1 Sound Waves

Why did the teacher agree with the child on the swing?

How should the swings be counted?

- What type of motion does the swing have? (circular / oscillatory)

Observe the diagram showing the motion of the swing.

- What is the initial position of the swing when it starts oscillating from its free state (equilibrium position)?

  (A / O / B)

Fig. 1.1 (a)

Oscillation is a periodic motion in which an object moves to and fro at regular intervals of time about its equilibrium position.

- In the figure, what is the maximum displacement to one side from the equilibrium position?

  (2a, $\frac{a}{2}$, a)

The magnitude of maximum displacement to one side from its equilibrium position is amplitude. The symbol of amplitude is a. The SI unit of amplitude is metre (m).

- When does the swing complete one oscillation?

(when the pendulum starts from O, reaches A and returns to O / when the pendulum starts from O, reaches A, then to B and back to O)

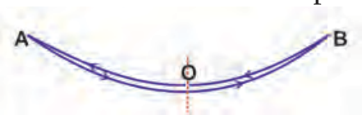

Fig. 1.1(b)

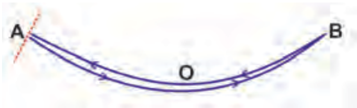

Fig. 1.1(c)

A swing completes one oscillation when the pendulum starts from O, goes to both sides and then returns to O [Fig 1.1(b)].

An oscillation is completed when the body returns to its initial position in the same direction from where it started.

What if counting starts from A? A swing completes one oscillation when it starts from A, reaches B and returns to A [Fig 1.1 (c)].


Fig. 1.2

In early pendulum clocks (Grandfather's clock), pendulum (seconds pendulum) of length 99.35 cm (about 1 m) was used. It was made of an alloy called invar (invar-invariable).

What could be the reason that the number of oscillations counted by the child waiting for his turn to swing and the child on the swing were different? Discuss and find out. Now you have understood how to count oscillations accurately.

Give more examples of oscillatory motion.

- Motion of the pendulum of a clock
-

Have you ever noticed how many oscillations the pendulum in a clock completes for a time change of one minute?

- If a pendulum takes 1 minute to complete 30 oscillations, how long does it take to complete one oscillation?

Time for 30 oscillations = 1 minute = 60 s

Time for 1 oscillation = $\frac{60\ s}{30} = 2\ s$

The time taken for one oscillation is called period. Its symbol is T. SI unit of period is second (s).

Heinrich Rudolf Hertz

Lifetime : 1857 - 1894

Place of birth : Hamburg, Germany

Major contributions : Experimentally proved the presence of electromagnetic waves. Laid the foundation for the future advancements of the radio, telephone, telegraph and television. Discovered photoelectric effect. The unit of frequency was named hertz, to honour him.

- Find the number of oscillations the same pendulum completes in one second.

Number of oscillations in 1 minute (60 s) = 30

$\therefore$ Number of oscillations in 1 second $= \frac{30}{60}$

$= \frac{1}{2} = 0.5$

The number of oscillations in one second is called frequency. The SI unit of frequency is hertz (Hz). Frequency is denoted by the letter f.

Let's find the period and frequency of a pendulum by swinging it at low amplitude. Tie a bob to a string and hang it on a stand. This system is called a simple pendulum. Complete table 1.1 by doing an experiment using a simple pendulum, meter scale, and a stopwatch.

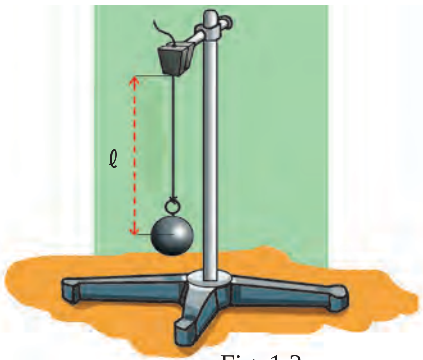

Fig. 1.3

Length of the pendulum (ℓ) cm	Time taken for 10 oscillations s	Period (T) $= \frac{\text{Total time}}{\text{Number of oscillations}}$ s	Frequency (f) $= \frac{\text{Number of oscillations}}{\text{Time}}$ Hz
25			
60			
100			

Table 1.1

- What is the change in frequency when the length of the pendulum increases? (increases / decreases)

When the length of the pendulum increases, frequency decreases.

PhET→ Pendulum bob

- What is the relation between period and frequency?

The time required for one oscillation = T

Number of oscillations per second = f

In radio and television transmission you may have heard the units kilohertz and megahertz. These are also practical units of frequency.

1 kHz =1000 Hz = 10^3 Hz

1 MHz =1000000 Hz = 10^6 Hz

Frequency (f) = $\frac{1}{\text{period (T)}}$

As the period increases, frequency decreases.

Aren't tuning forks used for experiments connected with sound? Have you noticed the marking on them? Observe various tuning forks and note down the markings on each of them with their units.

- 256 Hz
-

Is there any relation between the marking on the tuning fork and its number of vibrations?

The marking on a tuning fork indicates the frequency of the tuning fork. Excite tuning forks of different frequencies in a similar manner and listen to the sound.

- Do you feel any difference?

Note the frequency marked on each of them.

- Isn't the difference in frequency the reason for the difference in sound here?

Find the number of times each tuning fork vibrates independently in one second using the ICT facility (Audio Frequency Counter).

When an object vibrates freely, it vibrates in its innate frequency. This is the natural frequency of that object.

Factors that influence the natural frequency of an object :

- Length of the object
- Size of the object
- Elasticity
- Nature of the material etc.

Change in any one of these factors will affect the natural frequency of an object.

Do all objects vibrate only in their natural frequency?

Forced Vibration & Resonance

Have you ever felt the vibration of the table when a mixie kept on the table works?

Excite a tuning fork and listen to it. What is the change in the sound heard when the stem of the excited tuning fork is pressed on the table? What could be the reason for the sound being louder?

In this case, the sound became louder because the table also vibrated along with the tuning fork.

> Forced vibration is the vibration of an object induced by an external vibrating object.

Fig. 1.4

Observe figure 1.5 (a).

Try the activities given below using the device in which two sets of three identical hacksaw blades each of length about 13 cm and 17 cm are fixed between two wooden blocks.

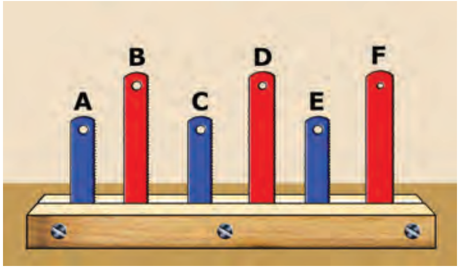

Fig. 1.5 (a)

- Excite the hacksaw blade A by tapping with your finger. What do you observe?

  (all blades vibrate / only A vibrates)
- Are all the blades vibrating with the same amplitude?
- Which of them vibrates with maximum amplitude?
- After all the blades have stopped vibrating, excite B and record the observation in the science diary.
- When blade A vibrates why would the hacksaw blades C and E vibrate with maximum amplitude?

Since the natural frequency of C and E are equal to the natural frequency of A, they vibrate with maximum amplitude.

> If the natural frequency of the forcing object and that of the forced object are equal, the objects are said to be in resonance. The objects undergoing resonance will vibrate with maximum amplitude.

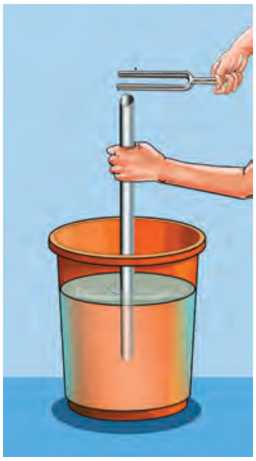

Fig. 1.5 (b)

- Immerse in water a PVC pipe of about 50 cm length and 4 cm (1½ inch) diameter. Excite a tuning fork of frequency 512 Hz and hold it close to the mouth of the pipe. Vary the length of the air column inside the pipe by gradually raising both the tuning fork and the pipe. Don't you hear a louder sound at a particular stage? What could be the reason for this? Record in your science diary.

Applications of forced vibration and resonance

- MRI scanning
- Radio tuning
- In musical instruments like guitar, violin, veena, harmonium, mridangam etc.
- Can't you hear even the faintest sound of the heartbeat when you listen to it using a stethoscope? A stethoscope used to listen to even a feeble sound in the body utilises forced vibration and resonance.
- In instruments like megaphones, horns and musical instruments such as trumpets and *nagaswaram*.

Fig. 1.6 (a)

Fig. 1.6 (b)

The frequency of a simple pendulum is 1 Hz. What is its period?

If a pendulum takes 0.5 s to complete one oscillation, what is its frequency?

A tuning fork of frequency 512 Hz is excited and its stem is pressed on a table. Does the table vibrate in this situation? What is this phenomenon known as?

When a tuning fork of frequency 256 Hz vibrates, the air around it and the eardrum of the person hearing that sound vibrate 256 times per second.

How does the air near it vibrate when the tuning fork vibrates?

Wave Motion

A child conducted an experiment in connection with the transmission of sound in the school science club. A scene during the experiment is illustrated here.

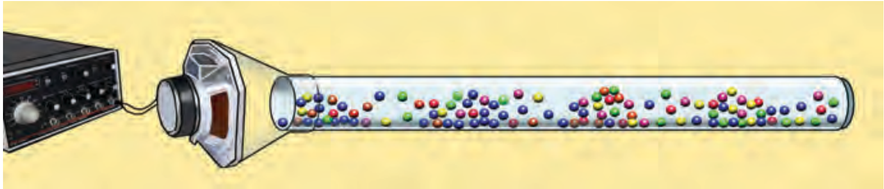

Fig. 1.7

Place light paper balls inside a long, transparent tube closed at one end. Pass a loud sound with uniform frequency through the free end of the tube. The paper balls are seen vibrating back and forth from their equilibrium position. Without moving the paper balls to the other end, they are found to be close in some regions and apart in some other regions alternately. How is it formed?

PhET→ Sound waves

Let's do an activity.

Stretch both ends of a slinky placed on a table as shown in figure 1.8 (a).

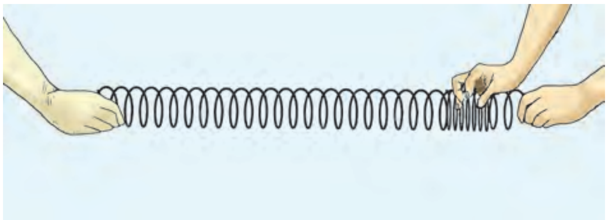

Fig. 1.8 (a)

Compress and release a few coils at one end of the slinky. Notice the disturbance formed in the slinky.

Move one end of the slinky back and forth as shown in figure 1.8 (b). What do you observe?

Fig. 1.8 (b)

Don't you see the disturbances formed in the slinky moving from one end to the other?

- Are the coils in the slinky moving towards the other end along with the disturbances?

It is seen that the disturbance formed in one part of the slinky spreads to the other parts without any displacement of the coil.

Here the energy received in one part of the medium spreads to the other parts by transferring it to the adjacent part and so on.

Wave motion is one of the modes of transfer of energy from one part of the medium to other parts.

The continuous propagation of energy from one part to the other parts through oscillations is called wave motion.

Some examples of waves are given below :

- Radio waves
- Seismic waves
- Light waves
- Sound waves
- Ripples on the surface of water

- Do all these waves require a medium to travel? Complete table 1.2 appropriately.

Waves that require a medium for transmission	Waves that do not require a medium for transmission
• Seismic waves	• Radio waves
•	•

Table 1.2

Electromagnetic Waves

Radio waves, microwaves, infrared rays, visible light, ultraviolet rays, X-rays and gamma rays are electromagnetic waves. They do not require a medium for transmission.

Mechanical Waves

Mechanical waves are those that require a medium for transmission. Mechanical waves are mainly of two types. They are longitudinal waves and transverse waves.

Longitudinal Waves

- In figure 1.8 (b), did the coils in the slinky move parallel or perpendicular to the direction of propagation of the wave?

Longitudinal waves are those in which the particles in the medium vibrate parallel to the direction of propagation of the wave.

Pressure variations occurring in air when the tuning fork vibrates

Fig 1.9

We have studied that sound requires a medium for transmission. Let's see how sound travels through air. Observe the picture.

- In figure 1.9, as the prong of the tuning fork moves from the equilibrium position to the side A, the air pressure on that side (increases / decreases).
- What about the air pressure on side A when the same prong moves to side B?
- When the prongs of the tuning fork vibrate continuously, aren't regions of high and low pressure formed intermittently in the air?
- Compare the wave produced in the slinky with the wave produced by the tuning fork in the air.

Sound from a source creates continuous and regular pressure variations in the air. A region of high pressure is created where distance between the air molecules decreases. Such regions are called compressions (the region denoted by C in the figure) and a region of low pressure is called rarefactions (the region denoted by R in the figure). Sound travels through a medium forming alternating compressions and rarefactions. You have now understood that sound is a longitudinal wave.

Transverse Waves

Try an activity.

Fix a spring vertically on a table using a nail. Tie one end of a string to the top of the spring and the other end to a 50 g slotted weight. Pass the string through the pulley fixed at the end of the table as shown in the figure.

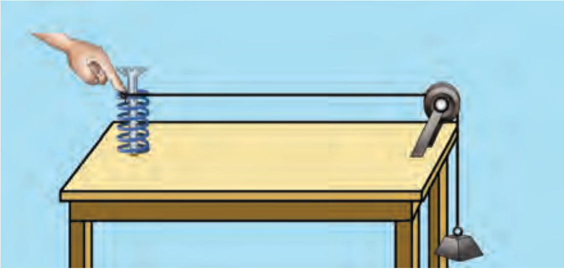

Fig. 1.10 (a)

Press and release the spring continuously. What do you observe?

- What is the direction of motion of the particles in the string, with respect to the equilibrium position? (parallel / perpendicular)
- Does each point on the string move parallel or perpendicular to the direction of propagation of the wave formed in the string?
- Do the particles on the string undergo resultant translatory motion other than moving vertically up and down from their equilibrium position?

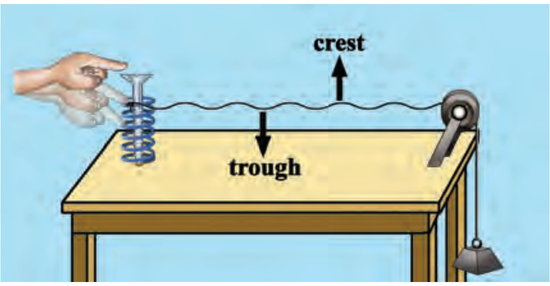

Fig. 1.10 (b)

When the particles of a medium vibrate perpendicular to the direction of propagation of the wave they are called transverse waves.

Observe the transverse waveform shown in figure 1.10 (b). In transverse waves, the elevated portions from the equilibrium position are called crests and the lowest portions from the equilibrium position are called troughs.

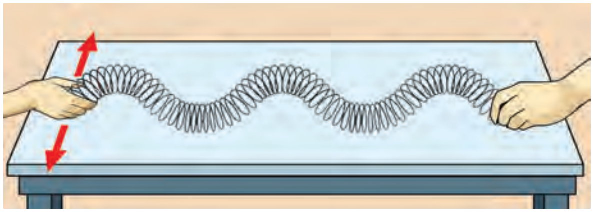

Fig. 1.10 (c)

Place a slinky on a table. Stretch both ends of it. Hold one end of the slinky and oscillate it as shown in figure 1.10 (c).

- Are the coils moving parallel or perpendicular to the waveform created on the slinky?
- What type of waveform is formed in the slinky?

Electromagnetic waves are transverse waves.

PhET→ Wave on a String

Some of the characteristics related to transverse waves and longitudinal waves are given below. Classify them and complete the table.

- Particles in the medium vibrate perpendicular to the direction of propagation of the wave.
- Compressions and rarefactions are formed.
- Pressure variations occur in the medium.
- Crests and troughs are formed.
- Particles in the medium vibrate parallel to the direction of propagation of the wave.
- No pressure variations occur in the medium.

Longitudinal waves	Transverse waves
• Particles in the medium vibrate parallel to the direction of propagation of the wave. •	• Particles in the medium vibrate perpendicular to the direction of propagation of the wave. •

Table 1.3

What are the features of waves?

Characteristics of Waves

The main characteristics of waves are :

- Amplitude
- Frequency
- Period
- Wavelength
- Speed of wave

Amplitude

The displacement-time graph of a particle in a wave is depicted.

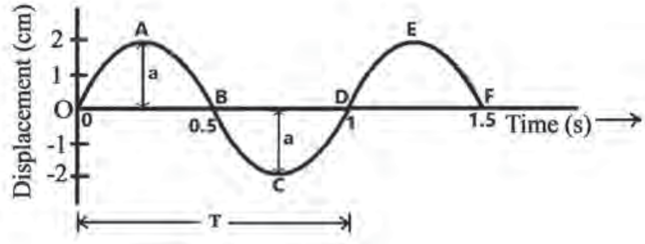

Fig. 1.11

- In the figure, which are the points with maximum displacement from the equilibrium position of the wave?

  (A, B, C, D, E)

- What is the amplitude of this wave?

> **Cycle**
>
> A cycle is one complete oscillation of a particle in wave motion.
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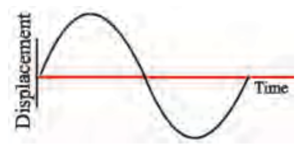
> 
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> Fig. 1.12

Period

- In figure 1.11, what is the time taken by the particle in the medium to complete one vibration?
- What is the period of the wave in the figure?

Frequency

The frequency of a wave is the number of cycles that pass through a point in one second.

- If the wave shown in figure 1.11 takes 1 s to travel from O to D, find the frequency of the wave.

Wavelength

The state of the particles in a wave at a particular time is depicted in figure 1.13 (a).

Wavelength is the distance between two consecutive particles which are in the same phase of vibration. It is the distance travelled by the wave during the time taken by each particle in the medium to complete one vibration.

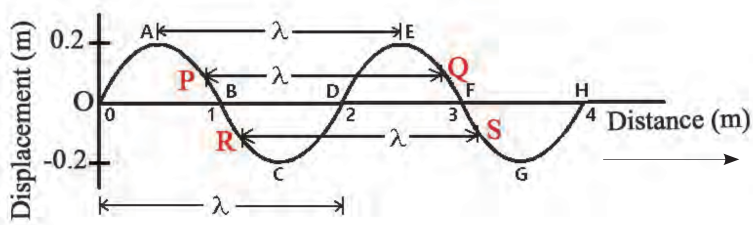

Fig. 1.13 (a)

The distance between two consecutive crests or two consecutive troughs is also considered as the wavelength of a transverse wave.

The Greek letter λ (lambda) is used to denote wavelength. The unit of wavelength is metre (m).

- In figure 1.13 (a), which particle is in the same phase of vibration as particle A? (B, C, D, E)
- In the case of particle P?
- In the case of particle B?
- In figure 1.13 (b), which represents the wavelength (λ)? (CR, RR)
- Here CR represents $(\lambda, \frac{\lambda}{2}, \frac{\lambda}{4})$

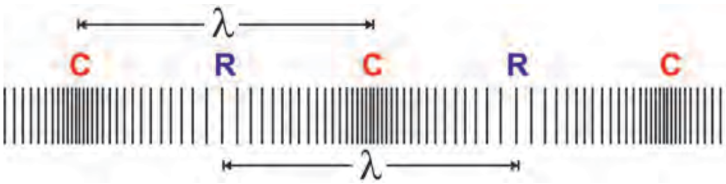

Fig. 1.13 (b)

The distance between two consecutive compressions or two consecutive rarefactions is considered as the wavelength of a longitudinal wave.

Speed of wave

The speed of a wave is the distance travelled by the wave in one second. The unit of speed of a wave is m/s.

- If a wave travels 700 m in 2 s, what is the speed of the wave?

Is there a relation between frequency and wavelength?

Place a slinky on a table. Stretch both ends of it. Hold one end of the slinky and oscillate it to produce a transverse waveform. Then increase the frequency of oscillation. Observe the change in frequency and wavelength of the waveform generated in the slinky.

If the frequency of the wave is changed, will the wavelength change?

An illustration of two waves of the same amplitude passing through a medium at the same time interval is given.

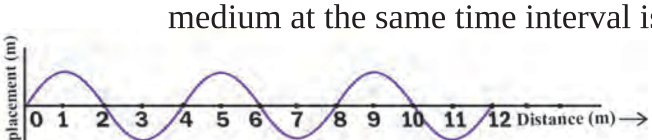

Fig. 1.14 (a)

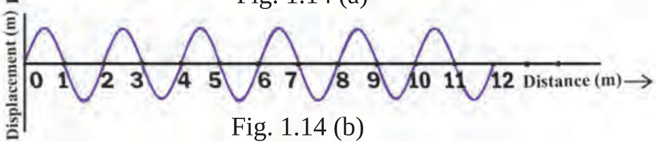

Fig. 1.14 (b)

- In figure 1.14 (a), what is the wavelength of the wave?
- What is the wavelength of the wave in figure 1.14 (b)?

- In figure 1.14 (a), if both the waves take 1 s to travel a distance of 12 m, what is the frequency of the wave?

- In figure 1.14 (b), what is the frequency of the wave?
- Which wave has a longer wavelength?
- Which wave has a higher frequency?
- What is the relation between wavelength and frequency?

The time taken by both the waves to travel a distance of 12 m is equal. So the speed of the wave will be equal.

When the speed is constant, frequency of the wave is inversely proportional to the wavelength. $f \propto \frac{1}{\lambda}$

The relation between the speed of wave, frequency and wavelength

Analyse figure 1.15 and answer the questions given below.

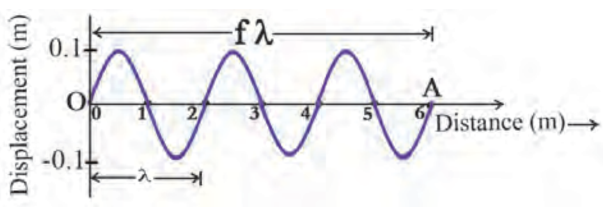

Fig.1.15

- What is the wavelength (λ)?
- If the wave takes 1 s to reach A from O, what is the frequency (f)?
- Isn't the speed of a wave the distance travelled by it in one second? What is the speed of the wave (v)?
- Find the relation between wavelength, frequency and speed of a wave. It is found that the speed of a wave is the product of its wavelength and frequency.

Speed of a wave = frequency × wavelength

ie, $v = f\lambda$

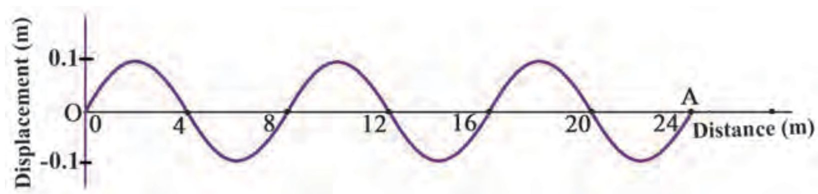

Fig.1.16

The state of the particles in a wave at a particular time is depicted in the figure.

a) How many crests are there in the figure?

b) How many troughs are there?

c) What is the wavelength?

If the frequency of a longitudinal wave travelling at a speed of 350 m/s in the air is 35 Hz,

a) What is the distance between two consecutive compressions of this wave?

b) What about the distance between two consecutive rarefactions?

A sound wave with a frequency of 175 Hz has a wavelength of 2 m. Calculate the speed of sound.

Sound and light are waves. Light reflects. Can sound also reflect?

Reflection of Sound

Do sound waves reflect when they hit objects? Let's see.

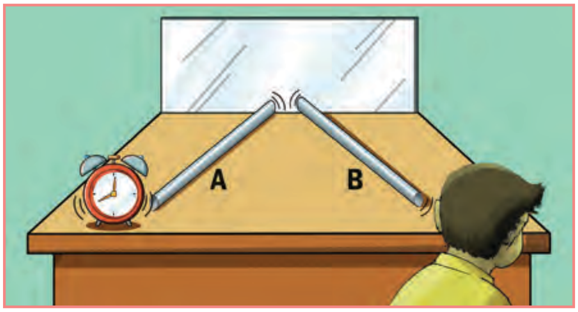

Fig. 1.17

Arrange two PVC pipes of 1 metre in length, a glass plate and an alarm clock as shown in the figure.

Adjust the pipe B at different angles and listen to the ticking sound from the clock. What could be the reason for the ticking sound being heard from the clock through the pipe B?

The sound is heard through the pipe B because sound waves reflect after striking the glass plate.

Repeat the experiment using rough surfaces instead of glass plate.

- Don't you feel a decrease in the loudness of the reflecting sound? What is the reason?

Smooth surfaces reflect sound more effectively than rough surfaces.

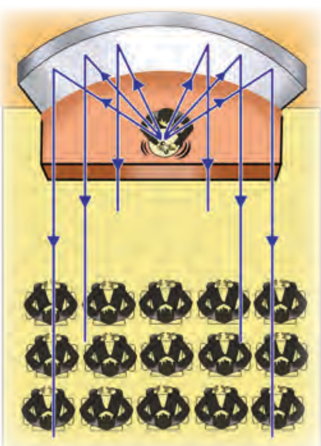

Fig. 1.18 (a)

Reflection of sound is utilised in :

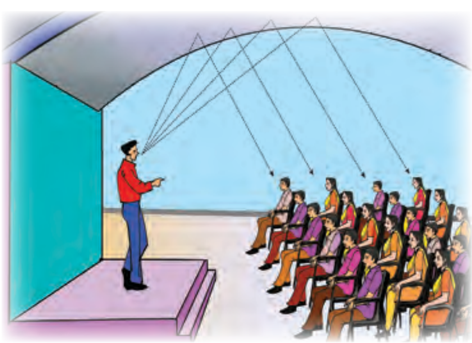

Fig. 1.18 (b)

- Soundboards [Fig.1.18 (a)]
- Curved ceilings in halls [Fig. 1.18 (b)]

These help to reflect sound from a source and spread it to all parts of the hall.

Multiple Reflection of Sound

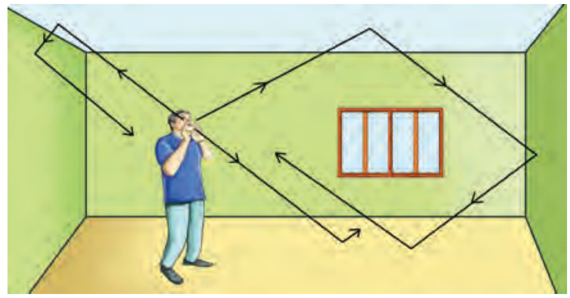

Fig. 1.19

The figure shows how sound from a source reaches a listener in a closed hall.

- Does sound from a source always travel directly to the listener?

Reflected sound waves get reflected again. This is multiple reflection of sound.

Are there instances when reflected sounds are heard distinctly?

Echo

Fig. 1.20

Have you ever had the experience of making a loud sound at the echo point and hearing the same sound again after a while?

While speaking loudly in a closed and empty large hall and calling or clapping loudly at a distance from a great mountain, isn't it possible to hear the same sound again after a while? This is possible due to the phenomenon of echo.

Echo is the sound heard after a while due to the reflection of the initial sound.

Why don't we hear echo inside a small room?

What should be the minimum distance from the listener to the reflecting surface, if the first sound is to be heard distinctly after reflection?

The auditory experience produced by a sound persists for about $\frac{1}{10}$ of a second. This characteristic is known as persistence of hearing. If another sound falls on the ear during this time, it is felt as if they are heard together.

- How long will it take to hear the echo distinctly after hearing the first sound?
- How far does the sound travel during this time?

(Consider the speed of sound in air as 350 m/s.)

$$\text{Distance} = \text{speed} \times \text{time}$$
$$= 350 \text{ m/s} \times \left(\frac{1}{10}\right) \text{s} = 35 \text{ m}$$

For the echo to be heard, the reflecting surface must be at least 17.5 m away, ie, half of 35 m. If the distance to the reflecting surface is more than 17.5 m, the same sound can be heard and distinguished again.

? The echo of fire cracker (kathina) is heard after 1 s by the person who burst it. How far is the reflecting surface from the person hearing the echo? (speed of sound in air is 350 m/s).

Let d be the distance to the reflecting surface. Then the total distance travelled by the sound to the reflecting surface and back will be 2d.

$$\text{Speed of sound} = \frac{\text{Total distance travelled}}{\text{Time}}$$
$$v = \frac{2d}{t}$$

$d = \frac{(v \times t)}{2} = \frac{(350 \times 1)\text{ m}}{2} = 175$ m. The reflecting surface will be 175 m away.

? What should be the minimum distance between the source and the reflecting surface to hear the echo in water? (Consider the speed of sound in water as 1480 m/s)

If sound is made in an empty room, why is a boom felt?

Fig. 1.21

Reverberation

Even if a small sound is produced inside the whispering gallery of Gol Gumbaz in Bijapur, Karnataka, it can be heard repeatedly throughout the gallery. This is due to the boom caused by the multiple reflections of sound waves on the spherical walls.

Reverberation is the lingering of sound, even after the original sound has ceased. It is due to the multiple reflection of sound and the boom fades away gradually.

Why are the walls of large halls like cinema theatres made rough?

Can a person with normal hearing ability hear all sounds?

Limits of audibility

Note the limits of frequency of sound audible to humans in figure 1.22.

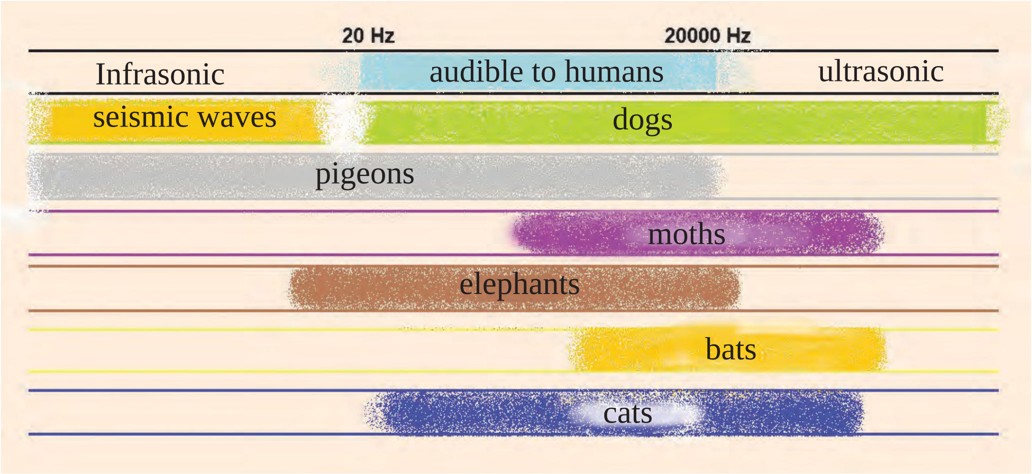

Fig. 1.22

The frequency of sound produced in a galton whistle used for training dogs is about 30000 Hz.

- Can humans hear the sound of a galton whistle?

Fig. 1.23

There are high and low-frequency sounds in nature. But humans cannot hear the sound of all frequencies. That is, there is a limit to the range of frequency of sounds that humans can hear. For a person with normal hearing, the lower limit of audible sound is about 20 Hz and the upper limit is about 20000 Hz (20 kHz). Sound with a frequency below 20 Hz is infrasonic. Sound with frequency more than 20000 Hz is ultrasonic.

Fig. 1.24

Using ultrasonic sound, bats can travel smoothly and catch prey easily even in the dark. Ultrasonic waves are used in many situations.

Uses of Ultrasonic Waves

Fig. 1.25

In the medical field, ultrasonic waves are used for diagnosis and treatment.

- To crush small stones in the kidneys.
- In physiotherapy
- To take images of internal organs such as kidney, liver, gall bladder and uterus.

Ultrasonic waves that travel through body tissues strike and reflect at areas of varying density in the tissues. These waves are converted into electric signals to form an image of the organ (Fig. 1.25). This technique is ultra sonography.

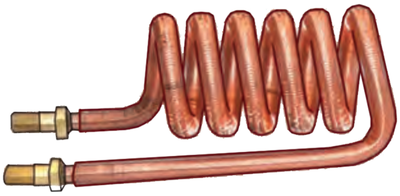

Fig. 1.26

- For cleaning spiral tubes, irregular machine parts, electronic components etc. (Fig. 1.26).
- In the device called SONAR which is used to find the distance to the underwater objects (Fig. 1.27).

Fig. 1.27

If an ultrasonic wave emitted by a transmitter, installed on a ship on the surface of the water, strikes a rock at the bottom of the sea and returns after 0.2 s, what is the distance from the ship to the rock? Consider the speed of ultrasonic waves in seawater as 1522 m/s.

Can waves cause any harm?

You have understood the characteristics and uses of different types of waves. Any type of wave above a certain intensity can cause harmful effects. There are also destructive waves.

Seismic Waves and Tsunami

A building that was destroyed by the earthquake is seen in figure 1.28. Earthquakes often cause disaster.

Fig. 1.28

Seismic waves are those which travel through the Earth's crust as a result of earthquakes, volcanic eruptions, and massive explosions. Seismology is the study of seismic waves. The intensity of earthquakes is determined by the Richter scale.

Earthquakes that occur at the bottom of oceans or along coastal areas can sometimes trigger tsunami waves (Fig. 1.29). Tsunami is a series of gigantic ocean waves caused by the displacement of large volumes of water in the sea.

Fig. 1.29

- What measures can be taken to safeguard against tsunamis? Discuss and make notes.

Follow the instructions given by the official tsunami warning centres.

Let's Assess

1. Which of the following statements is correct?
   a) Sound and light are transverse waves.
   b) Sound and light are longitudinal waves.
   c) Sound is a longitudinal wave and light is a transverse wave.
   d) Sound is a transverse wave and light is a longitudinal wave.
2. The upper limit of frequency of sound that a bat can hear is 120 kHz. If so, what is the maximum wavelength of sound it can hear? Consider the speed of sound as 350 m/s.

3. A graphic illustration of two waves travelling at a speed of 3.2 m/s is given.

   a) Find out the frequency, period, and wavelength of each wave.

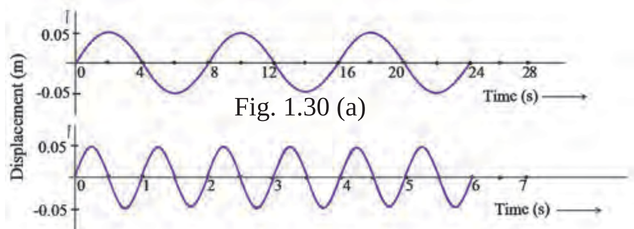

Fig. 1.30 (a)

Fig. 1.30 (b)

4. Which of the following frequency can be heard by humans?

   a) 5 Hz   b) 2000 Hz   c) 200 kHz   d) 50 kHz

5. A wave has a frequency of 2 kHz and a wavelength of 35 cm. How far does this wave travel in 0.5 s?

6. What is the frequency of a wave that produces 50 crests and 50 troughs in 0.5 s?

7. Which of the following is different regarding the waves given in the figures 1.31 (a) and 1.31 (b)?

   (frequency, amplitude, wavelength)

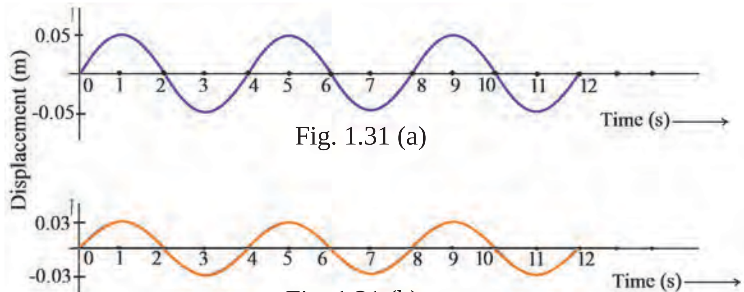

Fig. 1.31 (a)

Fig. 1.31 (b)

8. The distance between two adjacent troughs of a transverse wave is 2 m. Find the frequency if its speed is 20 m/s.

9. When sound passes through a medium, …………….. travels.

   (the particles in the medium / the wave / the source of sound / the medium)

10. Two pith balls are suspended near the two prongs of a tuning fork fixed on a table so as to touch the prongs. A person plays a piano sitting near this system.

    a) In this case the pith balls move slightly. What is the reason?

       (forced vibration / echo)

    b) While playing certain notes on the piano, the pith balls are thrown to a maximum distance. Which phenomenon is responsible for this?

       (reverberation / resonance)

Extended activities

1. Plan an activity that illustrates the resonance of sound.

2. Prepare and present a seminar paper on the topic : 'Ultrasonic Waves and their Applications.'