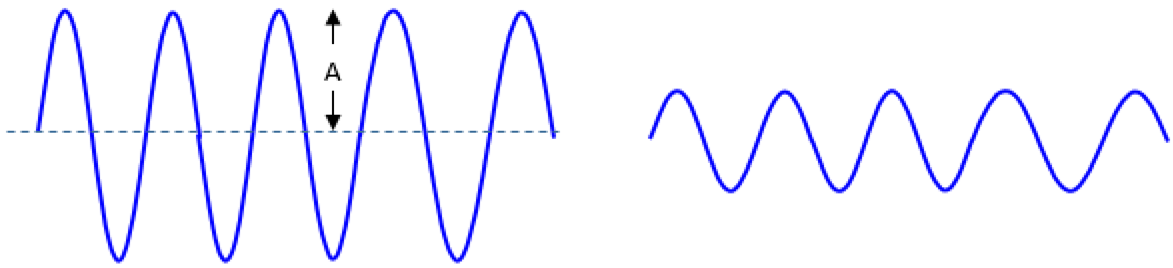
The time interval between two successive compressions is equal to the time period of the wave. We know that,

Time period = $\frac{1}{Frequency} = \frac{1}{500}$ = 0.002 s

Exercise 5:

1. Distinguish between loudness and intensity of sound.

Answer: The intensity of a sound wave is defined as the amount of sound energy passing through a unit area per second. The loudness or softness of a sound is determined basically by its amplitude. The amplitude of the sound wave depends upon the force with which an object vibrates. Intensity helps to decide the amplitude of a sound wave, which in turn is recognized by the ear as loudness.



A loud sound – large amplitude

A soft (quiet) sound – small amplitude

Exercise 6:

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

Answer: Sound travels the fastest in solids, i.e., iron followed by water and air at a particular temperature.

Exercise 7:

In the above question it is given that:

Speed of sound is v = 342 m/s .

Echo returns in time, $t = 3s$.

Distance travelled by sound: $v \times t = 342 \times 3 = 1026$ m

As the sound travels and gets reflected back, the distance of the reflecting surface from the source will be: $\frac{1026}{2} = 513$ m

Exercise 8:

1. Why are the ceilings of concert halls curved?

Answer: Ceilings of concert halls are curved so that the sound waves can spread uniformly in all directions after reflection.

Exercise 9:

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

Ans: The audible range of an average human ear is between

20 Hz to 20,000 Hz . Humans cannot hear sounds with frequency less than 20 Hz and greater than 20,000 Hz .

2. What is the range of frequencies associated with

(a) Infrasound?

Answer: Infrasound has frequencies less than 20 Hz .

(b) Ultrasound?

Answer: Ultrasound has frequencies more than 20,000 Hz .

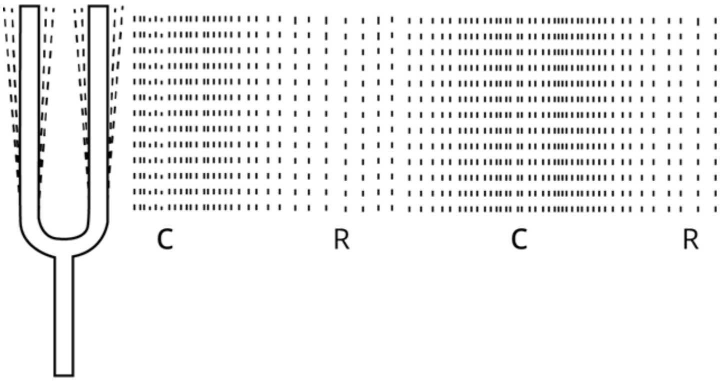
Main Exercise Questions:

1. What is sound and how is it produced?

Answer: Sound is a form of energy which produces the sensation of hearing produced by vibration. When an object vibrates, it causes the neighbouring particles of the medium to vibrate which are further passed to adjacent particles. This creates a disturbance in the medium, which travels in the form of waves. Hence, when this disturbance reaches the ear, sound is produced.

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

Answer: Consider the figure given: The most common medium through which sound travels is air. When a vibrating object moves forward, it pushes and compresses the air forward creating a region of high pressure. This region is called a compression (C). This compression starts to move away from the vibrating object.

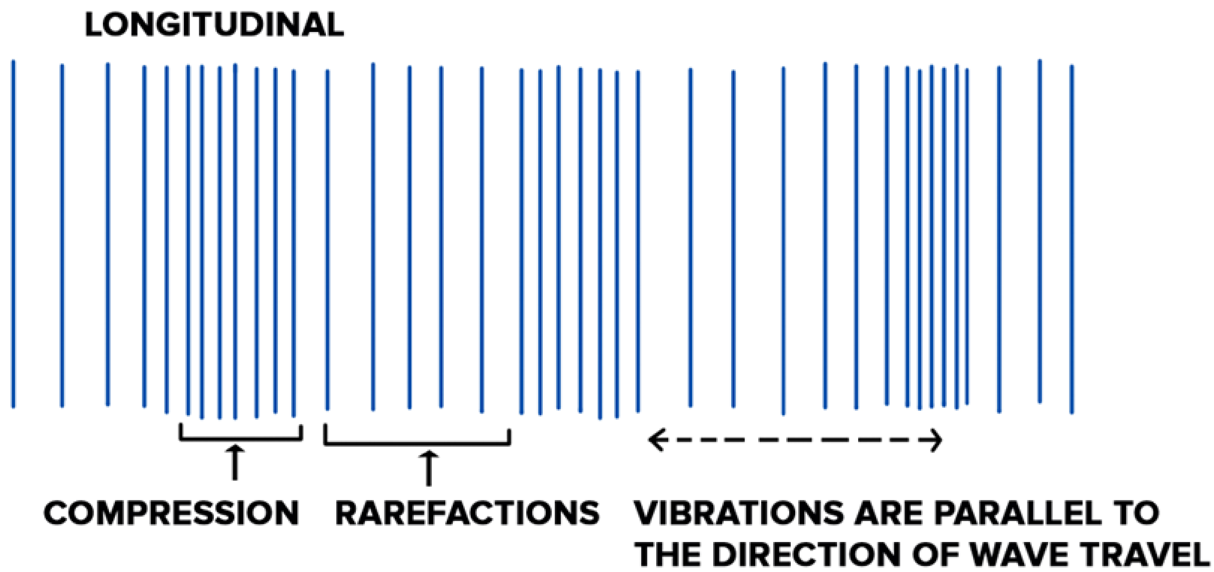


When the vibrating object moves backwards, it creates a region of low pressure called rarefaction (R). As the object moves back and forth rapidly, a series of compressions and rarefactions are created in the air. These make the sound wave that propagates through the medium. Compression is the region of high pressure and rarefaction is the region of low pressure and the pressure is related to the number of particles of a medium in a given volume.

More density of the particles in the medium gives more pressure and vice versa. Hence, propagation of sound can be visualised as propagation of density variations or pressure variations in the medium.

3. Why is a sound wave called a longitudinal wave?

Answer: In the case of sound waves, the particles do not move from one place to another but they simply oscillate back and forth about their position of rest. In sound waves the individual particles of the medium move in a direction parallel to the direction of propagation of the disturbance. Hence, a longitudinal wave is called a sound wave.



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

Answer: The characteristic of the sound which helps you to identify your friend by his voice while sitting with others in a dark room is the quality or timber of sound which enables us to distinguish one sound from another having the same pitch and loudness.

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

Answer: Velocity of sound is 344 m/s and that of light is 3×10^8 m/s. As the speed of light is greater than that of sound, the sound of thunder requires longer time than light to reach Earth. Therefore, before we hear thunder, a flash is seen.

6. 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

Ans: In the above question it is given that:

A person has a hearing range from 20 Hz to 20 kHz .

Speed of sound in air is 344 m/s .

We know that:

Speed = Wavelength × Frequency

$\therefore v = \lambda \times \upsilon$

For, υ_1 = 20 Hz

$$\therefore \lambda_1 = \frac{v}{v_1} = \frac{344}{20} = 17.2 \text{ m}$$

For, υ_2 = 20 kHz

$$\therefore \lambda_2 = \frac{v}{v_2} = \frac{344}{2000} = 0.0172 \text{ m}$$

Hence, humans have the wavelength range for hearing from 0.0172 m to 17.2 m.

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

Ans: Consider the length of the aluminium rod to be d.

Speed of sound waves in aluminium at 25°C is v_{Al} = 6420 m/s

Therefore, time taken by the sound wave to reach the other end will be:

$$\rightarrow t_{Al} = \frac{d}{v_{Al}} = \frac{d}{6420}$$

Speed of sound waves in air at 25°C is v_{Air} = 346 m/s

Therefore, the time taken by a sound wave to reach the other end will be:

$$\rightarrow t_{Air} = \frac{d}{v_{Air}} = \frac{d}{346}$$

Hence, the ratio of time taken by the sound wave in air and aluminium will be:

$$\rightarrow \frac{t_{Air}}{t_{Al}} = \frac{\frac{d}{346}}{\frac{d}{6420}} = \frac{6420}{346} = 18.55$$

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

Answer: In the above question it is given that:

Frequency of sound is 100 Hz .

Total time = 1 min = 60 s .

We know that:

Frequency is defined as the number of oscillations per second. It is given by the relation:

Number of oscillations = Frequency × Total time

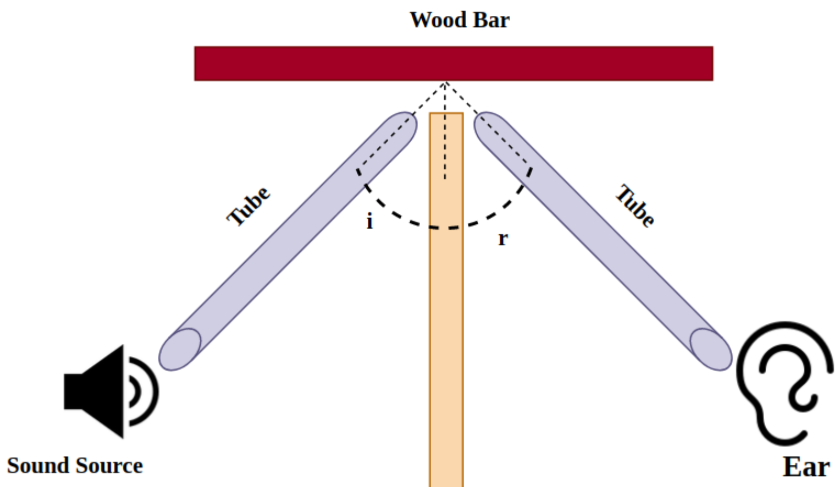
Number of oscillation= 100 × 60 = 6000

Hence, the source vibrates 6000

times in a minute, producing a frequency of 100 Hz.

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

Answer: The incident and the reflected sound wave create the same angle at the point of incidence with the normal to the surface. In addition, the sound wave incident, the sound wave reflected, and the normal sound wave to the point of incidence are all in the same plane. Hence, sound follows the same laws of reflection as light does.



Reflection of Sound

10. 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 remain the same. Do you hear the echo sound on a hotter day?

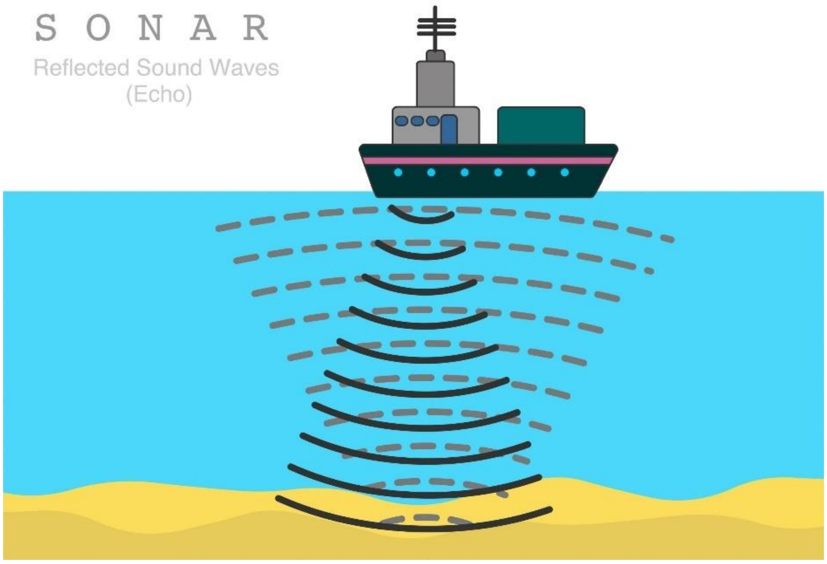
Answer: An echo is heard when the time interval between the original sound and the sound reflected is at least 0.1s. Sound speed in a medium is directly proportional to the temperature.

Hence, time interval will be inversely directly proportional to the temperature. Therefore, the time interval between the original sound and the sound reflected will decrease on a hotter day.

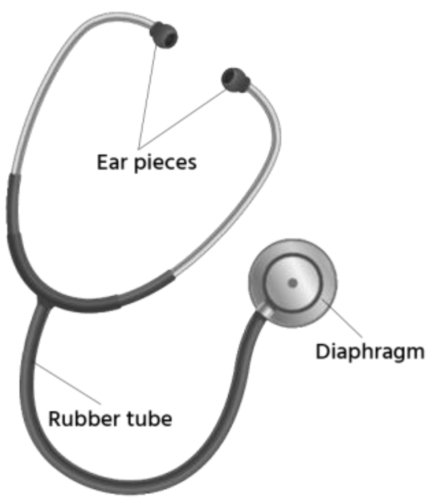
11. Give two practical applications of reflection of sound waves.

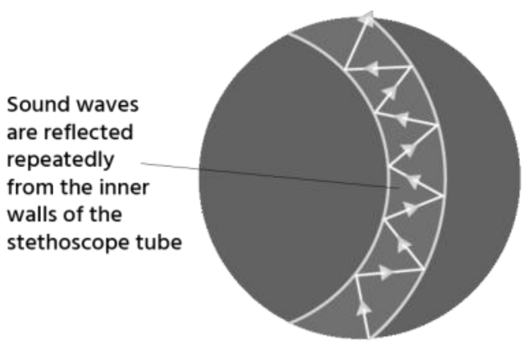
Answer: Following are the two practical applications of reflection of sound waves:

(a) SONAR: SONAR is a technology where reflection of sound is used to measure the distance and speed of underwater objects.



(b) Stethoscope: A stethoscope is a device where the sound of the patient's heartbeat reaches the doctor's ear by multiple reflection of sound.





12. 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/s² and speed of sound = 340 m/s² .

Ans: In the above question it is given that:

Height of the tower is

s = 500 m.

Velocity of sound is v = 340 m/s .

Acceleration due to gravity is $g = 10\ m/s^2$.

As the stone is initially at rest, initial velocity of the stone will be u = 0 m/s .

Let the time taken by the stone to fall to the base of the tower be t_1 .

According to the second equation of motion:

$$s = ut_1 + \frac{1}{2} g t_1^2$$

$$\Rightarrow 500 = \frac{1}{2} \times 10 \times (t_1)^2$$

$$\Rightarrow (t_1)^2 = 100$$

$$\Rightarrow t_1 = 10s$$

Now, time taken by the sound to reach the top from the base of the tower will be

$$\Rightarrow t_2 = \frac{500}{340} = 1.47\ s$$

Hence, the splash is heard at the top after time $t = t_1 + t_2 = 10 + 1.47 = 11.47s$

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

Answer: In the above question it is given that:

Speed of sound is 339 m/s.

Wavelength of sound is λ= 1.5 cm = 0.015 m

We know that:

Speed of sound = Wavelength × Frequency

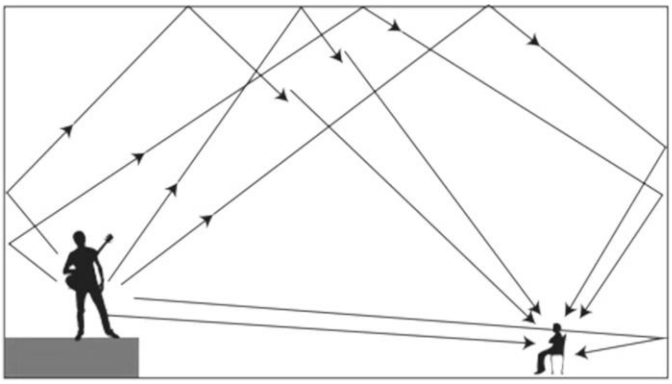
$$\Rightarrow v = \lambda \times \upsilon$$

Therefore, frequency υ will be:

➔ $\upsilon = \frac{v}{\lambda} = \frac{339}{0.015}$ = 22600Hz

As the frequency range of audible sound for humans lies between 20 Hz to 20,000 Hz. Since the frequency of the given sound is more than 20,000 Hz, it won't be audible.

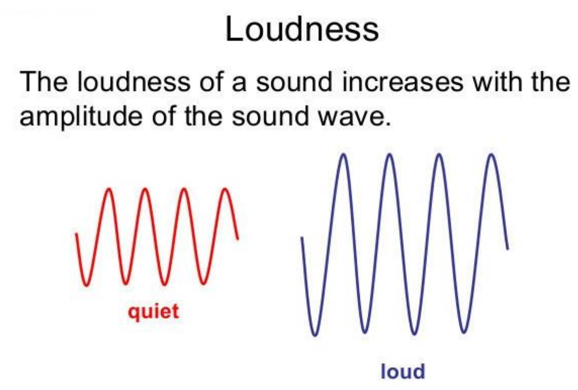
14. What is reverberation? How can it be reduced?



Answer: Reverberation is defined as persistence of sound (after the source stops producing sound) due to repeated reflection. When a sound is created in a big hall, it persists by repeated reflection from the walls until it is reduced to a value where it is no longer audible.

To reduce reverberation, the roof and walls of the auditorium are generally covered with sound-absorbent materials like compressed fibreboard, rough plaster or draperies. The seat materials are selected based on their sound absorbing properties.

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

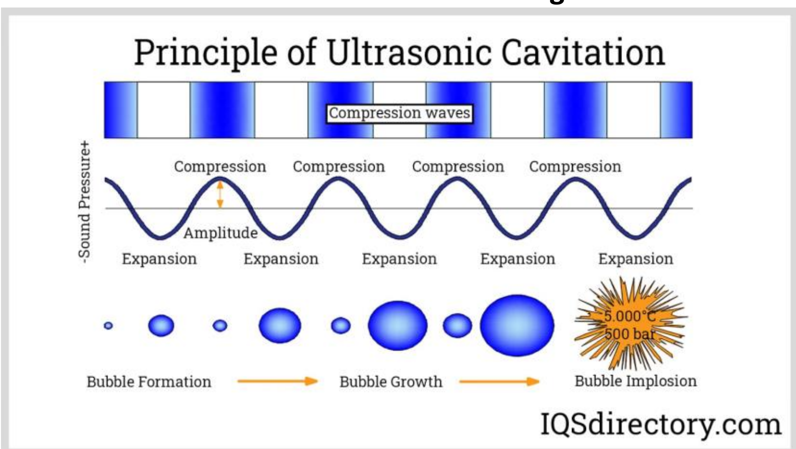


Answer: The measure of the response of the ear to the sound is defined as the loudness of sound.

The loudness or softness of sound is determined basically by its amplitude which depends upon the force with which an object is made to vibrate. A loud sound has high energy.

Loudness depends on the amplitude of vibrations such that loudness is proportional to the square of the amplitude of vibrations.

16. How is ultrasound used for cleaning?



Answer: Ultrasound waves are used for cleaning by passing through the objects kept in the cleaning solution. Their high frequency removes dirt from the objects.

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

Answer: Metallic components are generally used in construction of big structures like buildings, bridges, machines and also scientific equipment. Ultrasounds are used to detect cracks and flaws in metal blocks.

The cracks or holes inside the metal blocks that are invisible from outside reduce the strength of the structure. Ultrasonic waves are allowed to pass through the metal block and detectors are used to detect the transmitted waves.

If there is even a small defect, the ultrasound gets reflected back. This indicates the presence of the flaw or any defect.