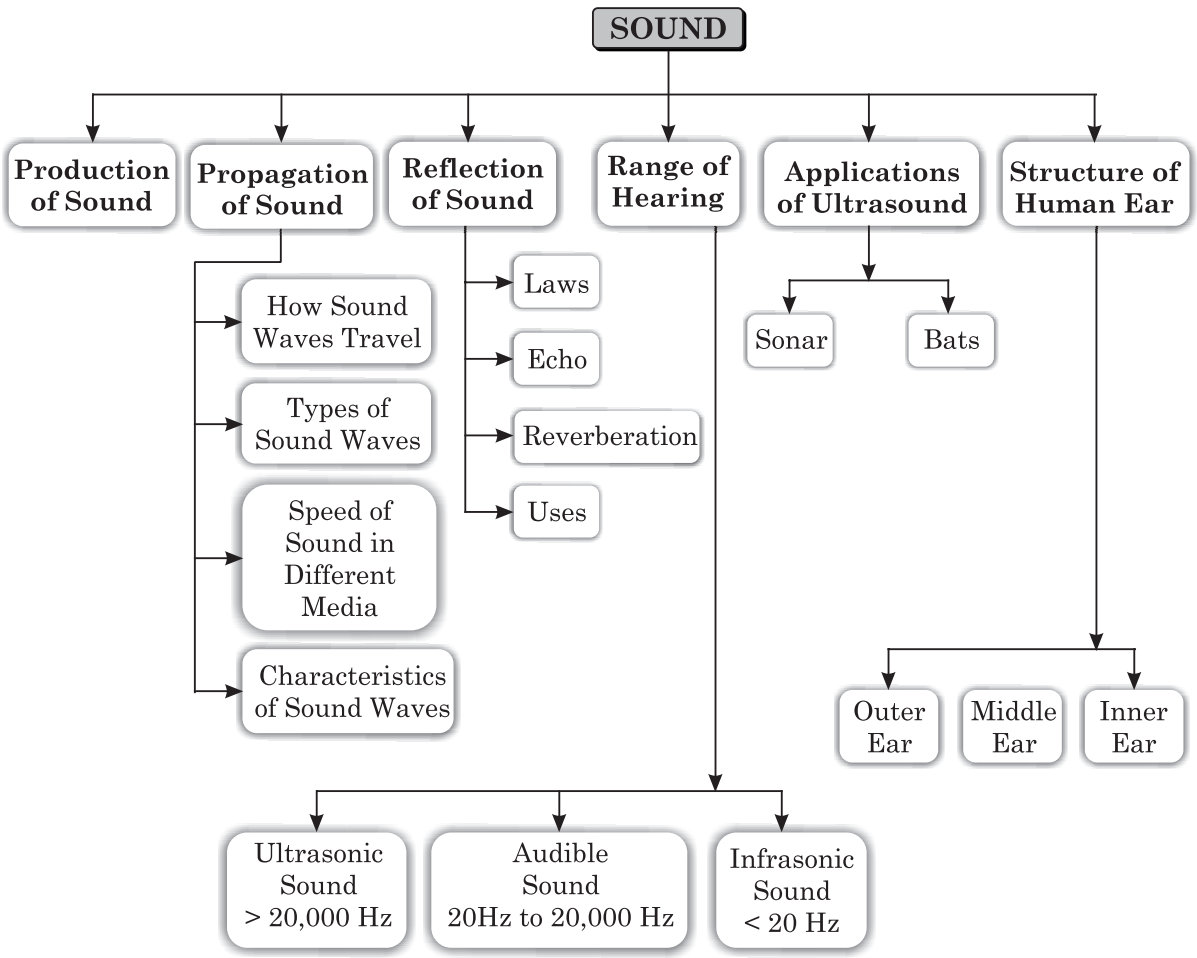
12 Sound

Topics Covered

12.1 Production and Propagation of Sound
12.2 Reflection of sound

CHAPTER MAP



QUICK REVISION NOTES

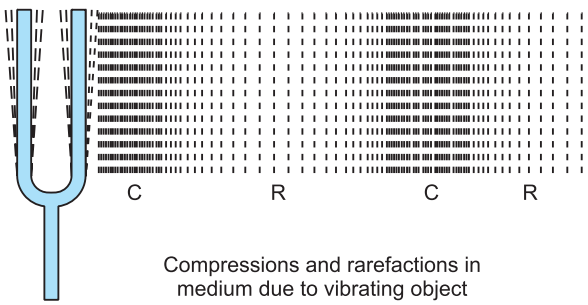
Sound: It is a form of energy which makes us to hear. It is produced by vibrations. For examples when we clap, sound is produced.

- Law of conservation of energy is also applicable to sound.
- Sound travels in a medium in the form of waves.

Production of sound: Sound is produced by vibrating objects, e.g. sound by a drum is produced by vibrations of its membrane when we struck it with a wooden stick.

Propagation of sound: The substance through which sound travels is called medium which may be a solid, liquid or gas.

- Sound requires a medium for its propagation. Sound cannot propagates through vacuum because there are no molecules to pass on the vibrations through vaccum.
- When an object vibrates, the air particles around it also starts vibrating in exactly the same way and are displaced from their stable position.
- These vibrating air particles exerts a force on the nearby air particles which are displaced in the form of sound waves.
- The disturbance produced by sound travels through the medium (not the particles of the medium).
- Wave is a disturbance which travels through a medium and carries energy.
- Sound is known as mechanical waves or the elastic wave because it requires a material medium for their propagation.
- Sound is a longitudinal wave. It appears as a succession of compressions and rarefactions.
- A longitudinal wave is a wave in which the vibrations of the particles are parallel to the direction of propagation of the wave.



Compressions and rarefactions in medium due to vibrating object

⟶ direction of propagation of wave

⟷ direction of vibration of the particles of the medium.

- The **wavelength** (λ) of a sound wave is the distance between two consecutive (successive) compressions or rarefactions.

$$\boxed{\nu = \frac{1}{T}} = \boxed{\nu = \frac{v}{\lambda}}$$ (where v is the speed of the sound wave, ν is the frequency of sound wave, 'λ' is the wavelength of sound wave and T is the time period)

- Sound travels faster in a denser medium than a rarer medium. It travels fastest in solids followed by liquids and least in gases.
- An obstacle of large size which may be polished or rough is needed for the reflection of sound waves.
- The direction in which the sound wave is incident and is reflected makes equal angle with the reflecting surface and all lies in the same plane.
- The roaring of thunder is due to successive multiple reflections of the sound from a number of reflecting surfaces, such as clouds, land high buildings etc.
- Lightening is seen before thunder because light travels faster than sound.

- Megaphones or loud speakers, horns, musical instruments like trumpet, shehnais, etc. are a desired to send sound a particular direction without spreading them in all the directions. It is due to successive reflections of sound in a particular direction.
- In stethoscope, patients heart beat reaches the doctor's ear by multiple reflection of sound.
- The ceiling of cinema halls are made curved so that sound can be heard from all the corners after its reflection.

Infrasound or infrasonic sound is the sound whose frequency is below 20 Hz.

- Rhinoceros, whales and elephants communicate using infrasound of frequency 5 Hz.
- Some animals get disturbed by earthquakes because it produces infrasounds, before the main shock waves begin.

Ultrasound or ultrasonic sound have frequency higher than 20000 Hz (20 kHz) which is produced by bats, dolphins and porpoises.

- Dogs can hear upto 25 kHz (25000 Hz) of sound.
- The spiral tubes, odd shaped parts and other electronic components which are difficult to be cleaned are cleaned by using cleaning solutions when ultrasonic waves are sent into these solutions.
- Ultrasound can be used to detect cracks and flaws in metal blocks. Ultrasonic waves are reflected back from the defective locations inside the metal block.
- Ultrasound scanners uses ultrasonic waves for getting images of internal organs of the body like liver, gall bladder, uterus, kidney, etc.

Echocardiography: Ultrasonic waves are used to be reflected from various parts of the heart and it forms image of heart.

SONAR stands for sound navigation and ranging. It is a device which uses ultrasonic waves to measure the distance, direction and speed of the under water objects like submarines, icebergs, sunken ships etc.

- The nature of reflection tells the bat where the obstacle or prey is and what it is like. Porpoises uses ultrasound for navigation and location of food in dark.
- Hearing aids can give amplified electric signals to sound and sends the waves clearly for hearing by ear.

Human ear consists of outer ear, middle ear and inner ear, ear drum, cochlea, auditory nerves.

- Human ear can hear frequency from 20 Hz to 20000 Hz. This frequency range is called audible frequency range.
- Ear converts the pressure vibrations in air with audible frequencies into electrical signals that travels to the brain via auditory nerves.

Loudness of sound is measured in terms of decibels which in turn depends upon the amplitude of sound waves. Higher the amplitude, more will be loudness and energy.

The **pitch** of sound depends upon the frequency of the sound waves. Sound of higher frequency and shorter wavelength has higher pitch and vice-versa.

Intensity of sound: The amount of sound energy passing each second through a unit area.

Echo ranging: It is the sonar technique which is used to determine the depth of the sea and locate under water hills, icebergs, sunken ships, submarines etc.

Mechanical waves are of two types:

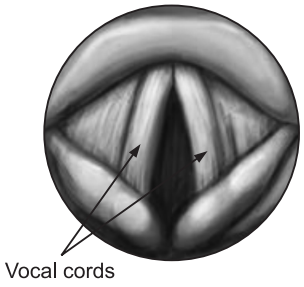
- *Longitudinal waves:* Such waves in which particles of medium oscillates about their mean position in the same direction of wave propagation are called longitudinal waves.
- *Transverse waves:* Such waves in which particles of the medium vibrates perpendicular to the direction of wave propagation is called transverse waves.

1. Production and Propagation of Sound

Production of Sound

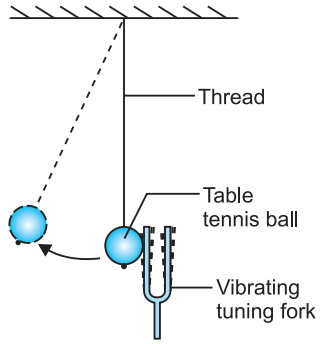
- Sound is produced when an object vibrates, e.g. sound by a drum is produced by vibration of its membrane of drum when it is struck.
- Sound of our voice is produced by the vibration of two vocal cords in our throat.

Sound is produced when the skin of a drum vibrates



Sound is produced when our vocal cords vibrate

- Sound is produced by a vibrating tuning fork: The vibration of tuning fork can be shown by touching a small ball (cork ball) with a prong of sounding tuning fork. The pitched ball is pushed away by force or energy produced by the sound waves.



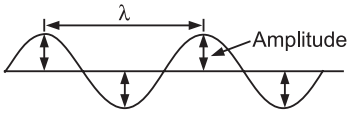
Propagation of Sound

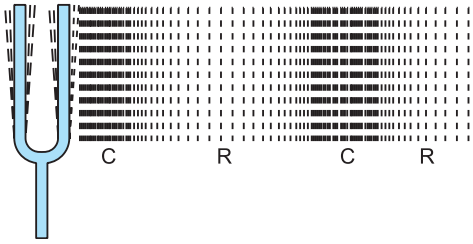
Sound Needs a Medium for Its Propagation

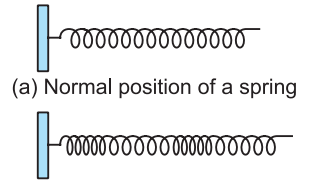
- **Electromagnetic** waves like light rays do not need any medium to propagate. These are **transverse waves**, i.e. made up of crests and troughs. The particles oscillates in perpendicular to the direction of propagation of the wave.

Sound Waves are Longitudinal Waves

- Sound waves are longitudinal waves having **compressions** (points of maximum density) and **rarefactions** (points of minimum density).







The direction of oscillation is parallel to the direction of propagation of the waves.

Characteristics of Sound Waves

- **Wavelength:** The separation between two consecutive compressions or rarefactions is called wavelength.
- **Frequency:** The number of oscillations taking place per second in a wave is called its frequency of the wave. Its unit is Hz or s^{-1}.

  Time period: The time taken by a particle to complete one oscillation is called time period.

$$\text{Time period} = \frac{1}{\text{Frequency}} \qquad \text{or} \qquad \boxed{T = \frac{1}{\nu}}$$

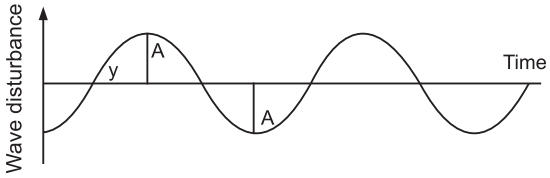
Velocity of sound: It is defined as the distance travelled by the sound per unit time or wavelength per unit time.

$$v = \frac{\text{Distance}}{\text{Time}} = \frac{\lambda}{T}$$

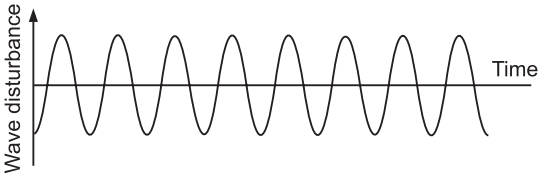
$\boxed{v = \lambda \times \nu}$ where 'ν' is the frequency, 'λ' is the wavelength and, 'v' is the velocity.

Displacement (*f*): Displacement is the position of particle from its mean position at a certain time.

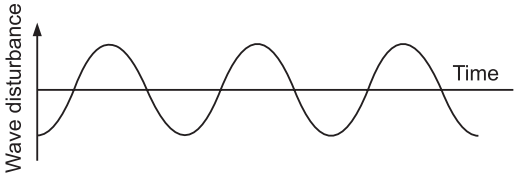
Amplitude (A): The maximum displacement of vibrating particles from their mean position is called **amplitude** (A) of oscillation.



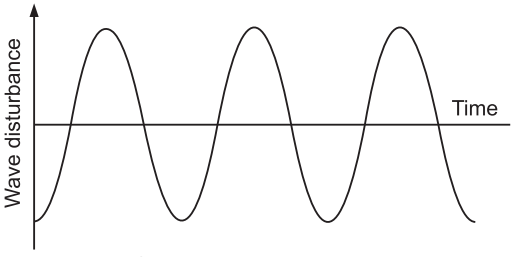
Wave of low pitched sound with lower frequency



Wave of high pitched sound with higher frequency



Wave of soft sound with small amplitude



Wave of loud sound with high amplitude

Speed of Sound in Different Media

The velocity of sound depends upon the medium and temperature. It is maximum in solids and minimum in gases.

Quality or Timbre of Sound

It is a property of sound which enables us to distinguish between one sound from another sound having the same pitch and loudness.

Pleasant Sound: It is of rich quality.

Tone: A sound of single frequency is called a tone.

Note: A sound which is produced due to mixture of frequencies is called a note and it is pleasant to hear.

Noise: It is the unpleasant sound produced by intermixing of high frequency sounds with high pitch and loudness.

Exercise 12.1

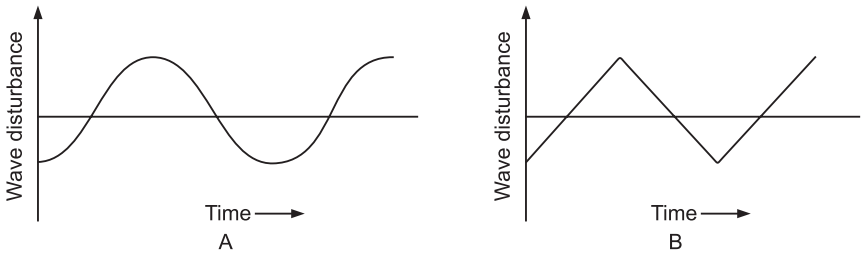
I. Very Short Answer Type Questions (1 Mark)

1. What happens to sound when it goes from solid to gaseous state? [*CBSE* 2010]
2. How are the wavelength and frequency of a sound wave related to its speed? [*NCERT*]
3. What is the frequency of a wave whose time period is 0.025 s? **[*CBSE* 2010]**
4. Which wave property determines (*a*) loudness, (*b*) pitch of sound waves?
5. What is the nature of sound waves? **[*CBSE* 2010]**

6. A baby recognises her mother's sound by her voice. Name the characteristic of sound involved. **[*CBSE* 2010]**
7. Give one example each for transverse and longitudinal waves. [*CBSE* 2010]
8. On what factors does quality of sound depend? **[*CBSE* 2010]**
9. The frequency of a source of sound is 200 Hz. How many times does it vibrate in a minute?
10. Suppose you and your friend are on the moon. Will you be able to hear any sound produced by your friend? [*NCERT*]
11. What is the frequency of a sound wave whose time period is 0.05 seconds? [*DOE*]
12. What is the audible range of human beings?
13. What is the SI unit of frequency? Give its bigger unit also.

II. Short Answer Type Questions–I (2 Marks)

14. How does the sound produced by a vibrating object in a medium reaches your ear? [*NCERT*]
15. A sound wave has a frequency of 2 kHz and wavelength of 35 cm. How long will it take to travel 1.5 km?
16. In which of the three media, air, water or iron, does sound travel the fastest at a particular temperature?
17. What are infrasonic and ultrasonic sounds?
18. The following figure shows the wave shapes of two sounds of some frequency. Which of these is likely to represent the sound of a car horn? **[CBSE 2010]**



19. Why are sound waves called mechanical waves? [*NCERT*]
20. Why is light not a mechanical wave?
21. Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen, why? [*NCERT*]
22. Give four characteristics of sound waves.
23. Draw a diagram showing density or pressure variation in sound waves.
24. Which characteristic of sound determines its (*a*) pitch (*b*) loudness? **[DOE]**

III. Short Answer Type Questions–II (3 Marks)

25. Explain an activity with a labelled diagram to prove that sound needs a material medium for propagation. **[DOE]**
26. Explain how sound is produced by your school bell. [*NCERT*]
27. How longitudinal waves are produced in a slinky?
28. What are wavelength, frequency, time period and amplitude of a sound wave? [*NCERT*]
29. A wave is moving in air with a velocity of 340 m/s. Calculate the wavelength, if its frequency is: (*i*) 512 vibrations per second (*ii*) 100 Hz. **[DOE]**

IV. Long Answer Type Questions (5 Marks)

30. How transverse waves are produced in a slinky? Give one another example of transverse waves? Explain with the help of a diagram.

31. Give four difference between transverse waves and longitudinal waves and give one example of each.

Answers 12.1

1. The speed of sound decreases.

2. $\nu = \frac{v}{\lambda}$, where ν = frequency,

v = velocity and λ = wavelength

3. $\nu = \frac{1}{T} = \frac{1}{0.025} = \frac{1000}{25} = 40$ Hz

4. **Loudness:** Higher the amplitude of wave, more will be the loudness. It is measured in decibel units. It is a measure of response of the ear to sound. Two sounds of equal intensity may have different loudness. The louder one is better detected by our ear.

Intensity: The amount of sound energy passing each second per unit area is called intensity of sound.

5. Sound waves are longitudinal waves.

6. Quality of sound

7. Light waves are transverse waves whereas sound waves are longitudinal waves.

8. It depends upon how different frequencies are mixed up to get a pleasant sound.

9. Number of vibrations in a minute = 200 × 60 = 12000 times

10. No, we will not be able to hear any sound because there is no atmosphere, i.e. no medium to conduct sound waves on the moon.

11. $\nu = \frac{1}{T} = \frac{1}{0.05} = 20$ Hz

12. 20 Hz to 20000 Hz (20 kHz).

13. SI unit of frequency is Hz. Some of its bigger units are:

1 kHz = 1000 Hz, 1 MHz = 10^6 Hz

14.
- When an object vibrates, it set the particles of the medium around it to vibrate in the same manner.
- The medium in contact with the vibrating object is first displaced, which exerts a force on the adjacent particles which get displaced. The process is continuous till sound reaches our ear.

15. ν = 2 kHz = 2000 Hz

λ = 35 cm = 0.35 m

$\nu = \frac{v}{\lambda}$

$v = \lambda \times \nu = 0.35 \times 2000 = 700 \text{ m s}^{-1}$

$T = \frac{\text{Distance}}{\text{velocity}} = \frac{1.5 \times 1000 \text{ m}}{700 \text{ m s}^{-1}}$

$= \frac{1500}{700} = 2.14$ seconds.

16. Sound waves travel the fastest in iron at a particular temperature.

17. Sound waves with frequency less than 20 kHz are infrasonic whereas more than 20000 Hz or (20 kHz) are ultrasonic sounds.

18. 'B' because its frequency is more, therefore pitch will be higher.

19. Sound waves are longitudinal waves. The individual particles of the medium move about their mean position as the wave travels. These waves need a material medium to travel. Therefore, sound waves are also called mechanical waves.

20. Light is a transverse wave. The oscillations produced are not of the medium or their pressure or density. Therefore, do not require any medium to travel and so it is not a mechanical wave.

21. It is because light waves travels faster than sound waves.

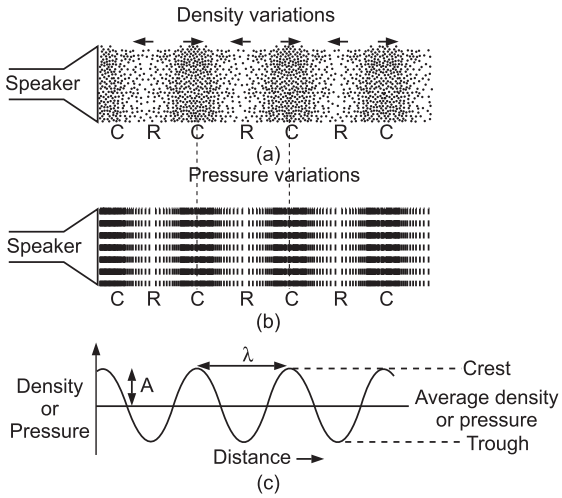
22. (*i*) When wave travels in air the density and pressure of air changes from their mean position.

(*ii*) Compression can be shown by crests and rarefaction by troughs.

(*iii*) Compression is the region of maximum density or pressure.

(*iv*) Rarefaction is the region of minimum density or pressure.

23.



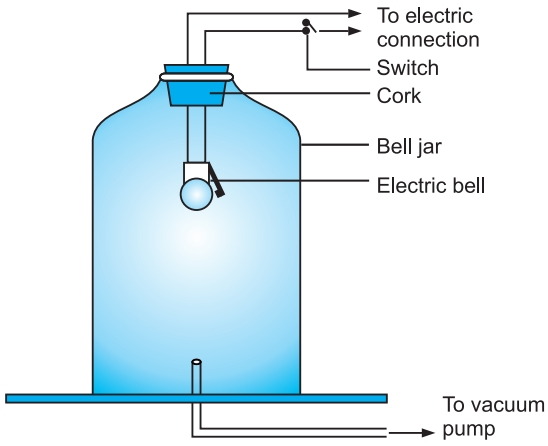
24. (*i*) **Pitch:** It depends upon the frequency of vibration. Higher the frequency, higher will be the pitch.

(*ii*) **Loudness:** It depends upon the amplitude of wave. Higher the amplitude, higher will the loudness.

25. (*i*) Take an electric bell and an airtight glass bell jar.

(*ii*) An electric bell is suspended in an airtight bell jar.

(*iii*) The bell jar is connected to a vacuum pump as shown in the diagram:



(*iv*) Press the switch. The sound of the bell can be heard clearly.

(*v*) Remove air with the help of the vacuum pump and press the switch.

(*vi*) Now try to hear the sound.

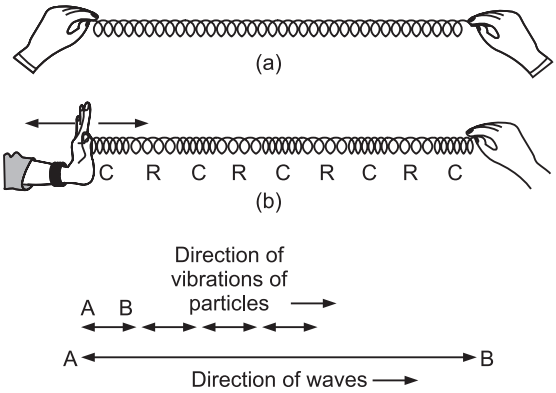
Observation: You will not be able to hear any sound.

Conclusion: It shows that sound needs a material medium for its propagation.

26. The sound is produced when bell is struck with a hard metallic rod or wooden hammer which produces vibrations. These vibrations reaches our ear through the air.

27. When we push and pull the slinky compressions (number of turns are more or closer) and rarefactions (number of turns are less or farther) are formed.

When the wave travels along with slinky, its each turn moves back and forth by only a small distance in the direction of the wave, the wave is a longitudinal wave because the direction of propagation of wave is parallel to the direction of vibration of particles as shown by the given diagram.



28. Wavelength: The separation between two consecutive compressions or rarefactions is called the wavelength.

Frequency: The number of oscillations taking place per second in a sound wave is called frequency. Its unit is Hz.

Time period: The time taken by a particle to complete one oscillation is called the time period.

$$\text{Time period} = \frac{1}{\text{Frequency}} \quad \text{or} \quad T = \frac{1}{\nu}$$

Amplitude: The maximum displacement of the vibrating particle about its mean position is called the **amplitude** (A) of the oscillation.

29. (*i*) $\nu = \dfrac{v}{\lambda} \Rightarrow \lambda = \dfrac{v}{\nu} = \dfrac{340\,\text{m s}^{-1}}{512\,\text{s}^{-1}} = 0.66\ \text{m}$

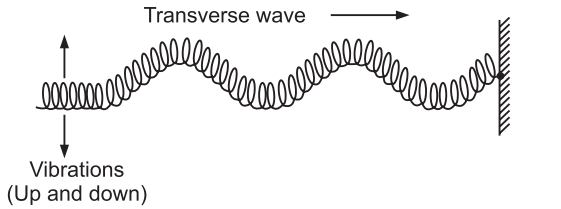
(*ii*) $\lambda = \dfrac{v}{\nu} = \dfrac{340\,\text{m s}^{-1}}{100\,\text{s}^{-1}} = 3.4\ \text{m}.$

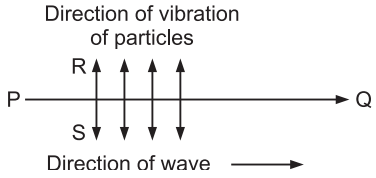
30. When one end of a slinky is moved up and down rapidly whose one end is fixed, it produces transverse waves.

This wave passes along the slinky in the horizontal direction whereas particles of medium vibrate up and down at right angle to the direction of the wave.

This wave is called transverse wave as shown in the diagram:

Light is another example of transverse wave, it does not require a medium to travel.





31.

Transverse Waves	Longitudinal Waves
(*a*) The particles of the medium vibrate perpendicular to the direction of wave propagation.	(*a*) The particles of the medium vibrate in the same direction of wave propagation.
(*b*) They can propagation in solid, medium.	(*b*) These can propagate in any type of medium.
(*c*) These form crest and trough.	(*c*) These forms compressions and rarefaction.
(*d*) These can be polarised.	(*d*) These cannot be polarised.
(*e*) One successive crest and one trough constitute a wave.	(*e*) One compression and one rarefaction constitute a wave.

2. Reflection of Sound Echo

Reflection of Sound

Sound bounces back when it falls on a hard surface. It is called reflection of sound.

Laws of Reflection:

- The incident sound wave, the reflected sound wave and normal at the point of incidences all lie in the same plane.
- The angle of incidence of sound is always equal to angle of reflection of sound waves,

$$\angle_i = \angle_r$$

where, '$\angle_i$' is angle of incidence, '$\angle_r$' is angle of reflection.

Echo

The repetition of sound due the reflection of sound waves from a distant object is called an **echo**.

- We can hear an echo when there is at least a time gap of 0.1 second in the original sound and echo (reflected sound).
- Hard surface reflects sound and produces an **echo** whereas soft surface tends to absorb sound.
- To calculate the minimum distance to hear an echo:

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

Speed of sound in air is 344 m s^{-1} at 22°C, Time = 0.1 second

$$344 \text{ m s}^{-1} = \frac{\text{Distance}}{0.1 \text{ s}}$$

$$\text{Distance} = 344 \text{ ms}^{-1} \times 0.1 \text{ s} = 34.4 \text{ m}$$

So the distance between reflecting surface and audience must be equal to $\frac{34.4\,\text{m}}{2} = 17.2$ m (at 22°C).

Reverberation

The persistence of sound in a big hall due to repeated reflection from walls, ceiling and floor of the hall is called **reverberation.** If it is too long, sound becomes blurred, distorted and confusing.

***Sonic Beam*:** It is an explosive noise caused by shock waves.

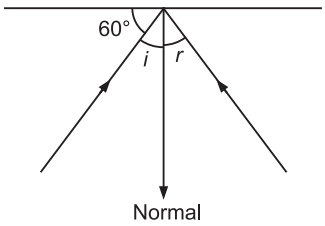
- Some aircrafts, bullets, rockets, etc. have 'supersonic speed'.
- Supersonic is the speed of an object which is greater than the speed of sound and it produces extremely loud sound waves called 'shock waves' in air.
- It emits tremendous sound energy which can shatter the glass pane of windows.

***Echo Range*:** The sonar technique which is used to determine the depth of the sea and locate underwater hills, icebergs, sunken ships, submarines, etc. is called **echo ranging**.

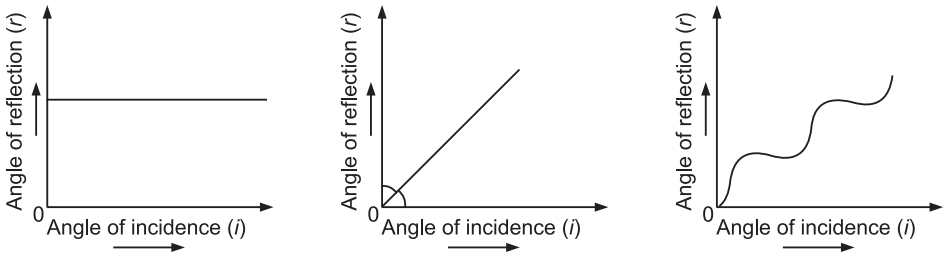
Exercise 12.2

I. Very Short Answer Type Questions (1 Mark)

1. Does sound follow the same laws of reflection as light does? [*NCERT*]
2. Write the full form of SONAR.
3. Which instrument measures the intensity of sound?
4. Which scale is used to measure intensity of earthquake?
5. Give two examples of mechanical waves.
6. If the source of sound produces 1000 compressions and 1000 rarefactions in air in 25 seconds, find the frequency of sound produced.
7. In an experiment to verify the laws of reflection of sound the angle of reflection in the figure depicted is:



8. If the reflected and incident sound waves are at 90° with respect to respect to each other, what is the angle of incidence? [*DOE*]
9. A pulse travels through a slinky 10 m long from one end to the other end and then back to the point of origin in 3 seconds. What is the velocity of pulse in the slinky? [*DOE*]
10. Which quantity is transferred through the medium during the propagation of sound waves? **[HOTS]** [*CBSE* 2015]
11. How a pulse can be generated?
12. For the reflection of sound by a metal plate, which graph shows the correct relation between the angle of incidence and the angle of reflection? [*CBSE* 2016]



13. Name two devices which work on the basis of reflection of sound.
14. Why is a time interval of 0.1 s necessary to hear the echo sound?

15. Velocity of sound in air is 344 m s^{-1} and in Aluminium is 6420 m s^{-1}. Find the ratio of time taken to reach the sound to the listener via air and Aluminium. **[HOTS]**
16. The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute? [*NCERT*]
17. 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 produced remains the same. Do you hear the echo sound on a hotter day? [*NCERT*] **[HOTS]**
18. Give two practical applications of reflection of sound waves. [*NCERT*]
19. Name the part of human ear which converts sound vibrations into electric signals.
20. Dolphins, bats and porpoise use which type of sound for communication?
21. What is the range upto which children can hear sounds?
22. How can sound with same pitch and loudness be detected?
23. Why do loud sounds can travel larger distances?
24. A wave in slinky travelled to and fro in 5 seconds. The length of slinky is 5 m. What is the the velocity of wave?
25. The loudspeaker emit sound waves. In which direction does the air vibrate?
26. What do you mean by siesmic waves?
27. The sound of an explosion on the surface of a lake is heard by a boatman 100 m away and a diver 100 m below the point of explosion. Who would hear the sound first, boatman or the driver? [*CBSE* 2011] [*NCERT Exemplar*] **[HOTS]**

II. Short Answer Type Questions–I (2 Marks)

28. On a cloudy day, a thunder sound was heard 14 second after the flash of lightning. How far was the cloud? (Given speed of sound is 340 m/sec).
29. How multiple echoes of a single sound can be produced? [*CBSE* 2014]
30. A radar signal is received in 2×10^{-5} sec after it was sent and reflected back by an aeroplane. how far is the aeroplane if speed of waves is 3×10^{8} m s^{-1}? [*CBSE* 2016]
31. 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}? [*NCERT*]
32. What should be the minimum distance between two objects to hear an echo clearly? [v = 344 m s^{-1} for sound at 22°C]
33. A person clapped his hands near a cliff and heard the echo after 5 s. What is the distance of the cliff from the person if the speed of the sound, v is taken as 346 m s^{-1}? [*NCERT*]
34. Why are ceilings of concert halls made curved? **[***NCERT***]**
35. A ship sends out ultrasound waves that returns from the sea—bed and is detected after 3.42 s. If the speed of ultrasound through seawater is 1531 m/s, what is the distance of the seabed from the ship? [*NCERT*]
36. 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, how far away is the cliff? [*NCERT*]
37. A person has a hearing range from 20 Hz to 20 kHz. What are the typical wavelength of the sound waves in air corresponding to these two frequencies? Take the speed of sound in air as 344 m s^{-1}. [*NCERT*]
38. 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? [*NCERT*]
39. A sonar device on a submarine sends out a signal and receives an echo in 5 s later. Calculate the speed of sound in water if the distance of the object from the submarine is 3625 m. [*NCERT*]
40. When a clamped ruler is pulled on one side and then released, it vibrates and produces sound waves. Explain why there are compressions and refractions in the sound waves that are produced?

41. How is noise different from music?
42. Distinguish between a note and a tone.
43. A hospital uses an ultrasonic scanner to locate tumours in a tissue. What is the wavelength of sound in a tissue with a speed of 1.7 km/s? The operating frequency of the scanner in 4.2 MHz. [*CBSE* 2010]
44. A sound wave has a frequency of 3 kHz and a wavelength of 45 cm. How long will it take to travel 1.8 km? [*CBSE* 2010]
45. The sound produced by a thunderstorm is heard 10 seconds after the lightning is seen. Calculate the approximate distance of the thunder cloud.
(Given speed of sounds in air = 340 m s^{-1}) [*NCERT Exemplar*]
46. A girl is sitting in the middle of a park of dimension 12 m × 12 m. On the left side of it, there is a building adjoining the park and on right side of the park, there is road adjoining the park. A sound is produced on the road by a cracker. Is it possible for the girl to hear echo of this sound? Explain your answer. [velocity of sound in air = 342 m s^{-1}]
[HOTS] [*NCERT Exemplar*]
47. A child hear an echo from a cliff in 10 seconds, after the sound from an animal is produced. Calculate the distance between the cliff and the child. (Take velocity of sound as 340 m s^{-1})
[*DOE*]

III. Short Answer Type Questions–II (3 Marks)

48. (*a*) Draw a labelled diagram showing graphical representation of low pitch and high pitch sound. [*DOE*]
(*b*) Write any two applications of SONAR.
49. How are ultrasonic waves used for signalling directions? [*CBSE* 2014]
50. 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 ms^{-2} and speed of sound = 340 m s^{-1}. [*NCERT*] **[HOTS]**
51. What is reverberation? How can it be reduced? **[***NCERT***]**
52. Explain how defect in metal blocks can be detected using ultrasound? **[***NCERT***]**
53. When a stone is thrown in a pond, what type of waves are produced? Draw its displacement time graph. Label the crest, trough and wavelength on the graph. [*CBSE* 2016]
54. A sound wave is emitted downward from a ship. The sound wave is deflected back on the ship in 0.25 s. The seabed is 180 m below the ship.
(*a*) Calculate the speed of sound in sea water.
(*b*) Suggest why sound waves cannot move from Earth to the moon?
55. A construction worker's helmet slips and fall when he is 78.4 m above the ground. He hears the sound of the helmet hitting the ground 4.23 seconds after it has slipped. Find the speed of sound in air. [*NCERT Exemplar*] [*CBSE* 2011]
56. How do bats locate their prey? [*NCERT*]

IV. Long Short Answer Type Questions (5 Marks)

57. With the help of labelled diagram explain the echo ranging technique. [*CBSE* 2016]
58. Explain how human ear works? [*NCERT*]

Answers 12.2

1. Yes, it follows the same laws of reflection.
2. Sound Navigation and Ranging
3. Decible meter
4. Richter scale

5. (*i*) Sound waves,
(*ii*) Ripples on water surface (ocean waves)
(*iii*) Waves in a stretched string

6. No. of waves = 1000; t = 25 seconds

$$\therefore \quad \nu = \frac{1000}{25} = 40 \text{ Hz.}$$

7. $\angle i = 90° - 60 = 30° \Rightarrow \angle i = \angle r = 30°$

8. $\angle i + \angle r = 90°$

$\angle i = \angle r$; $2\angle i = 90°$; $\angle i = 45°$.

9. Distance = 2 × 10 m = 20 m, time = 3 seconds

$$\therefore \quad \text{Velocity} = \frac{\text{distance}}{\text{time}} \Rightarrow \frac{20}{3} = 6.66 \text{ m s}^{-1}$$

10. Energy

11. A pulse can be generated by giving a jerk to string (slinky) tied at one fixed end.

12. (*b*) $\because \angle i = \angle r$. As the angle of incidence increases, angle of reflection also increases.

13. Megaphones and Stethoscope, Sonar.

14. This is because the sensation of sound persist in our ear for about 0.1 s.

15. $\frac{t_1}{t_2} = \frac{v_2}{v_1}$ [$\because$ Higher the velocity, lesser the time taken to reach the sound]

$$\therefore \quad \frac{t_1}{t_2} = \frac{6420 \text{ m s}^{-1}}{344 \text{ m s}^{-1}} \Rightarrow \frac{t_1}{t_2} = 18.66$$

The sound will reach in 'Aluminium' 18.66 times faster than in air.

16. ν = 100 Hz , t = 1 minute = 60 seconds
No. of vibrations per minute = $\nu \times t$ = 100 × 60 = 6000 vibrations per minute.

17. The speed of sound increases with increase in temperature, therefore on a hotter day, tendency to hear an echo decreases $\because t = \frac{2d}{v}$. If the time decreases below 0.1 s, then echo cannot be heard.

18. (*i*) Hearing aids (*ii*) Stethoscope

19. Cochlea.

20. Ultrasonic sound.

21. Upto 25 kHz

22. It can be detected by the timbre of the sound.

23. It is because they have more energy.

24. $v = \frac{2d}{t} = \frac{2 \times 5}{5} = 2 \text{ m s}^{-1}$

25. The sound waves (longitudinal waves), air molecules will oscillate in the direction which is parallel to the direction of sound waves.

26. The waves produced under the crust of the earth during an earthquake are called siesmic waves.

27. Diver will hear the sound first as sound travels faster in water than in air.

28. t = 14 seconds
$d = v \times t \Rightarrow 340 \times 14 = 4760$ m

29. The sound created in a big hall will persist by repeated reflections from the walls.
It can be produced by megaphones or loud speakers.

30. $2d = v \times t = 3 \times 10^8 \times 2 \times 10^{-5}$
$2d = 6 \times 10^3 \Rightarrow 2d = 6000 \text{ m} \Rightarrow d = 3000 \text{ m}$

31. $2d = \dfrac{v}{t} \Rightarrow \dfrac{342}{3} = 114$

$d = \dfrac{114}{2} \Rightarrow 57$ m.

32. The sound must go to the obstacle and come back to the ear in 0.1 s.

$v = \dfrac{2d}{t}$

$2d = v \times t \Rightarrow 344 \times 0.1 = 34.4$ m

$d = \dfrac{34.4}{2} \Rightarrow 17.2$ m

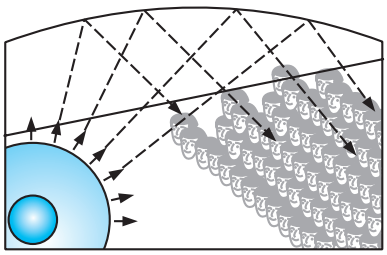
33. $t = 5$s, $d = ?$, $v = 346$ m s^{-1}

$2d = v \times t$

$= 346 \times 5 \Rightarrow 1730$ m

$2d = 1730$ m; $d = 865$ m

34. The ceiling of concert halls are made curved so that sound after reflection reaches all the corners of the hall as shown in the diagram.



35. $t = 3.42$ s, $v = 1531$ m s^{-1}, $d = ?$

$2d = v \times t \Rightarrow 1531 \times 3.42 = 5236$ m

$d = 2618$ m $\Rightarrow 2.618$ km

36. $t = 1.02$ s, $v = 1531$ m/s

$2d = v \times t \Rightarrow 1531$ m s$^{-1} \times 1.02$ s

$2d = 1561.62$ m

$d = \dfrac{1561.62}{2} = 780.81$ m

37. $\nu = 20$ Hz, $v = 344$ m s^{-1}

$\nu = \dfrac{v}{\lambda}$; $\lambda = \dfrac{v}{\nu} \Rightarrow \dfrac{344 \text{ m s}^{-1}}{20 \text{ s}^{-1}} = 17.2$ m

$\lambda = \dfrac{344 \text{ m s}^{-1}}{20000 \text{ Hz}} = 0.0172$ m

Wavelength ranges from 0.0172 m to 17.2 m.

38. $v = 339$ m s^{-1}, $\lambda = 1.5$ cm $= \dfrac{1.5}{100}$ m, $\nu = ?$

$\nu = \dfrac{v}{\lambda} \Rightarrow \dfrac{339 \text{ m s}^{-1}}{\frac{1.5}{100}} \Rightarrow \dfrac{33900}{1.5} = 22600$ Hz

No, it will not be audible as it is more than 2000 Hz.

39. $t = 5\ s, \quad v = ?, \quad d = 3625$ m

$$2d = v \times t$$

$$2 \times 3625 = v \times 5$$

$$v = \frac{2 \times 3625}{5} = \frac{7250}{5} = 1450 \text{ m/s}$$

40. When the ruler is released, it vibrates. As it moves to the right, the ruler moves to the left, it frees up (vacates) more space for the air molecules to move further apart. This produces a region of low density (rarefaction).

41. Noise is produced by irregular vibrations and has irritating effect on our ears.
Music is produced by regular and systematic vibrations and gives a soothing and pleasant effect on our ears.

42. Tone is a sound of single frequency while note is produced by mixing sounds of several frequencies.

43. $\lambda = ?, \quad v = 1.7 \text{ km s}^{-1} = 1.7 \times 10^3 \text{ m s}^{-1}$

$$\nu = 4.2 \text{ MHz} = 4.2 \times 10^6 \text{ Hz} = 4.2$$

$$\nu = \frac{v}{\lambda} \quad \Rightarrow \quad \lambda = \frac{v}{\nu} = \frac{1.7 \times 10^3 \text{ m s}^{-1}}{4.2 \times 10^6 \text{ s}^{-1}}$$

$$= \frac{17 \times 10^{3-6}}{4.2} = 4.05 \times 10^{-3} \text{ m}$$

44. $\nu = 3$ kHz $= 3000$ Hz; $\quad \lambda = 45$ cm $= \frac{45}{100}$ m

$$v = \nu\lambda \quad \Rightarrow \quad 3000 \text{ Hz} \times \frac{45}{100} \text{ m}$$

$$= 1350 \text{ m s}^{-1}$$

$\because \quad d = 1.8$ km $\Rightarrow d = 1800$ m

$$\therefore \quad t = \frac{d}{v} = \frac{1800 \text{ m}}{1350 \text{ m s}^{-1}} = 1.33 \text{ s}$$

45. $v = 340 \text{ m s}^{-1}, \quad t = 10$s

distance $= v \times t \quad \Rightarrow \quad 340 \times 10 = 3400$ m

$d = 3.4$ km.

46. Girl is standing in the middle, 6 m on left and 6 m on right. [$\because l = b = 12$ m]

'l' is the length, 'b' is the breadth.

Sound will travel $6 + 12 = 18$ m distance.

$$\therefore \quad t = \frac{6+12}{342} = \frac{18}{342} = 0.05 \text{ s}$$

Since 't' is less than 0.1 seconds, therefore echo will be heard.

47. $t = 10$ sec.

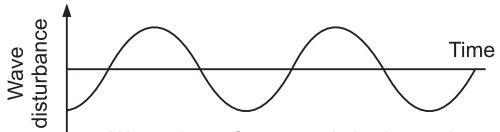
$$v = \frac{2d}{t} \Rightarrow 2d = v \times t \Rightarrow 340 \times 10 = 3400 \text{ m}$$

$$2d = 3.4 \text{ km}$$

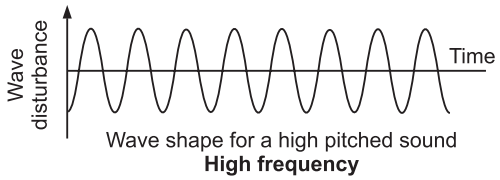
Since echo is heard when sound reaches back after reflection

$$\therefore \quad 2d = 3.4 \text{ km}; \ d = 1.7 \text{ km}$$

48. (*a*)



Wave shape for a low pitched sound
Low frequency



(*b*) (*i*) It is used to find the depth of sea.

(*ii*) It is used to find the location of ice bergs, sunken ships and submarine.

49. The position and direction of motion of distant objects such as ships, aircrafts can be detected with the help of ultrasonic sound waves.

If the beam is interrupted by a solid object, a part of the energy is reflected back to the aerial which are passed to the receiver end where these are amplified and detected.

An echo from reflection of the solid object is indicated by sudden rise in the detector output.

$\boxed{d = \frac{vt}{2}}$ where 'v' is the velocity of sound wave , 't' is time and 'd' is distance.

50. $h = 500$ m, $t = ?$, $g = 10$ m s^{-2}, $v = 340$ m s^{-1}

$$s = ut + \frac{1}{2}gt^2; \qquad 500 \text{ m} = 0 + \frac{1}{2} \times 10 \times t^2$$

$$t^2 = \frac{500 \times 2}{10} \Rightarrow 100 \text{ s}^2 ; t = 10 \text{ s}$$

This is the time taken by the stone to reach the top of water.

$s = 500$ m, $v = 340$ m s^{-1}

$$s = vt; \qquad t = \frac{s}{v} \Rightarrow \frac{500}{340} = 1.47 \text{ s}$$

Time taken by the sound to reach the top of water = 1.47 s

Total time after splash is heard = 10 + 1.47 = 11.47 s

51. **Reverberation:** It is the persistence of sound in a big hall due to repeated reflections of sound from the walls, ceiling and floor of the hall.

Methods to reduce reverberation:

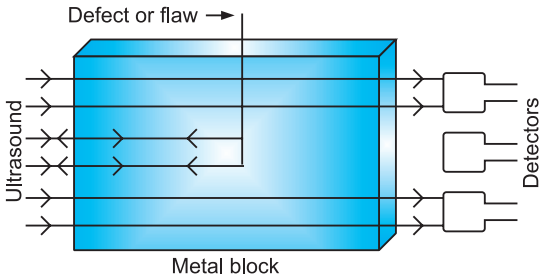
(*i*) Panels made up compressed fibre are inserted on the walls and ceiling board to absorb sound.

(*ii*) Heavy curtains are inserted on doors and windows.

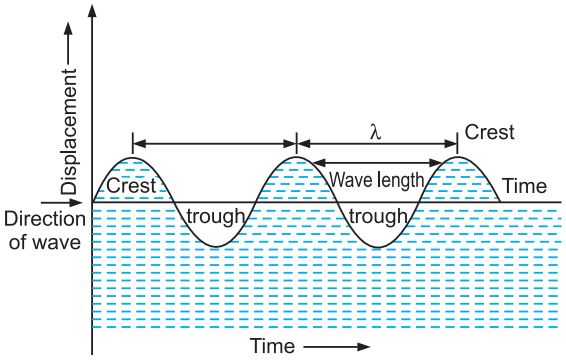
(*iii*) Carpets are put on the floor.

(*iv*) Seats are made up of sound absorbing materials.

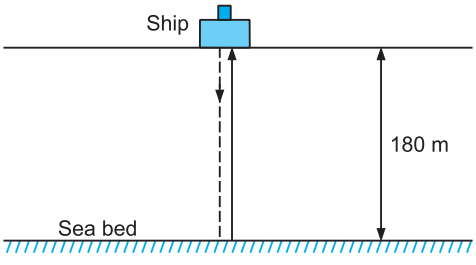
52. Metallic components are generally used in the construction of big structures like buildings, bridges, machines and also scientific equipments. The ultrasonic waves passing through the cracks or holes inside the metal blocks get reflected back indicating the presence of flaw or defect as shown below:



53. The transverse waves travelling on the surface of water is shown in the figure below. The crests, troughs are labelled in the figure.
'λ' is the wavelength, i.e. the distance between centre of two consecutive crests or troughs.



54. (*a*) Speed of sound in sea water $= \dfrac{2 \times 180\,\text{m}}{0.25\ \text{s}} = 1440\ \text{m s}^{-1}$



(*b*) The Earth and the Moon are separated by a vacuum. Since sound waves require a medium for propagation, sound waves cannot move from the Earth to the Moon.

55. $h = 78.4$ m, $\quad g = 9.8\ \text{m s}^{-2}$, $\quad u = 0$

$$h = ut + \frac{1}{2}gt^2; \qquad \text{'}h\text{' is height}$$

$$78.4 = 0 + \frac{1}{2} \times 9.8 \times t^2\ ; \qquad t^2 = \frac{78.4 \times 2}{9.8} = \frac{78.4}{4.9} = 16\ \text{s}^2$$

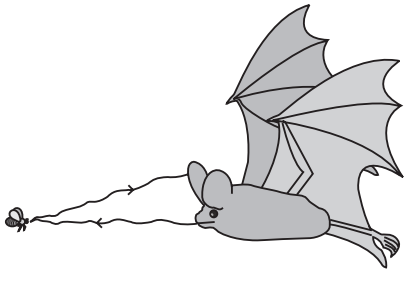
$$t = 4\ \text{s}$$

Time taken by helmet to fall = 4 s
Time taken by sound = 4.23 s – 4s = 0.23 s

$$\text{Speed of sound} = \frac{\text{Distance}}{\text{Time}} = \frac{78.4}{0.23} = 340.87\ \text{m s}^{-1}$$

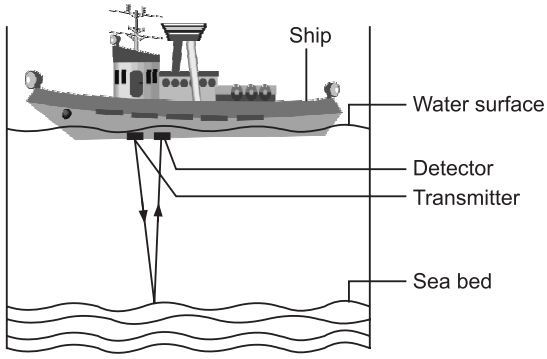
56. Bats search out their prey and fly in dark by emitting and detecting reflections of ultrasonic waves.

- The high pitched ultrasonic squeaks of bat are reflected from the prey (acts as obstacle) and returned to bat's ear as shown in the diagram:
- The nature of reflection tells the bat where the obstacle or prey is and what is it like.



57. Echo ranging technique is also called **SONAR** (Sound Navigation and Ranging)

- SONAR consists of a transmitter and a receptor or detector which is installed at the bottom of the ship.



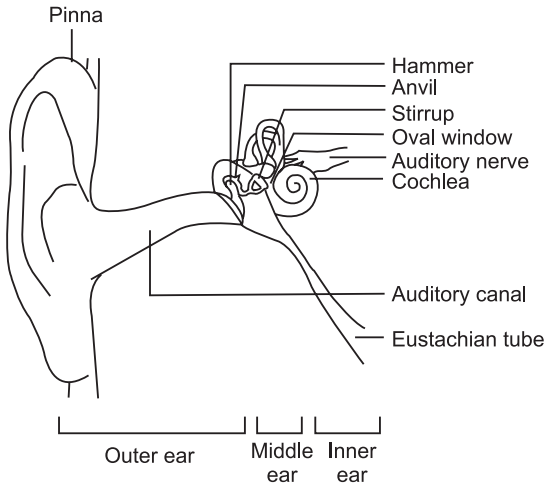
- The transmitter produces and transmits ultrasonic sound waves.
- These waves are reflected back by the under water objects which are received and converted into electric signals by the detector.
- The sonar device measures the time taken by ultrasound waves to travel from the ship to the bottom of the sea and again back to the ship.
- Half the time taken gives the time taken by ultrasound waves from ship to the bottom:

$\boxed{2d = v \times t}$ 'd' the is distance, v is the velocity of sound, t is the time. It is the used to locate the depth of sea, to locate under water hills, icebergs, sunken ships, etc.

58. Working of Human Ear

- When compression of sound waves strikes the ear drum, the pressure on the outside of ear drum increases and pushes the ear drum inwards, during rarefaction, ear drum moves outward. Thus eardrum vibrates.
- The vibrations are increased by three bones and middle ear transmits these amplified pressure vibrations received by sound waves to inner ear.
- In the inner ear, the pressure waves are converted to electrical signals by cochlea.
- These electric signals are sent to brain by auditory nerves and then brain interprets them as sound.

Pinna → Ear canal → Ear drum → Hammer → Anvil → Stirrup → Oval window → Cochlea → Auditory nerve → Brain.



Value Based Questions

1. On a hot summer afternoon a fruit vendor was selling fruits very loudly. As Amreen was preparing for her exams, she got disturbed. She inquired from her father about the instrument being used by the "fruit vendor". Father told her that it was a megaphone also known as "loudspeaker". He explained to the fruit vendor not to use megaphone near the home.

(*a*) State the principle on which the megaphone works.

(*b*) Explain its working.

(*c*) Why megaphones should not be used in residential areas? Mention the value shown by her father. **[CBSE 2016]**

2. Namita was watching 'amazing science' on television. It was shown that a sonar device attached to a ship sends ultrasonic waves in the sea. These waves are reflected from the bottom of the sea. Ultrasonic waves took four seconds to travel from the ship to the bottom of the sea and back to the ship. Namita being a student of grade IX started calculating the depth of the sea.

(*a*) Help Namita to calculate the depth of the sea if speed of the sound in sea water = 1500 m/s.

(*b*) What value of Namita's nature is depicted from this context? **[CBSE 2016]**

Answers

1. (*a*) In megaphones, sound is reflected successively to guide most of the sound waves from the source in the forward direction towards the audience.

(*b*) Megaphones have funnel tube which reflects sound waves repeatedly towards the audience Thus, amplitude of sound waves adds up to increase the loudness of sound.

(*c*) It creates lot of noise and disturb the sleep of patients, old age people. It also also interferes with the concentration of students who are studying. Her the father is concerned about the welfare of other people as well as her daughter.

2. (*a*) $t = 4$ seconds,

speed of sound, $v = 1500 \text{ m s}^{-1}$

$$v = \frac{2d}{t}$$

$$2d = v \times t = 1500 \times 4 = 6000 \text{ m}$$

$$d = 6000/2 = 3000 \text{ m}$$

(*b*) Namita has scientific aptitude and wants to explore the use of science in real life situations.

Practical Based Questions

Experiment 11: *Determination of speed of a pulse propagated through a stretched string/slinky*

Q1. What type of jerk should be given to slinky to produce a transverse wave? (Experimental Skills)

Ans. The free end is jerked at right angle to its length to produce transverse waves.

Q2. Which type of waves can be produced in a slinky? (Experimental Skills)

Ans. (*i*) Longitudinal waves (*ii*) Transverse waves

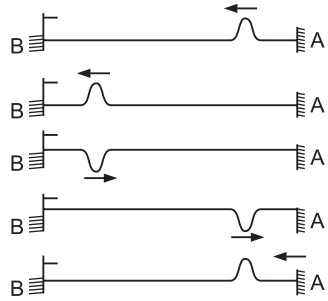
Q3. A teacher gave a metallic slinky to four students A, B, C and D, asked them to produce a longitudinal pulse. How can it be produced? Why? [*CBSE* 2012]

(Experimental Skills)

Ans. Tie one end of the slinky to a rigid support, stretched it and then compressed and released it along the length.

Reason: Longitudinal waves propagate along the length of slinky.

Q4. A student fixes two end of a rope to two rigid supports A and B placed at a distance of 7.5 m. He then gives a transverse horizontal jerk to create a pulse in the rope which moves from A to B, B to A, again from A to B and B to A.... and so on. The moment he gives jerk to the rope his friend immediately starts the stopwatch. The pulse dies after completing three to and fro journeys from A to B and back. The pulse take 1 min. and 15 seconds to complete its entire journey. The speed of the pulse moving on the rope is: (NUMERICAL SKILLS)



Ans. Speed $= \frac{\text{distance}}{\text{time}} = \frac{\text{Length} \times \text{No. of times} \times 2}{\text{Time in seconds}} = \frac{7.5\text{m} \times 3 \times 2}{75} = 0.6 \text{ m s}^{-1}$

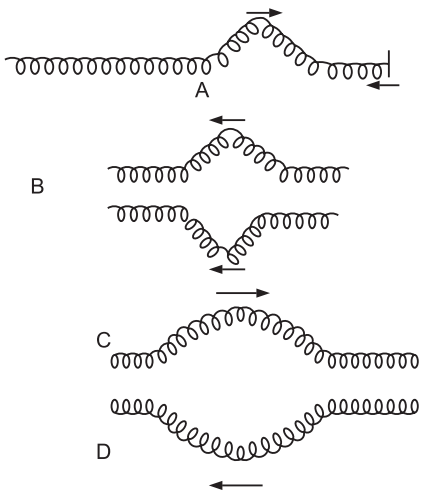
Q5. The distance between initial and final positions of a pulse is 6 m and time taken by the pulse to propagate is 0.83 seconds. Calculate the velocity of pulse? (NUMERICAL SKILLS)

Ans. $$\text{Velocity} = \frac{\text{distance}}{\text{time}} = \frac{6 \text{ m}}{0.83\ s} = 7.2 \text{ m s}^{-1}$$

Q6. Where is pulse produced and why? (CONCEPTUAL AND REASONING SKILLS)

Ans. Pulse is produced in a small part of medium. It is due to vibrations of the particles of medium, when jerk is given to a slinky.

Q7. When a pulse produced in a slinky moves through it and strikes a rigid pole or a wall as shown in the diagram, it is reflected back and the shape of the reflected pulse resembles the shape given in which of the following figure? Give reason. (REASONING SKILLS)



Ans. 'B' is the correct representation.

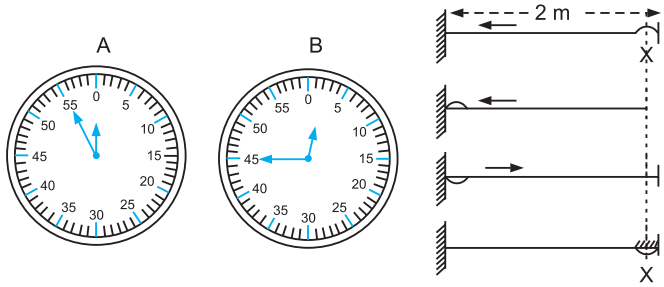
Reason: There will be equal and opposite pulse produced on reflection.

Q8. Shyamlal was calculating the velocity of wave using a slinky. He asked his teacher regarding the features of spring to be used. The teacher replied what type of the spring it should be? [*CBSE* 2011] (OBSERVATION SKILLS)

Ans. It should be long, soft and flexible and more elastic such so that velocity of sound can be calculated easily.

9. A string is stretched as shown and a 'pulse' is created along it. The stopwatch is started, from its position A, when the pulse is in position X and is stopped, in its position B, when the pulse has travelled back to its position 'X'. [*AI* 2009]

(Observation and Numerical Skills)



What will be the velocity of propagation of the pulse along the string?

Ans. Distance travelled = 2 × 2 = 4 m

Time = 12.45 – 11.55 = 50 seconds

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} = \frac{4\,\text{m}}{50} = 0.08\ \text{m s}^{-1}$$

Q10. In an experiment on determining the velocity of a pulse propagating through a stretched string, the stopwatch should be started and stopped at instant corresponding to the ones as shown in which of the following figure?

[*Foreign* 2009] (Observation and Interpretation Skills)

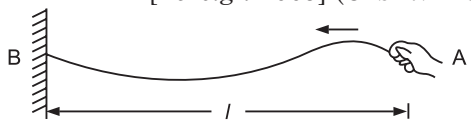


Fig. 1

Fig. 2

Fig. 3

Ans. Stopwatch should be started at the start of the wave and stopped when it hits the support as shown in Fig. 1 and Fig. 3 respectively.

Experiment 12: *To verify the laws of reflection of sound.*

Q1. Give two precautions while verifying the laws of reflection of sound. (Experimental Skills)

Ans. (*i*) The table top should be horizontal and length of pipe should be long.

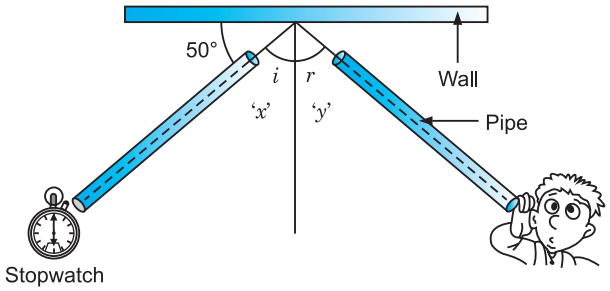
(*ii*) The reflecting surface should be smooth and hard.

(*iii*) Ear should be placed close to the pipe so that sound can be clearly heard.

Q2. What is the appropriate length of tube used for verifying the laws of reflection of sound? Where should the ear be kept to hear the reflected sound. (Experimental Skills)

Ans. The length of tubes should be about 50 cm. The ear should be placed as close as possible to hear clear sound.

Q3. For hearing the loudest ticking sound by the ear, following experimental setup is made:
(Conceptual Skills)



(*i*) Find the angles x and y in the figure above.
(*ii*) Name the phenomenon observed here.

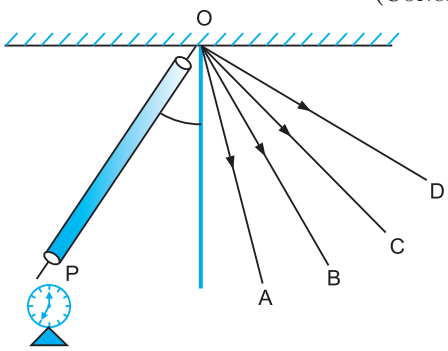
Ans. (*i*) $\angle i + 50° = 90° \quad \Rightarrow \quad \angle i = x = 40°$
$\angle r = y = 40°$
(*ii*) Reflection of sound is the phenomenon observed.

Q4. In order to hear an echo of sound wave, what should be the minimum distance between the body producing the sound and the reflecting surface? Speed of sound in air is 344 ms^{-1}.
(Conceptual and Numerical Skills)

Ans. The minimum distance should be half of the distance travelled by sound in one second. The echo is heard after a gap of 0.1 seconds.

$$\text{Distance} = \frac{1}{2} \times \text{speed} \times \text{time} = \frac{1}{2} \times 344 \times 0.1 = 17.2\,\text{m}$$

Q5. Along which of the following four directions OA, OB, OC and OD, a narrow tube be placed so that the ticking of a clock placed at P is heard the loudest after being reflected from the reflecting surface? Give reason. [*CBSE* 2012]
(Conceptual and Reasoning Skills)



Ans. OB is the direction in which loudest sound can be heard.
Reason: The angle of incidence should be equal to angle of reflection.

Q6. Can two persons hear each other's voice at moon? Justify your answer.
(Conceptual and Reasoning Skills)

Ans. No, they cannot hear each other's voice because moon does not have any atmosphere. Sound can travel only through a material medium.

Q7. Sound travels fastest in which of the following: vacuum, air, water, iron. Give reason.
(Conceptual and Reasoning Skills)

Ans. Sound will travel fastest in iron due to the high density of iron and its high elasticity as compared to air and water. Sound cannot travel through vacuum.

Q8. Ranjeet, while verifying laws of reflection of sound measured the angle between the incident sound wave and reflected sound wave to be 130°. What will be angle of incidence?
(Conceptual and Reasoning Skills)

Ans. $\angle i + \angle r = 130°$

$\angle i = \angle r$

$\therefore \quad 2\angle i = 130°$

$$\angle i = \frac{130°}{2} = 65°$$

Q9. A laboratory has the following apparatus available in it: [*CBSE* 2012]
(Identification and Experimental Skills)

A: Two thin hollow wooden tubes
B: An intense and broad source of sound
C: An intense pointed source of sound
D: A sharp pointed detector of sound
E: A well polished metal sheet
F: A white painted thermocol sheet

A student can do his experiment for verifying the laws of reflection of sound successfully by choosing which of these given apparatus?

Ans. A, C, D, E apparatus should be selected to get the best results.

Q10. What is the effect of speed of sound and density of medium on reflection of sound? If the air room warms up, what happens to the speed of sound? (Thinking Skills)

Ans. The speed of sound and density of medium does not affect but the nature of reflecting medium affects the reflection of sound. The speed of sound increases with increase in temperature.

IMPORTANT FORMULAE

1. Time period (T) $= \dfrac{1}{\text{Frequency}} = \dfrac{1}{\nu}$

2. Speed or Velocity (v) $= \dfrac{\text{Distance}}{\text{Time}} \quad \Rightarrow \quad \boxed{v = \dfrac{\lambda}{T}} \Rightarrow \boxed{v = \lambda\nu} \quad \left(\because \ \nu = \dfrac{1}{T}\right)$

3. $\nu = \dfrac{v}{\lambda}$

IMPORTANT NUMERICAL PROBLEMS

Q1. A sonar device on a submarine sends out signal and receives an echo 5 seconds later. Calculate the speed of the sound in water if the distance of the object from submarine is 3625 m.

Sol. Distance between the object and submarine = 3625 m, $t = 5$ s
Distance travelled by sound for echo = 2 × 3625 m

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \Rightarrow \frac{2 \times 3625}{5} = 1450 \text{ m s}^{-1}.$$

Q2. An echo is returned in 6 seconds. What is distance of reflecting surface from the sound?
[Speed of sound = 342 m s^{-1}]

Sol. $d = \dfrac{\text{speed} \times \text{time}}{2} \Rightarrow \dfrac{342 \text{ m s}^{-1} \times 6\text{s}}{2} = 1026 \text{ m}$

Q3. A person fires a gun standing at a distance of 55 m from a wall. If the speed of sound in air is 330 m s^{-1}, find the time for echo to be heard.

Sol. $$d = \frac{\text{speed} \times \text{time}}{2} \Rightarrow \text{time} = \frac{d \times 2}{\text{speed}} \Rightarrow \frac{55 \text{ m} \times 2}{330 \text{ m s}^{-1}} = 0.3 \text{ seconds}$$

Q4. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 m s^{-1} in a given medium.

Sol. $$\nu = \frac{c}{\lambda} \Rightarrow \lambda = \frac{c}{\nu} \Rightarrow \frac{440 \text{ m s}^{-1}}{220 \text{ s}^{-1}} = 2 \text{ m}$$

Q5. Ocean waves of time period 0.01 s have a speed of 15 m s^{-1}. Calculate the wavelength of these waves. Find the distance between the adjacent crests and troughs. **[HOTS]**

Sol. T = 0.01 s v = 15 m s^{-1}

$$v = \frac{\lambda}{T} \Rightarrow \lambda = v \times t \Rightarrow 15 \times 0.01 = 0.15 \text{ m}$$

Distance between a crest and a trough $\Rightarrow \frac{\lambda}{2} = \frac{0.15 \text{m}}{2} \Rightarrow 0.075$ m

Q6. The wavelength of vibrations produced on the surface of water is 2 cm. If wave velocity is 16 m s^{-1}, find the frequency and time period.

Sol. λ= 2 cm = 0.02 m; v = 16 m s^{-1}

$$\text{Frequency} = \frac{1}{\text{Time period}}$$

$$\nu = \frac{v}{\lambda} \Rightarrow \nu = \frac{16}{0.02} = 800 \text{ Hz.}$$

$$T = \frac{1}{\nu} = \frac{1}{800} = 0.00125 \text{ s.}$$

Q7. A sound wave has a frequency of 2 kHz and a wavelength of 45 cm. It takes 4 s to travel a certain distance. Calculate the distance it travels.

Sol. $\lambda = \frac{v}{\nu} \Rightarrow \lambda \times \nu = \frac{45}{100} \text{m} \times 2 \times 1000 \text{ Hz} = 900 \text{ m s}^{-1}$

Distance = $v \times t$ = 900 × 4 = 3600 m = 3.6 km

Q8. A person produced a sound with a siren near a cliff and heard echo after 6 seconds. Find the distance of the siren from the cliff if velocity of sound waves produced is 330 m s^{-1}.

Sol. T = 6 s d = ? v = 330 m s^{-1}

$$v = \frac{2 \times d}{T} \Rightarrow d = \frac{\nu \times T}{2} = \frac{330 \times 6}{2} = \frac{1980}{2} \Rightarrow 990 \text{ m}$$

Q9. If the sound produced by a thunder storm is heard 10 s after the lightning is seen. Calculate the approximate distance of the thunder cloud.
(Given speed of sound in air = 340 m s^{-1}) [*NCERT Exemplar Problem*]

Sol. $d = \nu \times t$ = 340 × 10 = 3400 m = 3.4 km.

Q10. The stone is dropped from a tower of 500 m height into pond of water at the base of the tower. When will be the splash heard at the top? (g = 10 m s^{-1}, speed of sound = 390 m s^{-1})

Sol. $$h = ut + \frac{1}{2}gt^2$$

$$u = 0$$

$$h = 0 + \frac{1}{2} gt^2 \Rightarrow t^2 = \frac{2h}{g} \Rightarrow t = \sqrt{\frac{2h}{g}}$$

$t_1 = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 500}{10}} = \sqrt{100}$ = 10 s is time taken by stone to reach water surface.

Time taken by the sound to reach the object

$$t_2 = \frac{h}{v} = \frac{500}{340} = 1.47 \text{ s}$$

Time at which the splash will be heard at the top = 10 s + 1.47 s = 11.47 s

COMMON ERRORS

Errors	Corrections
• Students take frequency in kHz and does not convert it in Hz.	☞ Frequency should always be taken in Hertz. (1 kHz = 1000 Hz)
• A stone is dropped in a well, 44.1 m deep. The sound of splash is heard 3.13 seconds after the stone is dropped. Calculate the velocity of sound in air. Students uses direct formula $\boxed{v = \frac{s}{t} = \frac{\text{distance}}{\text{time}}}$, which give wrong results.	☞ Use the formula $s = ut + \frac{1}{2} gt^2$ and calculate the time taken by stone to reach the water in well by taking $u = 0$, then calculate velocity = $\frac{\text{distance}}{\text{time}}$, where time = $(3.13 - t)$.
• Students write same definition of echo and reverberation.	☞ Actually the reflected sound is echo. Successive reflection of sound at surface leads to multiple echoes which leads to persistence of sound called reverberation.
• In numericals of sonar device involving echo, students take distance wrongly.	☞ Distance covered by echo is twice of the distance between object and submarines. $\boxed{v = \frac{2x}{t}}$
• Students take height of crest as wavelength and half of the width of crests as amplitude.	☞ The height of crest or trough is called amplitude of the wave whereas distance between the centre of two consecutive crests or troughs is called wavelength.

REVISION CHART

Sound

Sound is a form of energy which is produced by a vibrating object. It needs medium to travel.

Range of Hearing

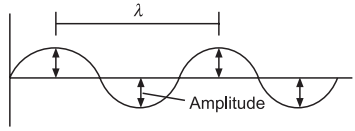
Audible Sound: Human ears can hear only between the range of 20 Hz to 20,000 Hz.

Infrasonic/Infrasound: Its range is less than 20 Hz. Whales, elephants and rhinos communicate by 5 Hz sound.

Ultrasonic/Ultrasound: Its range is more than 20,000 Hz. Travels along well defined path even in the presence of obstacles thus, used in industries and for medical purposes.

Characteristics of Sound

- Sound travels in the form of **longitudinal waves** having compressions and rarefactions.



- Distance between two consecutive compression or rarefactions is called its **wavelength**.
- Number of oscillations produced per second is called its **frequency** (Hz or kHz).
- Time to complete one oscillation is its **time period**.
- Distance travelled per unit time by the sound wave is termed as its **velocity**.

$$v = \frac{\lambda}{T} \quad \Rightarrow \quad v = \lambda\nu$$

- The maximum displacement of vibrating particles about its mean position in a sound wave is its **amplitude**.

Law of Reflection of Sound

It states that the incident wave, reflected wave and normal at the point of incidence all lie in the same plane.

Angle of reflection of sound is always equal to the angle of incidence of sound:

$$\angle i = \angle r$$

Types of Reflection

Echo: Repetition of sound waves caused by reflection of sound waves.

Reverberation: Persistence of sound in a big hall due to repeated reflections until it is reduced to a value where it is no longer audible.

Factors Affecting Sound

Medium: Sound travels faster in a denser than rarer medium. It cannot travel through vacuum.

Temperature: Speed of sound increases with increase in temperature.

Uses of Reflection of Sound

1. Conical opening of megaphones, horns, trumpets, etc. reflects sound in a particular direction.
2. Multiple reflection of sound in stethoscopes is used for listening heartbeat.
3. Curved ceiling of concert halls and cinema halls reflects sound to all corners of the hall.
4. SONAR is used to measure distance, speed and direction of underwater objects like submarines.
5. Bats uses it for finding its prey and obstacles.

Quality / Timbre of Sound

Properties of sound which enables us to distinguish between one sound from another having same **pitch** and **loudness is** quality.

- Sound of higher frequency, shorter wavelength has higher pitch.
- Higher the amplitude, more the loudness and energy.
- Tone : Sound of single frequency
- Note : Sound of mixed frequency
- Noise: Unpleasant sound of high frequency, high pitch and loudness.

Structure of Human Ear