CHAPTER 12

Sound

EXAM DRILL

ANSWERS

1. Ultrasonic waves can see the organs such as, liver, gall bladder kidneys etc.

2. The wave in which the particle of the medium vibrate in the same direction as wave called longitudinal wave.

3(i) The medium *Z*, is allowing sound to travel most slowly therefore it is least derived just like a gaseous medium which do not have a fixed shape and volume.

3(ii) In medium *W*, sound is travelling quickly compared to medium *Z* but it take time more than that of medium *X*. so, *W* is a liquid medium having fixed volume but no fixed shape.

3(iii) Moon is surrounded by vacuum in which sound cannot travel. The medium *Y* is failed to bring sound to the man therefore composition of medium *Y* is same as that on the Moon.

3(iv) Solids have a fixed shape and a fixed volume, medium-*X* allowing sound waves to travel most quickly just like a solid medium.

4(i) Tuning fork produces all types of sound waves shown in the given table.

4(ii) All these sound waves are produced by same device.

4(iii) (a) : In *B* and *D* frequency are same but amplitudes are different.

4(iv) (c) : Amplitudes of wave *A* and wave *D* are same but frequencies are different. Thus, they are having same loudness but different pitch.

5. **(c) :** Frequency is a characteristic of sound wave which does not change with the change of medium.

OR

(a) : When the pitch of note produced by a harmonium is lowered then the wavelength of the note increases because pitch is directly proportional to the frequency.

6. **(a) :** A mosquito buzz has a frequency around 500 Hz-600 Hz which is greater than that of a lion, a man and a woman.

OR

(a) : Dolphins, bats and porpoise use ultrasound.

7. **(c) :** During the propagation of sound, the disturbance created travels through the medium and not the particles of the medium.

8. **(b) :** The total distance travelled by the sonar signal from the ship to the sea bed and back,

$s = 2 \times 11$ km $= 22$ km $= 22{,}000$ m

Time taken by the sound to travel this distance is,

$$t = \frac{s}{v} = \frac{22000\ \text{km}}{1520\ \text{m s}^{-1}} = 14.47\ \text{s}$$

9. **(a) :** Loudness increases with increase in amplitude.

OR

(c) : Frequency × wavelength = velocity.

10. **(c) :** Sound travels through the stethoscope's tube by undergoing multiple reflection of sound.

11. **(b) :** Before the main shock waves, the earthquake produce low - frequency infrasonic sound.

12. **(d) :** Sound navigation and ranging (SONAR) technique is used to detect underwater objects.

13. **(c) :** A longitudinal wave motion travel in the form of compressions and rarefaction which involve changes in volume and density of the medium. As air possesses volume elasticity, therefore sound comes to us from the source in the form of longitudinal waves only.

14. **(c) :** Velocity of sound increases with increase in humidity so it depends on the medium.

15. **(a)** (i) The soft sound corresponds to lower decibel level. Therefore wave (ii) corresponds to lower decibel level.

(b) Loudness of sound decreases by amplitude.

(c) (i) Pitch (ii) quality (or timbre).

16. **(a)** The energy of the surface wave spreading on the surface of water comes from the kinetic energy of the stone shared by the water molecules on which it falls.

(b) Given Time period (T) = 0.1 s

Wavelength (λ) = 5.0 cm = 0.05 m

Speed of the waves (v) = ?

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

Substituting the given values of λ and T,

$$v = \frac{0.05}{0.1} = 0.5\ \text{m/s}$$

17. (a) The wave velocity (or phase velocity) is constant for a given medium and is given by $v = \upsilon\lambda$ while the particle velocity changes harmonically with time. It is maximum at the mean position and zero at the extreme position.

(b) As, $v = \upsilon\lambda$

or $\lambda = \frac{v}{\upsilon} = \frac{300\text{ m/s}}{300\text{ s}^{-1}} = 1\text{ m}.$

OR

(a) When a wave travels from one medium to other, its wavelength as well as velocity may change. But frequency does not change. This is the reason that frequency is the fundamental property of a wave.

(b) Frequency $= \frac{1200}{2\times 60} = 10\text{ Hz}.$

Frequency $= \frac{1}{T}$

$\therefore \quad T = \frac{1}{\text{Frequency}} = \frac{1}{10} = 0.1\text{ s}$

18. (a) The velocity of sound in a medium does not depend upon its loudness, pitch or quality. Thus the sound of bomb explosion and of a humming bee, even through having entirely different characteristics, travel with the same speed.

(b) Time (t) = 1 s

Frequency (υ) = ?

$\Rightarrow \quad \upsilon = \frac{\text{Number of waves}}{\text{Time taken}}$

$\upsilon = \frac{25}{1} = 25\text{ Hz}$

19. (a) The amount of water vapours present in the atmosphere is much higher on a rainy day than on a dry day. As the water vapours are lighter than dry air, hence density of wet air becomes less than that of dry air. As the speed of sound is inversely proportional to the square root of the density, hence sound travels faster on a rainy day than on a dry day.

(b) We have, v = 1000 Hz and λ = 34 cm $= \frac{34}{100}$ m.

The speed of the wave, $v = \upsilon\lambda$

$= (1000\text{ s}^{-1})\left(\frac{34}{100}\text{ m}\right) = 340\text{ m/s}.$

The time taken by the wave to travel 1 km is,

$$t = \frac{s}{v} = \frac{1\text{ km}}{340\text{ m/s}} = \frac{1000\text{ m}}{340\text{ m/s}} = 2.94\text{ s}.$$

OR

The reverberation time can be controlled by following methods:

(i) Covering walls and doors with absorbent materials like asbestos,perforated card board, etc.

(ii) Providing open windows in the space.

(iii) Providing heavy curtains with folds and folding or opening some of the curtains.

(iv) Decorating the walls with pictures and maps.

(v) By increasing the number of audience.

(vi) By the floors which help in absorbing sound.

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

Note : The sound which is produced due to a mixture of several frequencies is called a note.

Noise : The sound which is produced due to a mixture of several frequencies but is unpleasant to the ear is called noise.

OR

(a) Longitudinal waves travel in a medium as series of alternate compressions and rarefactions *i.e.*, they travel as vibrations in pressure and hence are called pressure waves.

(b) An explosion in a like produces shock waves thereby creating enormous increase in pressure in the medium (water). A shock wave is thus a longitudinal wave of ordinary intensity.

21. (a) Sonic boom is an explosive noise caused by the shock waves from an aircraft (or any other object) which is travelling faster than the speed of sound. These shock waves carry a great amount of energy and are associated with large pressure variations. The sonic boom in unpleasant to hear and can cause damage to buildings, window panes etc.

(b) When a supersonic aircraft flies low over a glass pane, due to its high speed greater than the speed of sound it produces sonic boom. The tremendous energy emitted by sonic boom causes the glass panes of the near by buildings to shatter.

22. (a) Amplitude is the maximum displacement of the vibrating particle on either side of the mean value.

Here amplitude, A = 5 cm

The minimum distance through which a sound wave repeats it self is called its wavelength.

Here wave length = 4 cm.

(b) Here λ_A = 100 mm = 0.10 m, λ_B = 0.25 m

v_A = 80 cm s^{-1} = 0.80 m s^{-1}

As the frequency of the wave remains same in the two media,

so $\upsilon = \frac{v_A}{\lambda_A} = \frac{v_B}{\lambda_B}$

$v_B = \frac{\lambda_B}{\lambda_A} \times v_A = \frac{0.25}{0.10} \times 0.80 = 2\text{ m s}^{-1}.$

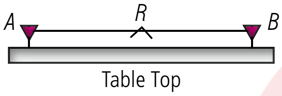
23. First hold a string or a slinky with one end attached to a rigid support with your hand. Mark a small dot *O* using a marker or by some other means on the slinky. Now vibrate the free end of the string/slinky in a direction perpendicular to its length. It can be observed that the point *O* vibrates in perpendicular direction to the length of the slinky while the wave starts propagating along the direction of its length.

24.

	Longitudinal Wave	Transverse Wave
(i)	It needs medium for propagation.	It may or may not need medium for propagation.
(ii)	Particles of the medium move in a direction parallel to the direction of propagation of the disturbance. Example, Sound wave.	Particles of the medium move in perpendicular direction of propagation of the disturbance. Example, light wave, seismic wave etc.

25. Sound is produced due to vibrating objects. The following simple experiment describe the experiment evidences in support of this statement.

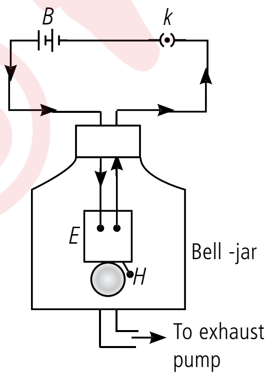
Take a metallic wire *AB* and stretch it tightly between two nails fixed on a table top as shown in figure.



When we pluck the wire, a sound is heard. If a *v*-shaped small paper rider (*R*) is placed near the centre of the wire, it starts vibrating and in case, the rider is at the centre of the wire, it flies off. This proves that the sound is produced due to vibrations in the wire.

Sound needs a material medium for propagation and cannot travel through vacuum. This can be demonstrated by the following experiment.

Let us consider an electric bell, *E* contained in a bell-jar. The electric bell is connected to a battery, *B* through a key, *K* as shown in figure. If we insert the plug in the key *K*, the electric circuit is closed and a sound is heard. When we go on taking air out of the bell-jar, the sound produced by the bell goes on getting fainter and fainter. If the process of evacuating the jar is continued so that a near perfect vacuum is created within it, we shall hear practically no sound through the hammer *H* of the bell will be seen to strike the bell and create sound. This sound is not heard as there is no medium in the jar to carry the sound to the listener. Thus, a material medium is essential for propagation of sound.



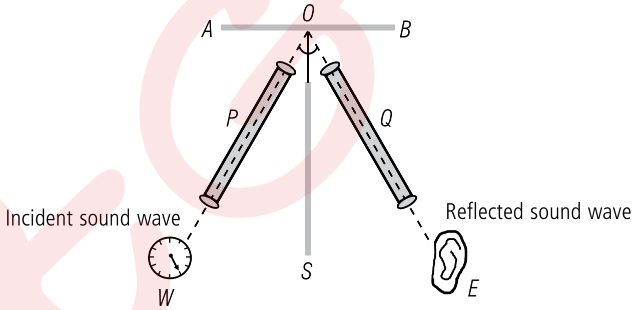
OR

First law : The angle of reflection (*r*) is always equal to the angle of incidence (*i*), *i.e.*,

$\angle r = \angle i$ or $i = r$

Second law : The incident wave, the reflected wave and the normal (at the point of incidence), all lie in the same plane.

Like light waves, sound waves also get reflected when these fall on the surface of an obstacle. But unlike light waves, sound waves do not necessarily require a polished surface for reflection, *i.e.*, for reflection of sound waves, the surface may be polished or rough. The following simple experiment establishes that reflection of sound follows the same laws as those for reflection of light.



(i) Place a large plane board, *AB* (or a metal, cardboard or wood) in the vertical position (*i.e.*, perpendicular to the plane of the paper).

(ii) Take two hollow metallic tubes *P* and *Q* (each about 1 m long and about 8 to 10 cm in diameter) and place them in the plane of the paper and in positions inclined to the board as shown in figure.

(iii) Hold a watch *W* at the free end of the tube *P* and try to hear the ticking sound of the watch by positioning the ear at *E*.

(iv) Put a cardboard screen *S* in between the two tubes so that the sound produced by the watch does not reach the ear directly.

(v) Turn the tube *Q* till the ticking sound of the watch is the loudest. In this position, it is found that the tubes are inclined to *S* at the same angle, *i.e.*, *i* (angle of incidence of sound wave) = *r* (angle of reflection of the sound wave). This follows the first law.

(vi) If the tube *Q* is lifted slightly vertically upwards, no sound is heard. This implies that the reflected sound wave (*OE*) lies in the same plane (*i.e.*, the plane of the paper) as the incident sound wave.

The normal *OS* to the surface lies in the same plane as that in which the incident and reflected sound waves lie. Thus second law also verified.

26. (a) Wave motion : It is a kind of disturbance which travels through a medium due to repeated vibrations of the particle of the medium about their mean positions.

(b) Wavelength : The minimum distance in which a sound wave repeats itself is called its wavelength.

(c) Frequency : The number of complete waves (or cycles) produced in one second is called frequency of the wave.

(d) Time period : The time required to produce one complete wave (or cycle) is called time period of the wave.

(e) Speed of wave : The distance travelled by a wave is one second is called velocity of the wave (or speed of the wave).

27. Speed of sound in air = 340 m/s.

Frequency = 20 kHz = 20×10^3 Hz

Wavelength = ?

∴ Speed = Wavelength × Frequency

$v = \lambda\upsilon$

$$\therefore\ \lambda = \frac{v}{\upsilon} = \frac{\text{Speed}}{\text{Frequency}} = \frac{340}{20\times10^3} = 0.017\,\text{m}.$$

Speed of sound in water = 1480 m/s

Frequency = 20×10^3 Hz

Wavelength = ?

∴ Speed = Wavelength × Frequency

$$\text{Wavelength} = \frac{\text{Speed}}{\text{Frequency}}$$

$$= \frac{1480}{20\times10^3} = 0.074\,\text{m}.$$

OR

(a) Transverse wave motion, because the vibrations of particles (kinks) of the spring are at right angles to the direction of wave propagation.

(b) Longitudinal wave motion, because the molecules of the liquid vibrate to and fro about their mean position along the direction of propagation of the wave.

(c) Combination of longitudinal and transverse waves, because the propeller of the motor boat cuts the water surface laterally and also pushes it in backward direction.

(d) Transverse wave motion, because the light waves are electromagnetic waves in which electric and magnetic fields vibrate in the direction at right angle to each other and also to the direction of propagation of the wave.

(e) Infrasonic waves produced by a quartz crystal in air are longitudinal because the molecules of air vibrate to and fro about their mean positions along the direction of propagation of wave due to the vibrations of quartz crystal.

28. From the definition, $\text{Velocity} = \dfrac{\text{Distance travelled}}{\text{Time taken}}$

So, for a wave,

$$\text{wave velocity} = \frac{\text{distance travelled by the wave}}{\text{time taken}}$$

A wave takes time equal to its time period (T) to travel a distance equal to its wavelength (λ). So,

$$\text{wave velocity} = \frac{\text{wavelength of the wave}}{\text{time period of the wave}} \qquad ...(i)$$

$$\text{or}\quad v = \frac{\lambda}{T} \qquad ...(ii)$$

As per definition,

$$\text{Frequency of the wave, } \upsilon = \frac{1}{\text{Time period of the wave}}$$

So, eqn. (ii) can be written as,

Wave velocity = Wavelength of the wave × Frequency of the wave ...(iii)

$$\text{or}\quad v = \lambda \times \upsilon \qquad ...(iv)$$

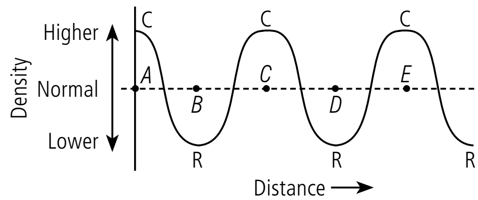
(a) $\text{Wavelength} = \dfrac{\text{Velocity of sound}}{\text{Frequency}}$

$$= \frac{340\,\text{m s}^{-1}}{256\,\text{s}^{-1}} = 1.328\ \text{m}$$

(b) $\text{Frequency} = \dfrac{\text{Velocity of sound}}{\text{Wavelength}} = \dfrac{340\,\text{m s}^{-1}}{0.85\,\text{m}}$

$= 400\ \text{s}^{-1} = 400$ Hz

29. Density – Distance plot for a disturbance produced by sound is shown below.



The position of compression (C) and rarefactions (R) are marked on the graph.

From this figure, Wavelength (λ) = Distance *ABC* (or *BCD*)

From figure, the time corresponding to the distance *ABC* is the time period of the wave. Thus, the time required to cover a distance equal to wavelength is called the time period.

OR

An echo is the phenomenon of repetition of sound of a source by reflection from an obstacle.

To distinguish an echo from the original sound, the obstacle must be situated at a suitable distance from the source of sound.

The sensation of sound lasts in our brain for 1/10 of a second. This property is called persistence of hearing. Therefore, to hear a distinct echo of a sound, the time taken by this sound to reach the listener after reflection should be 1/10 of a second.

Let us take,

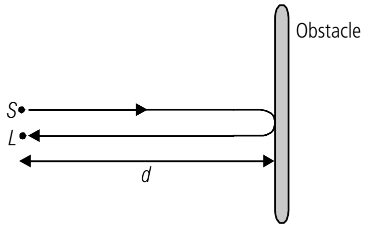
d = minimum distance of the obstacle from the source (S), as shown in figure,

v = speed of sound in air,

t = total time taken by the sound to reach the listener (L) after reflection.

As total distance travelled by sound = speed of sound × total time,

$$2d = v \times t \quad \text{...(i)}$$



Substituting $v = 344$ m s^{-1} (speed of sound in air at 20°C) and

$t = \frac{1}{10}$ s, we get from equation (i)

$$2d = 344 \text{ (m s}^{-1}) \times (1/10) \text{ s} = 34.4 \text{ m}$$

or $d = 17.2$ m

Hence, for hearing a distinct echo, the minimum distance of the obstacle from the source of sound should be 17.2 m. It is to be noted that this distance changes with the change in temperature of the air.

30. Some different applications of ultrasound are following :

(i) Cleaning instruments and electronic components : An instrument that needs cleaning but whose parts cannot be reached directly is placed in a liquid. The ultrasonic waves passing through the liquid produce tiny bubbles where the rarefaction of the ultrasonic wave reaches. When the compression of the wave reaches these bubbles, the bubbles are compressed until they implode (explode inward). This leads to the creation of several small localized shock waves. These shock waves blast away any dirt or contamination from the unreachable portions. Usually, frequencies in the range 20 kHz to 30 kHz are used for this purpose.

(ii) Plastic welding : Application of small pressures and ultrasonic vibration to two similar surfaces produce sufficient thermal energy to bond the surfaces together.

(iii) Detecting flaws and cracks in metal blocks : To construct big structures like buildings, bridges, machines and scientific equipment, a large number of metallic blocks are assembled together. Cracks in and holes within the blocks, which are invisible from outside, reduce the strength of a structure. To detect these flaws (cracks and holes) in a block, ultrasonic waves are passed through it. Transmitted waves are detected by detectors. Whereas ultrasonic waves pass through the flawless portions of the block, they are reflected back by even a minor defect and do not reach the detector.

(iv) Echocardiography : It is used to study the heart-valve action. An image of the heart is obtained by getting ultrasonic waves reflected from various parts of the heart.

(v) Ultrasonography : It involves sending ultrasonic waves to various organs (like brain, liver, kidneys) in the body and looking at the reflected or transmitted waves. The observations are made on an oscilloscope after the ultrasonic waves have been converted into electrical signals. Using ultrasonography, stones in gall-bladder and kidneys or tumours in different organs can be detected. Ultrasonography is also used in prenatal examinations. A three-dimensional image of a foetus in the womb is made using a sequence of ultrasound scans.

(vi) Surgical uses : Ultrasound is used for bloodless brain surgery as well as painless extraction of teeth etc. It is also used to break small stones formed in the kidneys into fine particles which inter on get flushed out with urine.

(vii) Therapeutic uses : Ultrasound is used for treatment of neuralgic and rheumatic pains.

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