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WAVE MOTION AND SOUND

Revision Module

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CHAPTER AT A GLANCE

1. Sound is mechanical energy which produces sensation of hearing.
2. For hearing sound there must be:
   (*i*) a vibrating body. (*ii*) a material medium for its propagation. (*iii*) a receiver, such as human ear.
3. Sound cannot travel in vacuum.
4. If the particles of the medium vibrate perpendicular to the direction of propagation of the wave, then the wave is called a transverse wave.
5. If the particles of the medium vibrate parallel to the direction of propagation of the wave, then the wave is called a longitudinal wave.
6. A longitudinal wave is one in which the disturbance is parallel to the line of travel of the wave.
7. Transverse waves can be produced in solids and liquids, but not in gases.
8. Sound travels fastest in solids, slower in liquids and slowest in gases.
9. The highest point on the hump or elevation of a transverse wave is called crest and the lowest point on the hollow or depression of a transverse wave is called trough.
10. The change in density from one maximum value to the minimum value and again to the maximum value makes one complete oscillation.
11. Compression is a region in a longitudinal wave, where the particles of the medium are crowded together.
12. Rarefaction in a region in a longitudinal wave, where the particles of medium are spread wide apart.
13. The time taken by two consecutive compressions or rarefactions to cross point is called time period.
14. **Frequency:** The number of compressions and rarefactions taken together passing through a point in one second is called frequency. Its unit is Hertz.
15. Amplitude is the magnitude of maximum displacement of a vibrating particle about its mean position.
16. The loudness of sound is determined by amplitude.
17. A conical tube used for addressing a small group of people is called megaphone.
18. The expression for the speed of a wave is $V = \nu\lambda$.
19. The audible range for a normal human is 20 Hz to 20,000 Hz.
20. Ultrasonics are the frequencies which are greater than 20,000 Hz.
21. Infrasonics are the frequencies which are lesser than 20 Hz.
22. When a shock wave passes a listener, it is heard as a loud "sonic boom".
23. An echo is the phenomenon of repetition of sound of a source by reflection from an obstacle.
24. For simple sounds to hear the echo of a sound distinctly, the reflecting surface should be at a minimum distance of 17 m from the observer. The minimum distance is not a constant because the velocity of sound changes with the change in temperature.
25. For articulate sounds the minimum distance between the source of sound and the reflecting sound should be 34 m.
26. Sound requires a medium to propagate.
27. SONAR (Sound Navigation And Ranging) is a technique for determining water depth and locating underwater objects, such as reefs, submarines, and schools of fish.

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ASSIGNMENT (In Class Discussion)

Q.1. Sound is produced by ..... object.

(*a*) moving (*b*) stationary

(*c*) vibrating (*d*) All of the above

Q.2. Which of the following statements are true?

(*a*) sound waves can propagate through solids and liquids

(*b*) sound waves can propagate through vacuum

(*c*) sound waves can propagate through gas

(*d*) Both (*a*) and (*c*)

Q.3. The distance between two consecutive compressions or two consecutive rarefactions is called the:

(*a*) amplitude (*b*) wavelength

(*c*) frequency (*d*) time period

Q.4. If 20 waves are produced per second, what is the frequency in Hertz?

(*a*) 20 Hz (*b*) 40 Hz

(*c*) 10 Hz (*d*) 60 Hz

Q.5. A baby recognises her mother's sound by her voice. Name the characteristics of sound involved.

(*a*) loudness (*b*) pitch

(*c*) shrillness (*d*) timbre

Q.6. Explain how sound waves are propagated.

Q.7. Define:

(*a*) Longitudinal wave (*b*) Transverse wave

Q.8. 20 vibrations are produced in a slinky in 10 sec. when a jerk is given to it. Find its time period and frequency.

Q.9. Briefly explain what do you mean by loudness of sound.

Q.10. If the wavelength of a sound of frequency 700 Hz is 0.5 m. Find the velocity of sound.

Q.11. Derive the formula for speed of sound.

Q.12. When a stone is thrown into a pond what type of waves are produced? Draw its displacement – time graph. Label crest, trough and wavelength on the graph.

Q.13. Briefly explain with an experiment that sound requires a material medium for propagation.

Q.14. A person fires a gun standing at a distance of 55 m from a wall. If the speed of sound is 330 m/s , find the time for an echo to be heard.

Q.15. Does sound follow the same laws of reflection as light does? Explain.

Q.16. The rolling of thunder is due to the ..... of the sound from a number of reflecting surfaces, such as the clouds and the land.

(*a*) reflection (*b*) successive reflection

(*c*) refraction (*d*) None of these

Q.17. Which kind of sound is produced in an Earthquake before the main shock wave begins?

(*a*) Ultrasound (*b*) Infrasound

(*c*) Audible sound (*d*) None of the above

Q.18. Ultrasound is also useful for:

(*i*) detecting fault in metal sheets

(*ii*) imaging marine depths

(*iii*) looking for metals beneath the earth's surface

(*iv*) detecting distances

(*v*) detecting earthquakes

(*a*) (*ii*), (*iii*), (*v*) (*b*) (*i*), (*iv*), (*v*)

(*c*) (*i*), (*ii*), (*iv*) (*d*) (*ii*), (*iii*)

Q.19. Name the part in human ear's which helps in converting pressure vibrations into electrical signals.

(*a*) Cochlea (*b*) Tympanic membrane

(*c*) Auditory canal (*d*) Hammer

Q.20. The vibrations are amplified several times in the middle ear to the bones known as:

(*a*) Anvil (*b*) Stirrup

(*c*) Hammer (*d*) All of the above

Q.21. What is reverberation? How can it be reduced?

Q.22. How does multiple reflection of sound come into play in a conference hall?

Q.23. What property of sound waves acts like the principle of ultrasound?

Q.24. How does a hearing aid work?

Q.25. Sound creates vibrations in our ear. We listen to the sound and understand it. But after this in which form of energy does it get converted into?

Q.26. Depending on the range of hearing, how can sound waves be classified?

Q.27. A ship sends ultrasound that returns from the seabed and is detected after 3.42 s. If the speed of the ultrasound through seawater is 1531 ms^{-1}, then the distance of the seabed from the ship would be?

Q.28. Explain how bats use ultrasound to catch a prey.

Q.29. Explain how defects in a metal block can be detected using ultrasound.

Q.30. Explain how the human ear works.

ASSERTIONS AND REASONING TYPE QUESTIONS (Self-Practice)

Directions: *In the following questions, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

(a) Both (A) and (R) are true and (R) is correct explanation of the assertion.

(b) Both (A) and (R) are true but (R) is not the correct explanation of the assertion.

(c) (A) is true but (R) is false.

(d) (A) is false but (R) is true.

Q.1. **Assertion (A):** A piece of paper place on the surface of water moves up and down when a wave is generated in water.
Reason (R): Waves carry energy and not matter.

Q.2. **Assertion (A):** Sound produces by different sources travel with different speed in air.
Reason (R): The velocity of sound is given by $V = \nu\lambda$.

Q.3. **Assertion (A):** When two persons talk on the moon they cannot hear each other.
Reason (R): Sound requires a material medium to propagate.

Q.4. **Assertion (A):** A sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value where it is no longer audible.
Reason (R): Sound undergoes reflection.

Q.5. **Assertion (A):** A human being cannot hear sound having frequencies lower than 20 Hz.
Reason (R): The audible limit for a normal human being is 20 Hz to 20 kHz.

QUESTION BANK

Short Answer Type Questions (3 Marks)

Q.1. Two astronauts cannot hear each other on the moon. Why?

Q.2. Bats have no eyes still they can ascertain distances, directions, nature and size of the objects. Explain, why.

Q.3. State three factors on which the speed of sound in a medium depends.

Q.4. (*i*) Define the time period of a wave.
(*ii*) Give the relation among speed of sound V, wavelength λ and its frequency.

Q.5. (*a*) Illustrate the use of Stethoscope.
(*b*) What are infrasonic and ultrasonic sound waves?

Q.6. (*a*) What type of wave is represented by density-distance graph?
(*b*) What is meant by transverse wave? Give an example.

Q.7. (*a*) What are the basic factors on which the speed of sound in a medium depends?
(*b*) Why sound waves are called mechanical waves?
(*c*) How will you differentiate a high pitch sound from a low pitch sound with the help of a graph?

Q.8. Give reasons for the following:
(*a*) The reverberation time of a hall used for speeches should be very short.
(*b*) A vibrating body produces sound. However, no sound is heard when a simple pendulum oscillates in air.
(*c*) Sounds of same loudness and pitch but produced by different musical instruments like a violin and flute are distinguishable.

Q.9. A person fires a gun standing at a distance of 55 m from a wall. If the speed of sound is 330 m s^{-1}, find the time for an echo to be heard.

Q.10. What is Galton's whistle? To what use it can be put?

Q.11. A continuous disturbance is created on the surface of water in a ripple tank with a small piece of cork floating on it. Describe the motion of cork. What does it tell about the disturbance?

Q.12. State three conditions necessary for sound to be heard.

Q.13. Give four practical uses of ultrasonic vibrations.

Q.14. Why the astronauts talk to each other through radio telephone?

Q.15. (*a*) Why the stage of an auditorium has curved background, curtains, carpets and false ceiling?
(*b*) The sound of a ringing bell inside a vacuum chamber cannot be heard. Why?

Q.16. (*i*) Even if a loud explosion were to take place at any place on the moon, it would not be heard at a nearby point. Give reason.
(*ii*) Explain in brief the dependence of speed of sound on nature of material medium and temperature.
(*iii*) Identify the two factors on which the loudness of sound depends.

Q.17. (*i*) How the bats make use of ultrasonic waves to catch their prey? Explain.
(*ii*) A radar signal is reflected by an aeroplane and is received 2×10^{-5} s after it was sent. If the speed of these waves is 3×10^{8} m s^{-1}, how far is the aeroplane?

Q.18. (*i*) What does the acronym SONAR stand for?
(*ii*) What is the audible range of sound for human beings?
(*iii*) How do the bats search and catch their prey in dark night?

Q.19. (*i*) What causes reverberation of Thunder sound?

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

Q.20. Define frequency, amplitude and speed of a sound wave.

Q.21. Define echo. Establish a mathematical relation between speed of sound, distance of reflecting body from source of sound and time for echo.

Q.22. (*a*) A boy strikes one end of a long pipe with a stone. Another boy who keeps his ear close to the other end of pipe heard two sounds in a short interval of time. Explain, why.

(*b*) List two uses of ultrasonics.

Q.23. (*a*) What is audible range of the average human ear?

(*b*) Explain how ultrasound is used to clean spiral tubes and electronic components.

Q.24. (*a*) A mobile ringing inside a vacuum chamber cannot be heard outside. Why?

(*b*) Represent transverse wave graphically.

(*c*) What is meant by loudness of sound? On what factor does it depend?

Q.25. (*a*) Why are sound waves called mechanical waves? List two practical applications of reflection of these waves.

(*b*) A stone is dropped from the top of a tower 125 m high into a pond of water at the base of the tower. When is the splash heard at the top? ($g = 10\ m\ s^{-2}$ and speed of sound = $340\ m\ s^{-1}$).

Q.26. What is a SONAR? For what it is used? Explain in brief its working.

Q.27. Define the following characteristics of sound:

(*a*) (*i*) Pitch (*ii*) Loudness (*iii*) Quality or Timbre

(*b*) A boy receives his echo 3 s later. Find the distance of the reflecting surface from the boy. Speed of sound in air is $342\ m\ s^{-1}$.

Q.28. What is an echo? When can we distinctly hear the echo of a sharp sound? Why cannot we hear an echo in a small halls?

Q29. (*a*) What is the cause of sensation of sound due to rolling of thunder?

(*b*) Give the audible range of human ear.

(*c*) What are infrasonic and ultrasonic waves?

Q.30. "A sound wave with frequency higher than 20 kHz is not audible for human ear". Answer the following in respect of this statement:

(*i*) What is the term used for such a sound?

(*ii*) Name two organisms producing sound in this range.

(*iii*) Write an application of such a wave.

Q.31. Draw the sound waves for a low pitched and the high pitched sound. Write one use of ultrasonography. Which wave property determines pitch?

Q.32. How does the sound produced by a musical instrument, reach your ears? Astronauts need radio transmitter to talk to each other on moon. Why?

Long Answer Type Questions (5 Marks)

Q.1. Explain with the help of a diagram, how defects in a metal block can be detected using ultrasound.

Q.2. (*a*) Briefly mention three uses of ultrasound in the field of medicine.

(*b*) A ship which is stationary is at a distance of 2800 m from the sea-bed. The ship sends an ultrasound signal to the sea-bed and its echo is heard after 4 s. Find the speed of sound in water.

Q.3. Answer the following:

(*i*) Can transverse waves travel in gases?

(*ii*) Can longitudinal waves travel in solid, liquid as well as gas?

(*iii*) At any instant a compression is formed at a point. After how much time (*a*) a rarefaction (*b*) a compression will be formed at the same point?

Q.4. State four differences between longitudinal and transverse waves. Give an example of each.

Q.5. (*a*) Mention two practical applications of reflection of sound waves.

(*b*) How is the pressure variation in a sound wave amplified in human ear?

(*c*) In a ripple tank, ten ripples are produced per second. If the distance between a trough and a neighbouring crest is 12 cm, calculate the frequency, wavelength and velocity of the wave.

Q.6. (*a*) What is meant by intensity of sound?

(*b*) Mention the conditions for an echo to be heard clearly.

(*c*) A ball is dropped into a pond from a height of 44.1 m. The splash of sound is heard 3.13 second after the ball is dropped. Determine the velocity of sound in air.

Q.7. Draw a labelled diagram of auditory parts of human ear and explain how the human ear works.

Q.8. Define the following terms and state their SI units: (*a*) Wavelength (*b*) Time period (*c*) Amplitude. Establish the relation $V = \nu\lambda$, where the symbols have their usual meanings.

Q.9. (*a*) How the sound propagated through the medium?

(*b*) Show a sound wave in graphic form and mention crest, trough, wavelength and amplitude of the wave in it.

(*c*) Why the sound waves are called longitudinal waves?

Q.10. (*i*) Which property of sound wave determines:

(*a*) loudness

(*b*) pitch?

(*ii*) A SONAR station picks up a return signal after 3 seconds. How far away is the object? (Speed of sound in water is 1440 m s^{-1})

(*iii*) How can reverberations in a big hall or auditorium be reduced?

Q.11. (*a*) Write two points of difference between sound wave and light wave.

(*b*) Write an expression relating wave velocity, wavelength and frequency if speed of sound in air is 340 m s^{-1}. Calculate:

(*i*) Wavelength when frequency = 256 Hz.

(*ii*) Frequency when wavelength = 0.85 m.

Q.12. (*a*) What is reverberation? Write two ways of reducing reverberation.

(*b*) Distinguish between tone and note.

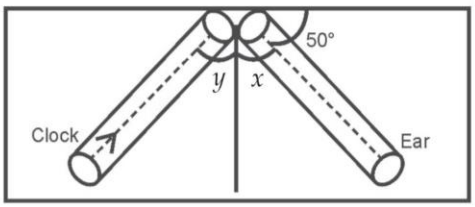
(*c*) With the help of a simple diagram, explain how defects in a metal block can be detected using ultrasound.

Q.13. For hearing the loudest ticking sound by the ear.

(*a*) Find the angles x and y in the figure.

(*b*) Name the phenomenon observed here.

(*c*) State the laws of the phenomenon.



Q.14. (*a*) A particular transmitter of Aakashvani broadcasts at 420.5 m wavelength. Given the speed of radio waves 3×10^8 m s^{-1}. Calculate the frequency at which the radio station broadcasts its programme.

(*b*) What is the direction of oscillations of the medium particles through which a:

(*i*) transverse wave is propagating?

(*ii*) longitudinal wave is propagating?

APPLICATION BASED QUESTIONS (Self-Practice)

Q.1. The rear view mirror of motor bike starts vibrating violently at some particular speed of motor bike.

(*a*) Why does this happen?

(*b*) What is the name of the phenomenon taking place?

(*c*) What could be done to stop the violent vibration?

Q.2. A vibrating tuning fork is placed over the mouth of a burette filled with water. The tap is opened and the water level gradually falls. It is observed that the sound becomes the loudest for particular length of air column:

(*i*) What is the name of the phenomenon taking place when this happens?

(*ii*) Why does the sound become the loudest?

(*iii*) How does the frequency of the loud sound compare with that of the tuning fork?

(*iv*) State the unit for measuring loudness.

Q.3. Two friends were playing on identical guitars whose strings were adjusted to give notes of the same pitch. Will the quality of the two notes be the same? Give a reason for your answer.

Q.4. The stem of a tuning fork is pressed against a table top. Answer the following questions:

(*i*) Would the above action produce any audible sound?

(*ii*) Does the above action cause the table to set into vibrations?

(*iii*) If the answer above is yes, what type of vibrations are they?

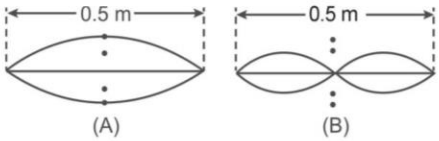
(*iv*) Under what conditions does the above action lead to resonance?

ANALYZING, EVALUATING & CREATING TYPE QUESTIONS (Self-Practice)

Q.1. How do you account for the fact that two strings can be used to give notes of the same pitch and loudness but of different quality?

Q.2. The stem of a tuning fork is pressed against a table top. Answer the following questions: (*i*) Would the above action produce any audible sound? (*ii*) Does the above action cause the table to set into vibrations? (*iii*) If the answer above is yes, what type of vibrations are they? (*iv*) Under what conditions does the above action lead to resonance?

Q.3. A stretched wire 0.5 m long is made to vibrate in two different modes as shown in diagram (A) and (B) given below: (*i*) If the wavelength of the wave produced in mode (A) is 1 m, what is the wavelength of the wave produced in mode (B) of the following diagram? (*ii*) In which case is the note produced louder? Give a reason for your answer. (*iii*) In which case is the pitch of the note produced higher? Give a reason for your answer.

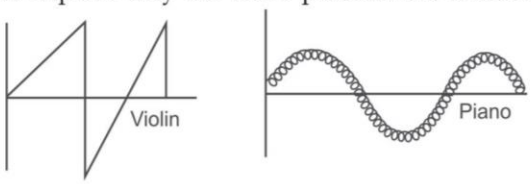


Q.4. State any two characteristics of a wave motion.

Q.5. If the amplitude of a wave is doubled, what will be the effect on its loudness?

Q.6. How do the frequency and amplitudes affect a musical sound?

Q.7. Two musical notes of same pitch and loudness are played on a violin and a piano. The waveforms are as shown in figures below. Explain why the wave patterns are different.



Q.8. Name the subjective property of sound related to its frequency and of light related to its wavelength.

Q.9. Two friends were playing on identical guitars whose strings were adjusted to give notes of the same pitch. Will the quality of the two notes be the same? Give a reason for your answer.

Q.10. Give one example each of natural vibration, forced vibration and resonance.

Q.11. Mention one practical use of echoes.

Q.12. How does a stretched string on being set into vibration, produce the audible sound?

Q.13. Will the sound be audible if the string is set into vibration on the surface of the moon? Give reason for your answer.

Q.14. What change, if any, would you accept in the characteristics of musical sound when we increase:

(*i*) its frequency and

(*ii*) its amplitude?

Q.15. Sound made in front of a tall building 18 m away is repeated. Name the phenomenon and briefly explain it.

CHAPTER TEST (Self-Practice)

Time: 1½ Hour **Maximum Marks: 50**

PART A: Give Short Answers:

Q.1. What is an echo?
Q.2. What is reverberation?
Q.3. What is SONAR?
Q.4. Sound is produced by a vibrating source. Why then a vibrating pendulum does not produce any sound?
Q.5. What is the audible range for a normal human being?

PART B: Give Reasons for the Following:

Q.6. Why sound waves are called mechanical waves?
Q.7. Why are ceilings of concert halls curved?
Q.8. Why sound wave is called a longitudinal wave?
Q.9. Why echoes can't be heard in a small room?
Q.10. Why echoes in long gallery and big halls can be heard?

PART C: Differentiate Between the Following:

Q.11. Transverse waves and longitudinal waves.
Q.12. Crest and trough.
Q.13. Infrasonic vibrations and ultrasonic vibrations.
Q.14. Compression and rarefaction.
Q.15. Loudness and intensity of sound.

PART D: Give Answers in Detail:

Q.16. With the help of a labelled diagram, explain the working of the human ear.
Q.17. Illustrate with the help of an experiment that sound requires a medium to propagate.

PART E: Numerical Problems:

Q.18. A sound wave of length 70 cm travels 840 m in 25 seconds. What is the velocity and frequency of sound?
Q.19. An echo is heard after 0.8 seconds, when a person fires a cracker 132.8 m from a high building. Calculate the speed of sound.
Q.20. A source of wave produces, 40 crests, and 40 troughs in 0.4 seconds. Find the frequency of the wave.
Q.21. Why an echo is not heard when distance between source of sound and reflecting body is 10 m?
Q.22. The distance between the crest and trough of a transverse wave is 15 cm, what is the velocity of the wave if its frequency is 1000 Hz?

PART F: Observation Based Questions:

Q.23. Two astronauts cannot hear each other on the moon. Why?
Q.24. Sometimes our dog begins to bark without any reason. Can you explain, why?
Q.25. In which case is the speed of sound more; the humming of a bee or the roaring of a lion?
Q.26. When is the velocity of sound more; during winters or during summers?
Q.27. Can elephants hear frequencies less than 20 Hz?

Solution

CHAPTER 05 SOUND

ASSERTIONS AND REASONING TYPE QUESTIONS (Self-Practice)

1. (*a*) **2.** (*d*) **3.** (*a*) **4.** (*a*) **5.** (*a*)

QUESTION BANK

Short Answer Type Questions (3 Marks)

1. Material medium is necessary for the propagation of sound. On the moon, there is vacuum, *i.e.*, no air, therefore, sound cannot propagate on the moon. Thus, the astronauts cannot hear each other.

2. Bats have special types of wings. When they fly they produce ultrasonic waves. These waves are received by the ears of bat after they have been reflected by the object. The ears of the bat are so sensitive and trained that they not only get information of distance of the obstacle but also that of the nature of the reflecting surface.

3. The three factors are:

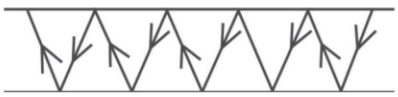
(*i*) Density of the medium (*ii*) Elasticity of the medium and

(*iii*) Temperature of the medium in kelvin.

4. (*i*) The time taken by two consecutive compressions or rarefactions to cross a fixed point is called the time period of a wave.

(*ii*) Speed of sound (V) = Wavelength (λ) × Frequency (ν) or $V = \lambda\nu$.

5. (*a*) The sound of a patient's heartbeat reaches the doctor's ears by multiple reflection of sound. This is shown in the figure.



(*b*) Infrasonics are the sounds having frequencies below 20 kHz.

Ultrasonics are the sounds having frequencies above 20 kHz.

6. (*a*) Longitudinal wave.

(*b*) It is a wave in which the particles of the medium vibrate perpendicular to the direction of propagation of the wave, *e.g.*, waves produced in vibrating strings.

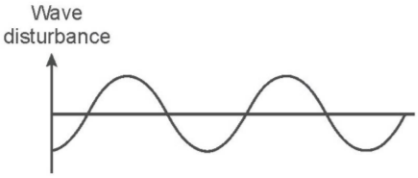
7. (*a*) The speed of sound in a medium depends upon:

(*i*) Elasticity of the medium

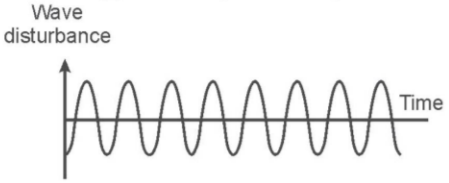
(*ii*) Density of the medium

(*b*) Sound waves are called mechanical waves because they are produced by the actual motion of the particles about their mean position.

(*c*) Pitch of sound depends upon frequency. Figs. (*a*) and (*b*) represent a low pitch and a high pitch sound respectively.



(*a*) Wave shape for a low pitched sound.



(*b*) Wave shape for a high pitched sound.

8. (*a*) The reverberation time of a speech should the small so that we are able to listen clearly the speech. If the reverberation time is large, the effect of speech heard will be lost for a longer time and new words will not be understood clearly.

   (*b*) To be heard a sound must have a minimum frequency of 20 Hz and a maximum frequency 20 kHz. The frequency of simple pendulum is less than 20 Hz and is hence not audible.

   (*c*) It is the quality of sound which enables us to distinguish between two sounds of same loudness and pitch.

9. Given $D = 55$ m, $V = 330$ m s^{-1}, $t = ?$

   $2D = V \times t$

   or $t = 2D/V = 2 \times 55 / 330 = 0.3$ s

10. It is a special kind of whistle which emits ultrasonic waves between 20,000 Hz and 40,000 Hz. These vibrations are not audible to human beings, but can easily be perceived by the dogs. Thus, dogs can be given special training to hear the sound from Galton's whistle. It is very useful, if an intruder enters someone's place. The whistle can be blown, which will alert the dog who may pounce on the unaware intruder.

11. The cork will move up and down at the same place while the waves will travel outwards from the point of disturbance. Thus, the cork is not carried away by the waves. The motion of the cork tells us that particles of medium are vibrating at right angles to the direction of wave propagation. It also tells us that in a wave there is a propagation of energy and not matter.

12. (*i*) There must be a vibrating body which should be capable of transferring its energy to its surroundings.

    (*ii*) There must be a material medium to pick up energy and then propagate it in forward direction.

    (*iii*) There must be a receiver, so as to receive the sound vibration and then transmit it to the brain for final interpretation.

13. (*i*) They are used for dissipating fog on runways at airports.

    (*ii*) They are used for making dish washing machines.

    (*iii*) They are used for homogenising milk.

    (*iv*) They are used for welding metals like tungsten.

14. The moon or the space has no air. Since sound waves require a material medium to propagate, therefore, astronauts cannot talk to each other on the moon. Therefore, they use radio waves which are electromagnetic waves. These waves do not require any material medium for propagation and hence can be picked by the radio receiver.

15. (*a*) The curved surface is used to spread the sound in all directions. The curtains, carpets and the false ceiling are used to prevent echo from occurring in the auditorium.

    (*b*) This is because sound requires a medium to propagate.

16. (*i*) Sound cannot travel through vacuum. Since Moon has no atmosphere. Hence, one can hardly hear the sound of loud explosion on the Moon.

    (*ii*) For different media, the speed of sound is different. Speed of sound is maximum in solids and lowest in gases. Speed of sound increases with increase in temperature.

    (*iii*) Loudness of sound depends upon amplitude, nature of listener.

17. (*i*) Bats can hear the ultrasonic waves and use these waves to navigate and detect insects in the flight. A bat sends out a wave and listens for the waves that are reflected by insect's body.

    (*ii*) Given, speed of radio waves = 3×10^8 m s^{-1}

    Total time taken to reach and come back from the aeroplane = 2×10^{-5} s

    Therefore, time taken to reach the aeroplane = $2 \times 10^{-5}/2 = 1 \times 10^{-5}$ s

    Distance of aeroplane = Speed of radio waves × time = $3 \times 10^8 \times 1 \times 10^{-5} = 3000$ m = 3 km

18. (*i*) Sound Navigation And Ranging.

    (*ii*) 20 Hz to 20,000 Hz.

(*iii*) The high-pitched ultrasonic squeaks of the bat are reflected from the obstacles or prey and returned to the bat's ear. Such reflections inform the bat where the prey is and what it is like.

19. (*i*) It is due to the successive and multiple reflections of the sound from a number of reflecting surfaces, such as the clouds and the land.

(*ii*) Given,

The distance of the object from the submarine = 3625 m

Distance travelled by the signs = 2 × 3625 m

Time taken in sending out the signal and to receive back = 5 s

Speed = Distance/Time = (2 × 3625)/5 =1450 m s^{-1}

20. **Frequency:** It is defined as the number of oscillations per unit time.

Amplitude: It is the magnitude of the maximum disturbance in the medium on either side of the mean position.

Speed: It is defined as the distance which a point on a wave, such as compression or a rarefaction travels per unit time.

21. The phenomenon due to which repetition of sound is heard after reflection from a distant object, after the original sound from a given source dies out is called an echo.

Let '*t*' be the time after which an echo is heard, '*d*' is the distance between the source of sound and reflecting body and 'V' is the speed of sound.

Then in time *t*, distance travelled by sound = 2*d*

Hence, in one second distance travelled by sound = 2*d*/*t*.

But distance travelled by sound in one second = Speed of sound (V)

Therefore, V = 2*d*/*t*

or *d* = V× *t*/2

22. (*a*) When a boy strikes an iron pipe, sound is produced. The produced sound wave travels through air and through the pipe. Since speed of sound in iron is greater than the speed of sound in air, so the sound travels faster through iron pipe than through air. Therefore, another boy at the end of the pipe hears two sounds one which travelled through iron pipe and the other which travelled through air.

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

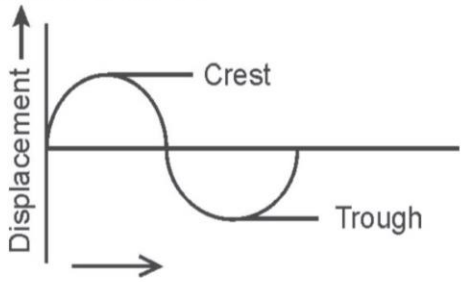
(*ii*) Ultrasonic waves are used for diagnosing diseases in human body.

23. (*a*) 20 Hz to 20,000 Hz.

(*b*) Spiral tubes and electronic components to be cleaned are placed in cleaning solution and ultrasound waves are sent into the solution, due to high frequency, the particles of the dust etc. get detached and drop out. This cleans the electronic components.

24. (*a*) This is because sound requires a medium to travel.

(*b*) The graphical representation is as shown:



(*c*) Loudness is the measure of the response of the ear to the intensity of sound. It depends on the amplitude of the vibrating particle of the medium.

25. (*a*) Sound waves are called mechanical waves because they are produced by the actual motion of the particles of a medium about their mean position.

The two practical applications of the reflection of sound are:

(*i*) In megaphones, to send sound waves in a particular direction.

(*ii*) In stethoscope, to listen to the heartbeats of a patient.

(*b*) Here, S = 125 m, g = 10 m s^{-2}, $u = 0$, $t = t_1$

Time taken by the stone to fall on the top of the pond.

Now, $S = ut + \frac{1}{2} gt^2$

$125 = 0 + \frac{1}{2} \times 10 \times t_1^2$

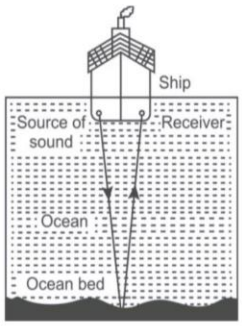
or $t_1 = 5$ s

Time taken by sound to travel from the top of the pond to the ear

$t_2 = S/V = 125/340 = 0.37$ s

Hence, total time = 5 + 0.37 = 5.37 s

26. A sonar which stands for Sound Navigation and Ranging is a technique used for determining the depth and also locating underwater objects such as reefs, submarines etc.



In this method, to find the depth of ocean, a strong ultrasonic wave is sent from the ship towards the bottom of the ocean. This ultrasonic is received back after it is reflected from the bottom of sea. The time interval t for travel of sound waves from the source to the receiver after reflection is noted.

Then the depth d of ocean is given by the velocity of $D = V \times t/2$, where V is the velocity of sound.

27. (*a*) **(*i*) Pitch:** It is that characteristic of sound which helps to distinguish between a shrill and a hoarse sound. Pitch of a sound is the sensation which depends upon frequency.

(*ii*) Loudness: It is the characteristic of sound which helps to distinguish between a loud sound and a faint sound. A loud sound has a large energy associated with it.

(*iii*) Quality or Timbre: It is the characteristic of a sound which helps us to trace source, *i.e.*, whether it is from Tabla or Guitar. It is this characteristic of sound by which we can recognise a friend only from his voice.

(*b*) Here, v = 342 m s^{-1}, t = 3 s, d = ?

We know that $d = Vt/2 = 342 \times 3/2 = 513$ m

28. An echo is the phenomenon of repetition of sound of a source by reflection from an obstacle. For hearing an echo, the obstacle must be situated at a suitable distance from the source. Due to persistence of hearing the sound must take at least $1/10^{th}$ of a second in reaching the listener. If d is the minimum distance of the reflecting object from the source, then time t taken to cover the distance $2d$ must be $1/10^{th}$ second.

Therefore, $t = 2d/V$ or $d = V \times t/2 = 340 \times 1/20 = 17$ m.

Echoes are not heard in a small room because the distance is less than the minimum distance of 17 m required for hearing the echo distinctly.

29. (*a*) The rolling of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as the clouds and the land.

(*b*) 20 Hz to 20,000 Hz.

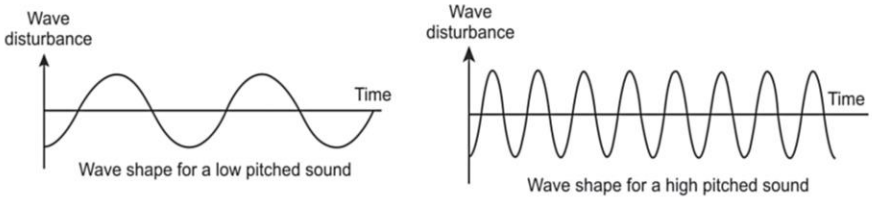
(*c*) Frequencies less than 20 Hz are called infrasonics and those greater than 20 kHz are called ultrasonics.

30. (*i*) Ultrasound.

(*ii*) Dolphins, bats.

(*iii*) Ultrasound scanning.

31. (*a*) The diagram is as shown:



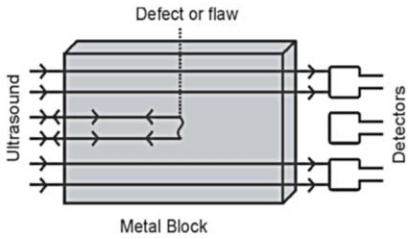
(*b*) Ultrasonography is used for examination of the foetus during pregnancy to detect congenital defects and growth abnormalities.

(*c*) Frequency.

32. The sound produced by the musical instrument makes the molecules of air vibrate. These vibrations are carried forward by the other molecules till they reach our ear. These then vibrate our eardrum to produce sound. Since sound requires a medium to propagate, therefore, sound cannot travel between astronauts on the moon, hence they use radio transmitters.

Long Answer Type Questions (5 Marks)

1. Ultrasounds can be used to detect cracks and flaws in metal blocks. Metallic components are generally used in construction of big structures like buildings, bridges, machines and also scientific equipment. The cracks or holes inside the metal blocks, which are invisible from outside reduces the strength of the structure. Ultrasonic waves are allowed to pass through the metal block and detectors are used to detect the transmitted waves. If there is even a small defect, the ultrasound gets reflected back indicating the presence of the flaw or defect, as shown in Fig.



2. (*a*) (*i*) Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called echocardiography.

(*ii*) Ultrasound scanner is an instrument which uses ultrasonic waves for getting images of internal organs of the human body. A doctor may image the patient's organs such as the liver, gall bladder, uterus, kidney, etc. It helps the doctor to detect abnormalities, such as stones in the gall bladder and kidney or tumours in different organs.

(*iii*) Ultrasonography is also used for examination of the foetus during pregnancy to detect congenial defects and growth abnormalities.

(*iv*) Ultrasound may be employed to break small 'stones' formed in the kidneys into fine grains. These grains later get flushed out with urine.

(*b*) Given: S = 2800 m, t = 4 s, V = ?

Using $S = \frac{V \times t}{2}$, we have

$$V = \frac{2S}{t} = \frac{2 \times 2800}{4} = 1400 \text{ m s}^{-1}$$

3. (*i*) No (*ii*) Yes

(*iii*) If T is the period of the wave, then:

(*a*) after time interval T/2, the point will have a rarefaction

(*b*) and after time T, the point will have a compression.

4.

Longitudinal waves	Transverse waves
1. The particles of medium vibrate in the same direction. 2. They are possible in all kinds of media.	1. The particles move at right angles to the direction of wave propagation. 2. They are possible only in solids.

3. They consist of regions of compression and rarefaction.	3. They consist of crests and troughs.
4. They cannot be polarised.	4. They can be polarised.
5. Sound waves in air is an example of longitudinal waves.	5. Vibrations in a string is an example of transverse waves.

5. (*a*) Megaphone, stethoscope.

(*b*) The pressure variation in the human ear is amplified by three bones anvil, hammer, stirrup.

(*c*) Frequency = 10 Hertz.

Distance between adjacent crest and trough = 12 cm.

Wavelength = Distance between adjacent crests = 12 + 12 = 24 cm.

Velocity = Wavelength × Frequency

$= 24 \times 10 = 240 \text{ cm s}^{-1}$.

6. (*a*) The amount of sound energy passing each second through unit area.

(*b*) (*i*) Time interval between the original sound and the reflected sound must be 0.1 s.

(*ii*) The minimum distance of obstacle from the source sound must be 17 m.

(*c*) Given, $h = 44.1$ m, $u = 0$, $g = 9.8 \text{ m s}^{-2}$

Using the equation $S = ut + \frac{1}{2} at^2$, we have

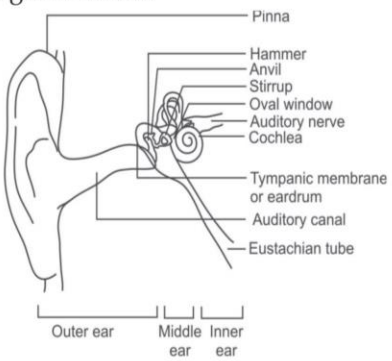
$$t^2 = \frac{44.1 \times 2}{9.8} = \frac{44.1}{4.9} = 9$$

or $t = 3$ second

Time taken by sound to reach height = 3.13 – 3 = 0.13 s

Hence, $V = d/t = 44.1/0.13 = 339.2 \text{ m s}^{-1}$

7. A labelled diagram of the ear is given below:



As is seen from the figure, the ear consists of three main parts namely (*i*) outer ear (*ii*) middle ear (*iii*) inner ear.

When sound enters the outer ear, it is directed to the eardrum along the auditory canal. The eardrum is a membrane which starts vibrating. The vibrations are transmitted through the middle ear through a set of connected bones. It is in the middle ear that the wave pressure is amplified. The amplified pressure wave enters the inner ear which includes semicircular canals and cochlea. It is in the cochlea that sound waves are translated into nerve impulses and the pitch or frequency discrimination is made when a region of the membrane is set into vibration by sound of a particular frequency, hair cells in that region are translated. The resulting nerve impulses are sent to the brain and are interpreted as sound.

8. **(*a*) Wavelength:** It is defined as the distance travelled by a wave during the time a particle of the medium completes one vibration. It is denoted by λ. Its SI unit is metre.

(*b*) Time period: It is defined as the time by a vibrating particle to complete one vibration. It is denoted by T. Its SI unit is second.

(*c*) **Amplitude:** It is defined as the maximum displacement produced in the vibrating particle on either side of the mean position. It is denoted by A. Its SI unit is metre.

Derivation of the relation V = νλ:

We know that, wavelength λ is the distance covered by the wave during the time a particle of the medium completes one vibration *i.e.*, T.

Velocity of the wave,

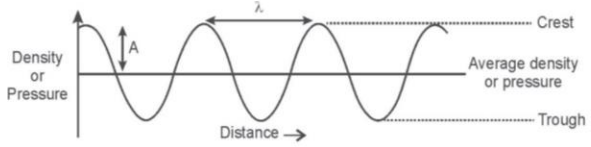
$$V = \frac{\text{Distance travelled by the wave}}{\text{Time taken}} = \frac{\lambda}{T}$$

But $\nu = 1/T$

Therefore, we have $V = \nu\lambda$

9. (*a*) When a sound wave is produced by a wave in a medium, it sets the particles of the medium. Consider, for example, vibration of the diaphragm of a speaker. As the diaphragm vibrates outwards, it sends in a wave of compression and the particles of air directly in front of it. Thus, compressed air travels away from the speaker with a speed of sound. Again, when the diaphragm reverses, its motion moves outwards, it then sends in a wave of rarefaction through the medium which travels with the velocity of sound. Then the sound travels in the form of compressions and rarefactions.

(*b*) The graphical representation is as shown:



(*c*) Sound waves are called longitudinal waves because the propagation of the sound wave takes place in the direction in which particles of the medium vibrate.

10. (*i*) (*a*) Loudness – amplitude

(*b*) Pitch – frequency

(*ii*) Given: t = 3 s, V = 1440 m s^{-1}, S = ?

Using the expression

$S = V \times t/2 = 1440 \times 3/2 = 2160$ m

(*iii*) Reverberation can be reduced by covering the roof and walls with sound absorbent materials like compressed fibreboard, rough plaster or draperies. The seat materials also covered with sound absorbing properties.

11. (*a*) Two differences are as follow:

Sound Waves	Light Waves
1. Longitudinal waves travel with a speed of 330 m s^{-1}.	1. Transverse waves travel with a speed of 3×10^8 m s^{-1}.
2. Require a medium to propagate.	2. Do not require a medium to propagate.
3. Sound waves are produced by oscillating particles of medium.	3. Light waves are produced by oscillating charged particles of medium.

(*b*) Velocity of sound = Frequency × Wavelength

(*i*) V = 340 m s^{-1}, ν = 256 Hz, λ = ?

$\lambda = 340/256 = 1.33$ m

(*ii*) V = 340 m s^{-1}, λ = 0.85 m, ν = ?

$\nu = 340/0.85 = 400$ Hz

12. (*a*) The persistence of sound in an auditorium as a result of repeated reflections of sound is called reverberation.

(*b*) A sound of single frequency is called a tone. The sound which is produced due to a mixture of several frequencies is called a note.

(*c*) See LAQ Q.1 above.

13. (*a*) $\angle x = \angle y = \angle i$

$\angle x = 90^\circ - 50^\circ = 40^\circ = \angle r$

$\angle y = \angle i = 40^\circ$

(*b*) Reflection of sound.

(*c*) (*i*) The incident ray, normal, reflected ray all lie in the same plane.

(*ii*) $\angle i = \angle r$

14. (*a*) Given: $\lambda = 420.5$ m, $V = 3 \times 10^8$ m s^{-1}, $\nu = ?$

Using the expression $V = \nu\lambda$, we have

$\nu = V/\lambda = 3 \times 10^8/420.5 = 7 \times 10^5$ Hz

(*b*) (*i*) The particles oscillate perpendicular to the direction of propagation of the wave.

(*ii*) The particles oscillate parallel to the direction of propagation of the wave.

APPLICATION BASED QUESTIONS (Self-Practice)

1. (*a*) This happens only when the frequency of vibration of the engine of bike becomes equal to the natural frequency of the rear view mirror.

(*b*) The name of this phenomenon is resonance.

(*c*) The speed of the bike should be change and this will change the frequency of vibration of the engine.

2. (*i*) The phenomenon is called resonance.

(*ii*) The sound becomes loudest because, the natural frequency of the length of air column becomes equal to the frequency of the vibrating tuning fork.

(*iii*) Frequency of the loud sound is either equal to or odd integral multiple of the frequency of tuning fork.

(*iv*) Decibel.

3. The quality of the two notes need not be the same. The pitch of the note is determined by its frequency. The quality depends upon the number, distribution and relative intensity of the different harmonics and overtones.

4. (*i*) Yes, the above action would produce audible sound.

(*ii*) Yes, the table top is set into forced vibrations.

(*iii*) The vibrations are forced vibration.

(*iv*) If the frequency of tuning fork is equal to the natural frequency of oscillation of the table top.

ANALYZING, EVALUATING & CREATING TYPE QUESTIONS (Self-Practice)

1. The 'quality' of a given note is determined by the overall effect of the harmonics present in it. The harmonics are multiples of the fundamental or basic frequency of the 'note'. Depending on the conditions under which vibrations are taking place, sometimes we get one set of harmonics and sometimes another set. The quality of the two notes will, therefore, different even though their fundamental frequencies may be the same.

2. (*i*) Yes, there is an audible sound produced.

(*ii*) Yes, the table top is set into 'forced vibrations' by this.

(*iii*) The vibrations are forced vibrations.

(*iv*) Pressing the stem of a vibrating tuning fork against a table top, would lead to resonance if the frequency of the tuning fork equals the natural frequency of oscillations of the table top.

3. (*i*) The wavelength of the wave produced in mode B is half of that in mode A *i.e.*, 0.5 m.
   (*ii*) The note produced in mode A is louder. This is because the amplitude of the wave in mode A is more than that of mode B. Loudness, being proportional to the square of the amplitude, would, therefore, be more in mode A.
   (*iii*) The pitch of the note produced in mode B is higher. This is because pitch becomes higher with an increase in frequency. As seen from the figure, the frequency of note in mode B is twice as much as that of the note in mode A.
4. The characteristics of a wave motion are:
   (*i*) It is a periodic disturbance.
   (*ii*) Energy transfer takes place at a constant speed.
5. Loudness depends upon the square of the amplitude of the wave, therefore, when the amplitude of wave is doubled the loudness becomes four times.
6. The 'frequency' of a musical sound affects its 'pitch'. The more the frequency of a (musical) sound, the 'sharper', and 'shriller' the sound becomes.

   The 'amplitude' of a musical sound affects its loudness, or intensity. The more the amplitude of the sound, the louder, (or more intense) the sound is.
7. The number, and nature, of harmonics and overtones present, affects the quality of the sound. The different combinations of the number and nature of harmonics and overtones present in the 'notes' gives these different wave patterns.
8. The subjective property of sound waves, related to its frequency, is known as its pitch. The name of the similar subjective property of light, related to its wavelength, is the colour of light.
9. The quality of the two notes need not be the same. This is because whereas the pitch of a note is determined solely by its frequency, the quality is determined by its harmonic or overtone contents. It is the number, distribution, and relative intensity of the different harmonics and overtones that determine its quality. All these factors need not be the same when the two notes have the same pitch.
10. (*i*) **Natural vibration:** The vibrations of a simple pendulum about its mean position.
    (*ii*) **Forced vibration:** A sonometer wire, under tension, vibrating under the influence of a vibrating tuning fork.
    (*iii*) **Resonance:** A correctly adjusted length of a sonometer wire under proper tension, vibrating under the influence of a vibrating tuning fork.
11. Echoes are used in radars to estimate the distance of flying objects.
12. On being set into vibrations, the stretched string, forces the surrounding air to vibrate. This vibrating air, in turn, affects our eardrum and produces an audible sound.
13. No, we will not hear any audible sound on the surface of the moon. This is because sound requires a medium to propagate, since there is no atmosphere on the surface of the moon, therefore, the sound will not be heard.
14. (*i*) Pitch of sound will increase.
    (*ii*) Loudness of sound will increase.
15. The phenomenon is known as Echo.

    We get echoes because of the reflection of sound. The reflected sound reaches the observer after a time $2d/v$, where d is the distance of the reflecting wall from the source and v is its velocity. For the human ear, this time must be at least 0.1 second to ensure that the reflected sound does not get mixed up with the direct sound. Since the velocity of sound in air is nearly 340 m s^{-1}, we must have $2d/340 > 0.1$ or $d > 17$ m. Since the building is at a distance of 18 m, we can hear the reflected sound in the form of an echo clearly.