Chapter 8

Propagation of Sound Waves

Class 9 - Concise Physics Selina Solutions

Exercise 8(A) — Multiple Choice Type

Question 1

The waves carry ..... energy of the vibrating particles with them so as to produce a sensation of hearing in our ears.

1. light
2. mechanical
3. chemical
4. nuclear

Answer

mechanical

Reason — Sound waves produce the sensation of hearing in our ears. They are mechanical waves that need a medium to travel, like air or water. When an object vibrates, it creates disturbances in the surrounding medium, propagating as mechanical waves. These waves carry the energy of the vibrating particles, allowing us to perceive sound.

Question 2

Identify the correct statements :

(i) A material medium is necessary for the propagation of sound from one place to another.

(ii) The medium must have inertia.

(iii) The medium must be inelastic.

(iv) The medium must be frictionless.

1. (i) and (ii)
2. (i), (ii) and (iii)
3. (i), (ii) and (iv)
4. (ii), (iii) and (iv)

Answer

(i), (ii) and (iv)

Reason — A material medium is necessary for the propagation of sound from one place to another.

Requisites of the medium are :

1. The medium must be elastic.
2. The medium must have inertia.
3. The medium must be frictionless.

Question 3

The correct statement is:

1. Sound and light both require medium for propagation
2. Sound can travel in vacuum, but light cannot
3. Sound needs medium, but light does not need medium for it's propagation
4. Sound and light both can travel in vacuum

Answer

Sound needs medium, but light does not need medium for it's propagation

Reason — Sound waves are mechanical waves. So, they require a medium, such as air, water, or solids, to travel through. In contrast, light waves are electromagnetic waves that can propagate through vacuum as well as various mediums. Light does not depend on a material medium for its transmission and can travel through empty space.

Question 4

Sound in air propagates in form of:

1. Longitudinal wave
2. Transverse wave
3. Both longitudinal and transverse wave
4. Neither longitudinal nor transverse wave

Answer

Longitudinal wave

Reason — The two kinds of waves in form of which sound travels in a medium are:

1. **Transverse waves** — The wave in which the particles of medium vibrate about their mean positions, in a direction perpendicular to the direction of propagation of the wave.
   Transverse waves can only be **produced in solids and on the surface of liquids. They cannot be produced inside liquids and inside gases.**
2. **Longitudinal waves** — The wave in which the particles of medium vibrate about their mean positions, in the direction of propagation of sound.
   Longitudinal waves can be produced in **solids, liquids as well as gases**.

Hence, sound in air propagates in form of **longitudinal wave.**

Question 5

The S.I. unit of wavelength is :

1. metre
2. hertz
3. second

4. m/s

Answer

metre

Reason — The distance travelled by the wave in one time period of vibration of a particle of the medium, is called its wavelength. Its S.I. unit is metre.

Question 6

The position of maximum upward displacement of medium particles in a transverse wave is known as :

1. trough
2. compression
3. rarefaction
4. crest

Answer

crest

Reason — A transverse wave is composed of crest and trough. The position of maximum upward displacement of medium particles in a transverse wave is known as crest and the position of maximum downward displacement is called trough.

Question 7

The wave in which the particles of a medium vibrate about their mean position in a direction ..... to the direction of propagation of the wave is called transverse wave.

1. parallel
2. similar
3. perpendicular
4. none of the above

Answer

perpendicular

Reason — In a transverse wave, the oscillations of the particles occur in a direction that is perpendicular to the wave's motion as it travels through the medium.

Question 8

In a longitudinal wave, the distance between two consecutive ..... is equal to ..... wavelength(s).

1. compressions, one
2. compressions, two
3. crests, one
4. crests, two

Answer

compressions, one

Reason — In a longitudinal wave, the distance between two consecutive compressions (regions of high pressure) is equal to one wavelength.

Question 9

Transverse waves can be produced inside :

1. solids
2. liquids
3. gases
4. both (b) and (c)

Answer

solids

Reason — Transverse waves can only be produced in solids and on the surface of liquids. They cannot be produced inside liquids and gases.

Question 10

Longitudinal waves can be produced in :

1. solids
2. liquids
3. gases
4. All of the above

Answer

All of the above

s

Rea on — The wave in which the particles of the medium vibrate about their mean positions, in a direction of propagation of sound, is called a longitudinal wave. Longitudinal waves can be produced in solids, liquids and gases.

Question 11

The maximum displacement of the medium particle on either side of its mean position is called ..... of the wave.

1. frequency
2. time period
3. wavelength
4. amplitude

Answer

amplitude

Reason — When a wave passes through a medium, the maximum displacement of the particle of the medium on either side of its mean position, is called the amplitude of the wave.

Question 12

At compressions, the density and pressure of a medium is ....., while at rarefactions the density and pressure of a medium is .....

1. minimum, minimum
2. minimum, maximum
3. maximum, maximum
4. maximum, minimum

Answer

maximum, minimum

Reason — At compressions, the density and pressure of a medium is maximum, while at rarefactions the density and pressure of a medium is minimum.

Question 13

Wave velocity is also defined as the ..... with which ..... is transferred from one place to another place by wave motion.

1. speed, energy
2. speed, compression
3. speed, rarefaction
4. velocity, pressure

Answer

speed, energy

Reason — Wave velocity is also defined as the speed with which energy is transferred from one place to another place by wave motion.

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Que tion 14

For sound to travel through medium, it need not :

1. be rigid
2. be elastic
3. possess inertia
4. be frictionless

Answer

be rigid

Reason — A material medium is necessary for the propagation of sound from one place to another.

Requisites of the medium are :

1. The medium must be elastic.
2. The medium must have inertia.
3. The medium must be frictionless.

Question 15

The speed of sound in air is not affected by change in :

1. temperature
2. moisture
3. pressure
4. density

Answer

pressure

Reason — The speed of sound in a gas is independent of pressure. Hence, there is **no effect** on sound when the pressure of air is changed.

Question 16

The speed of sound in a gas is given by :

1. $V = \sqrt{\frac{P}{\gamma\rho}}$
2. $V = \sqrt{\frac{\gamma P}{\rho}}$
3. $V = \sqrt{\frac{\gamma\rho}{P}}$
4. $V = \sqrt{\gamma\rho P}$

Answer

$V = \sqrt{\frac{\gamma P}{\rho}}$

Reason — According to Laplace, when sound travels in a gas, during the formation of compression and rarefaction, there is no exchange of heat in the medium i.e., the propagation of sound is an adiabatic change.

Hence, the speed of sound in a gas is given by $\sqrt{\frac{\gamma P}{\rho}}$

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Que tion 17

The speed of sound in air at 0°C is nearly :

1. 1450 m s^{-1}
2. 450 m s^{-1}
3. 5100 m s^{-1}
4. 330 m s^{-1}

Answer

330 m s^{-1}

Reason — The speed of sound in air at 0°C is 330 m s^{-1}

Question 18

The speed of sound in a gas is related to temperature (in Kelvin) as :

1. directly proportional to temperature.
2. directly proportional to the square root of temperature.
3. inversely proportional to temperature.
4. inversely proportional to the square root of temperature.

Answer

directly proportional to the square root of temperature.

Reason — The speed of sound in a gas increases with the increase in temperature of the gas. The reason is that with the increase in temperature, the density of the gas decreases and consequently the speed of sound increases. The speed of sound in a gas is directly proportional to the square root of temperature.

Question 19

Factors affecting the speed of sound are :

1. temperature
2. density
3. pressure
4. only (a) and (b)

Answer

only (a) and (b)

Reason — Factors affecting the speed of sound are:

1. density
2. temperature
3. humidity and
4. direction of wind.

Exercise 8(A) — Very Short Answer Type

Question 1

What causes sound?

Answer

Sound is produced when a body vibrates.

Question 2

Complete the following sentence —

Sound is produced by a ..... body.

Answer

Sound is produced by a ***vibrating*** body.

Question 3

There is no atmosphere on moon. Can you hear each other people on the moon's surface?

Answer

No, we cannot hear each other on the moon's surface because there is no medium for the propagation of sound on moon.

Question 4

Choose the correct word/words to complete the following sentence —

When sound travels in a medium ..... (the particles of the medium, the source, the disturbance, the medium) travels in form of a wave.

Answer

When sound travels in a medium ***the disturbance*** travels in form of a wave.

Question 5

Name the two kinds of waves in form of which sound travels in a medium.

Answer

The two kinds of waves in form of which sound travels in a medium are —

1. Transverse waves
2. Longitudinal waves

Question 6

What is a longitudinal wave? In which medium: solid, liquid or gas, can it be produced?

Answer

The wave in which the particles of medium vibrate about their mean positions, in the direction of propagation of sound is called a Longitudinal wave.

Longitudinal waves can be produced in **solids, liquids as well as gases**.

Question 7

What is a transverse wave? In which medium: solid, liquid or gas, can it be produced?

Answer

The wave in which the particles of medium vibrate about their mean positions, in a direction perpendicular to the direction of propagation of the wave is called a Transverse wave.

Transverse waves can only be **produced in solids and on the surface of liquids. They cannot be produced inside liquids and in gases.**

Question 8

Define the term amplitude of a wave. Write it's S.I. unit.

Answer

When a wave passes through a medium, the maximum displacement of the particle of the medium on either side of it's mean position is called amplitude of wave.

It's S.I. unit is **metre (m)**.

Question 9

How is the frequency of a wave related to it's time period?

Answer

The frequency (f) and time period (T) are related as

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

Question 10

Arrange the speed of sound in gases V_g, solids V_s and liquids V_l in an ascending order.

Answer

Speed of sound in gases V_g, solids V_s and liquids V_l in an ascending order is given below:

$V_g < V_l < V_s$

Question 11

State the speed of (i) light and (ii) sound in air?

Answer

(i) The speed of light = 3×10^8 m s^{-1}

(ii) The speed of sound in air = 330 m s^{-1}

Question 12

Answer the following —

(a) Can sound travel in vacuum?

(b) How does the speed of sound differ in different media?

Answer

(a) **No**, sound cannot travel in vacuum because sound needs a medium to propagate and there are no particles in vacuum to propagate sound.

(b) The speed of sound differs in different media. The speed of sound is **more in solids, less in liquids and least in gases (since solids are much more elastic than liquids and gases).** The speed of sound is nearly 5100 m s^{-1} in steel, 1450 m s^{-1} in water and 330 m s^{-1} in air at 0°C.

Question 13

Flash of lightning reaches us earlier than the sound of thunder. Explain the reason.

Answer

Flash of lightning reaches us earlier than the sound of thunder because light travels much faster than sound.

Light takes almost negligible time in comparison to sound in reaching us from the place of thunder because speed of light is

much more (3×10^8 m s^{-1}) than the speed of sound (= 330 m s^{-1}).

Question 14

How does the speed of sound in air vary with temperature?

Answer

The speed of sound is directly proportional to the square root of temperature of the medium.

It increases by about 0.61 m s^{-1} (or 61 cm per second) for each 1°C rise in temperature (provided that the rise in temperature is not very large).

i.e.,

$$\mathbf{V_t = V_0 + 0.61t}$$

Question 15

Complete the following sentences —

(a) Sound cannot travel through ..... ; it requires a .....

(b) When sound travels in a medium, the particles of medium ..... but the disturbance.....

(c) A longitudinal wave is composed of compression and .....

(d) A transverse wave is composed of crest and .....

(e) Wave velocity = ... x wavelength

Answer

(a) Sound cannot travel through ***vacuum*** ; it requires a ***medium***.

(b) When sound travels in a medium, the particles of medium ***do not move*** but the disturbance ***moves ahead***.

(c) A longitudinal wave is composed of compression and ***rarefaction***.

(d) A transverse wave is composed of crest and ***trough***.

(e) Wave velocity = ***frequency*** x wavelength

Exercise 8(A) — Short Answer Type

Question 1

State three characteristics of the medium required for propagation of sound?

Answer

The characteristics of the medium required for propagation of sound in a medium are —

(a) The **medium must be elastic** so that it's particles may come back to their initial position after displacement on either side, i.e.,

the particles are capable of vibrating about their mean position.

(b) The **medium must have inertia** so that it's particles may store mechanical energy.

(c) The **medium should be frictionless** so that there is no loss of energy in propagation of sound through it.

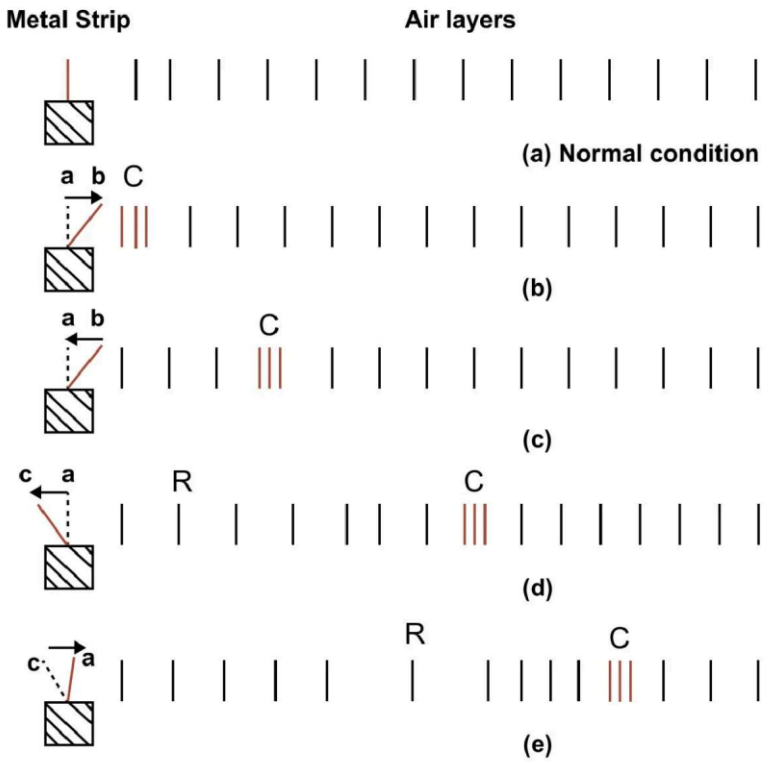
Question 2

Explain with an example, the propagation of sound in a medium.

Answer

When a source of sound vibrates, it creates a periodic disturbance in the medium near it. The disturbance then travels in the medium in the form of waves. This can be understood by the following example —

Take a thin metal strip. Keeping it vertical, fix it's lower end. Push it's upper end to one side and then release it. As it vibrates (i.e., moves alternatively to the right and left) sound is heard.



When the strip advances to the right from a to b, it pushes the particles of air in layers in front of it. So the particles of air in these layers gets closer to each other i.e., air of these layers gets compressed.

The particles of these layers while moving forward, push and compress the layers next to them, which then compress the next layers and so on. Thus, the disturbance moves forward in form of compression. The particles of the medium get displaced, but they do not move along with the compression.

As the metal strip starts returning from b to a as shown in figure, after pushing the particles in front, the particles of air near the strip starts

returning back to their mean positions due to the elasticity of the medium.

When the strip moves to the left from a to c, it pushes back the layers of air near it towards it's left and thus produces a space of very low pressure on it's right side. The air layers on the right side of the strip expand in this region thus forming the rarefied air layers. This region of low pressure is called the rarefaction R.

When the strip returns from c to it's normal position a, it pushes the rarefaction R forward and the air layers near the strip again pass through their mean positions due to the elasticity of the medium.

In this manner, as the strip moves to the right and left repeatedly, the compressions and rarefactions regions are produced one after the other which carry the disturbance with it with a definite speed depending on the nature of the medium. Gradually due to friction, the strip losses its energy to the medium and the disturbance dies out.

One complete to and fro motion of the strip forms one compression and one rarefaction which together constitute one wave. This is how sound waves propagate through a medium such as air.

Question 3

Explain the meaning of terms compression and rarefaction in relation to a longitudinal wave.

Answer

Compression — When a vibrating object advances, it pushes the particles of air in layers in front of it. So the particles of air in these layers gets closer to each other i.e., air of these layers gets compressed.

The particles of these layers while moving forward, push and compress the layers next to them, which then compress the next layers and so on. Thus, the disturbance moves forward in form of compression.

Rarefaction — When a vibrating object, moves left, it pushes back the layers of air near it towards it's left and thus produces a space near it towards it's right side and thus produces a layer of very low pressure on right side. The air layers on the right side of the strip expand in this region thus forming the rarefied air layers. This region of low pressure is called the rarefaction R.

Question 4

What do you mean by the term frequency of a wave? State it's S.I. unit.

Answer

The number of vibrations made by a particle of a medium in one second is called the frequency of wave. It is the same as the number of waves passing through a point in one second.

It's S.I. unit is **second^{-1} (symbol s^{-1})** or **hertz (symbol Hz).**

Question 5

Define the term wave velocity. Write it's S.I. unit.

Answer

The distance travelled by a wave in one second is called it's wave velocity or wave speed. It is the speed with which energy is transferred from one place to another by wave motion.

It's S.I. unit is metre per second (m s^{-1}).

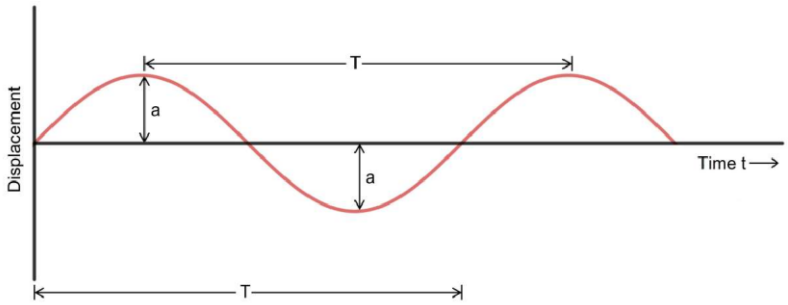
Question 6

Draw displacement-time graph of a wave and show on it the amplitude and time period of wave.

Answer

The figure below shows the variation of displacement with time for a particle of the medium at a given position, when a wave propagates through the medium. It is called displacement-time graph.

The amplitude is represented by the letter a and the time period is represented by the letter T.

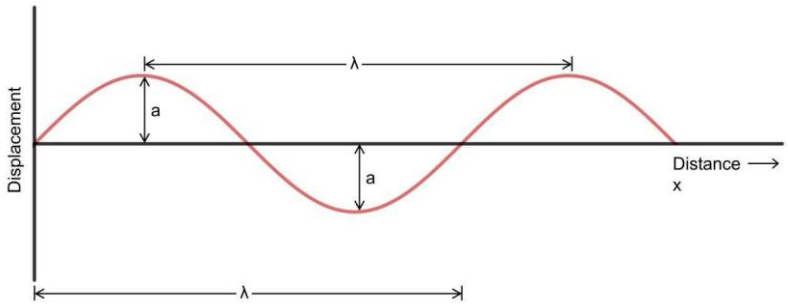


Question 7

Draw a displacement-distance graph of a wave and mark on it, the amplitude of wave by the letter a and wavelength of wave by the letter λ.

Answer

The figure given below shows the displacement-time graph of a transverse wave at an instant. The curve shows the displaced positions at an instant when wave propagates through the medium.



Question 8

State two properties of the medium on which the speed of sound in it depends.

Answer

Two properties of the medium on which the speed of sound in it depends are —

1. The elasticity (E) of the medium.
2. The density of the medium.

Question 9

Compare approximately the speed of sound in air, water and steel.

Answer

The speed of sound in air is 330 m s^{-1}

The speed of sound in water is 1450 m s^{-1}

The speed of sound in steel is 5100 m s^{-1}

Therefore, the comparison gives —

330 : 1450 : 5100

33 : 145 : 510

So approximately, the speed of sound in air, water and steel are in the ratio 1 : 4 : 15

Question 10

If you place your ear close to an iron railing which is struck some distance away, you hear the sound twice. Explain why?

Answer

As sound travels faster in iron than in air so first the sound through the iron rail is heard and then the sound through the air is heard. That's why we hear the sound twice.

Question 11

The sound of an explosion on the surface of a lake is heard by a boat man 100 m away and by a diver 100 m below the point of explosion.

(a) Who would hear the sound first — boat man or diver?

(b) Give a reason for your answer in part (i)

(c) If sound takes time t to reach the boat man, how much time approximately does it take to reach the diver?

Answer

(a) The **diver** would hear the sound first.

(b) The sound is heard by the diver first because **sound travels faster in water than in air.**

(c) As we know, the speed of sound in water (1450 ms^{-1}) is more than the speed of sound in air (330 ms^{-1}) so if 't' is the time taken by sound to reach the boat man, then the time taken by sound to reach the diver is 0.25t as sound travels nearly four times faster in water.

Question 12

How does the speed of sound change with change in (i) amplitude and (ii) wavelength, of sound wave?

Answer

(i) **Effect of amplitude of sound wave** — The speed of sound does not depend on the amplitude of sound wave. Hence, speed of sound **does not change** with change in amplitude of sound wave.

(ii) **Effect of wavelength of sound wave** — The speed of sound does not depend on the wavelength of sound wave. Hence, it **does not change** with change in wavelength of sound wave.

Question 13

In which medium the speed of sound is more — humid air or dry air? Give a reason to your answer.

Answer

The speed of sound is more in humid air.

From the relation.

$V \propto \sqrt{\frac{\gamma P}{\rho}}$, it is clear that $V \propto \frac{1}{\sqrt{\rho}}$ i.e., the speed of sound is inversely proportional to the square root of density of the gas.

As the density of air decreases with an increase in moisture level in air hence speed of sound increases in humid air.

Exercise 8(A) — Long Answer Type

Question 1(a)

What is sound? How is it produced?

Answer

Sound is a **form of energy that produces the sensation of hearing in our ears**. Sound is produced when a body vibrates.

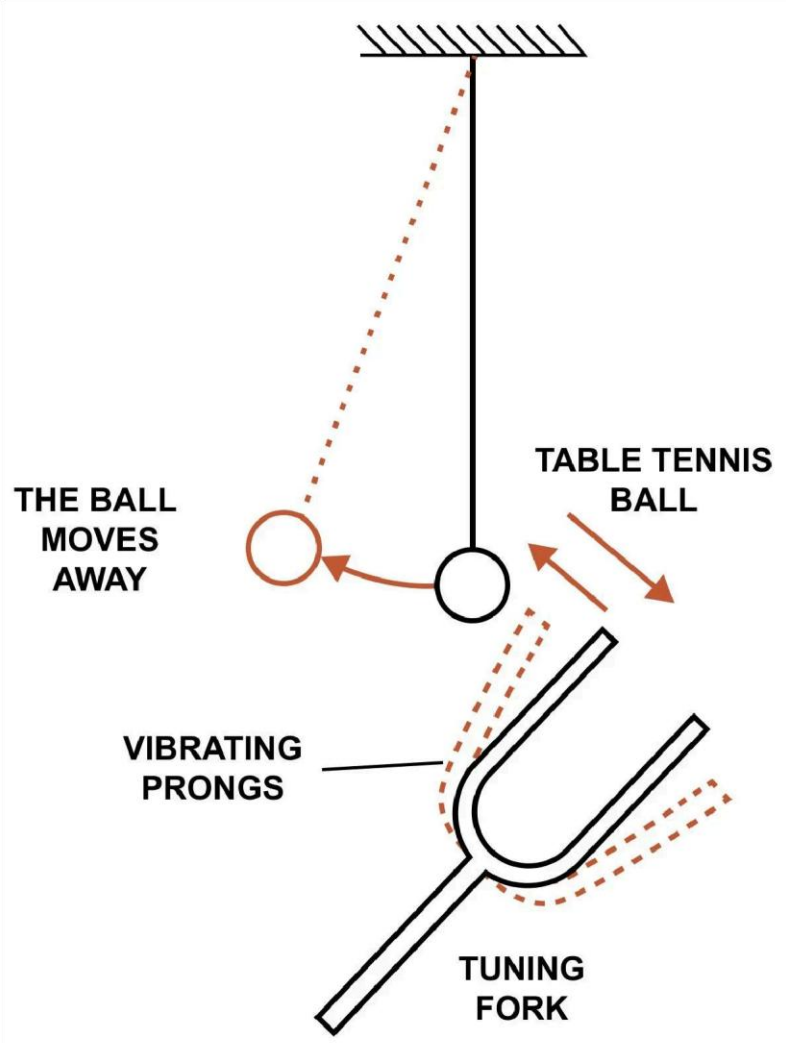
For example — sound of morning alarm, a dog barking, music from different instruments etc.

Question 1(b)

Describe a simple experiment which demonstrates that the sound produced by a tuning fork is due to vibration of it's arms.

Answer

Take a tuning fork which is a rectangular rod of steel bent in U shape, with a metallic stem at the bend. Strike it's one arm on a rubber pad and bring it near a table tennis ball suspended by a thread as shown in the figure below.



It is noticed that as the arm of the vibrating tuning fork is brought close to the ball, the ball jumps to and fro and sound of the vibrating tuning fork is heard. When it's arms stops vibrating, the ball becomes stationary and no sound is heard.

Hence, we can say that the sound produced by a tuning fork is due to vibration of it's arms.

Question 2

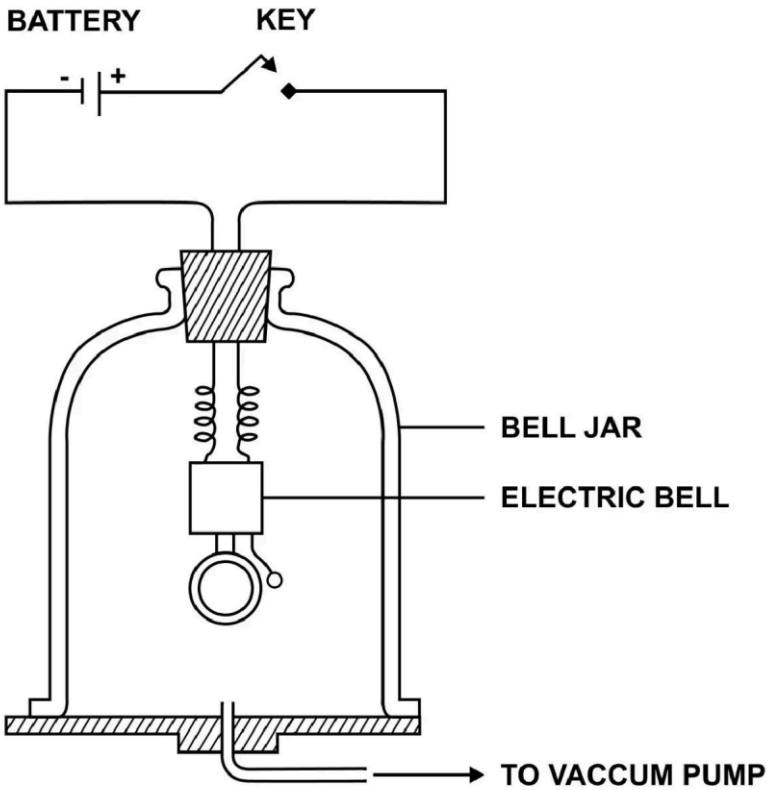
Describe in brief, with the aid of a labelled diagram, an experiment to demonstrate that a material medium is necessary for the propagation of sound.

Answer

A material medium is required for the propagation of sound.

Experiment —

Take an electric bell and an air tight glass bell jar. The electric bell is suspended inside the bell jar. The bell jar is connected to the vacuum pump as shown below.



As the circuit of electric bulb is completed by pressing the key, the hammer of the electric bell is seen to strike the gong repeatedly and sound of the bell is heard.

Now keeping the key pressed, air is gradually withdrawn from the jar by starting the vacuum pump. It is noticed that the loudness of sound goes on decreasing as the air is taken out from the bell jar and finally no sound is heard when the entire air from the jar has been drawn out.

The hammer of electric bulb is still seen striking the gong repeatedly which means that the gong is still vibrating to produce sound (as hammer strikes the gong), but it is not heard.

Explanation —

When the hammer of the bell hits the gong, sound is produced due to vibration of the gong which travels through the air to the wall of the jar. This causes the wall of jar to vibrate due to which the air outside the jar is also set in vibration.

Thus, sound is heard by us. But when air has been removed from the jar, sound produced due to vibrations of the gong could not travel to the wall of the jar , so wall could not vibrate and no sound is heard.

This clearly demonstrates that **sound requires a material medium for it's transmission and it cannot travel through vacuum.**

Question 3

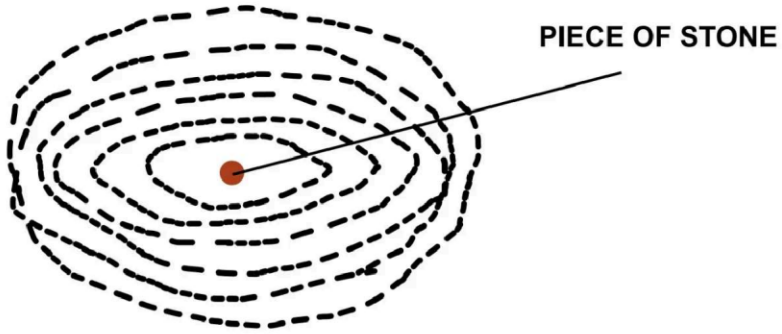
Describe an experiment to show that in wave motion, only energy is transferred, but particles of medium do not leave their positions.

Answer

The following experiment shows that in wave motion, only energy is transferred, but particles of medium do not leave their positions.

Experiment —

If we drop a piece of stone in the still water of a pond, we hear the sound of stone striking the water surface. A disturbance is produced in water at the point where the stone strikes it. This disturbance spreads in all directions radially outward in form of circular waves on the surface of water as shown in the figure below.



Now, if we place a piece of cork on the water surface at some distance away from the point where the stone strikes the water, we notice that the cork does not move ahead, it moves up and down while the wave moves ahead.

The reason is that the cork along with the particles of water (or medium) start vibrating up and down at the point where the stone strikes. These particles then transfer their energy to the other neighbouring particles and they themselves come back to their mean positions. This process continues and thus the disturbance moves ahead on the water surface in form of wave.

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Therefo e, the above experiment shows that particles do not move but only transfer energy to other particles.

Question 4

How do the following factors affect, if at all, the speed of sound in air —

(i) frequency of sound

(ii) temperature of air

(iii) pressure of air

(iv) moisture in air?

Answer

(i) **Frequency of sound** — The speed of sound does not depend on the frequency (or wavelength) of sound wave. Hence, there is **no effect** on sound when the frequency of sound changes.

(ii) **Temperature of air** — The speed of sound in a gas **increases with an increase in the temperature of the gas.**

(iii) **Pressure of air** — The speed of sound in a gas is independent of pressure. Hence, there is **no effect** on sound when the pressure of air is changed.

(iv) **Moisture in air** — The speed of sound in air **increases with an increase in the**

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moistu e level of air.

Question 5

How are the wave velocity V, frequency f and wavelength λ of a wave related? Derive the relationship.

Answer

The relation between wave velocity V, frequency f and wavelength λ of a wave is —

$V = f\lambda$

Derivation

Let velocity of a wave be V, time period T, frequency f, and wavelength λ.

By definition,

Wavelength λ = Distance travelled by the wave in one time period i.e., in T second
= wave velocity x time period
= V x T
or VT = λ ***[Equation 1]***

But, $T = \frac{1}{f}$

∴ From Equation 1

$V \times (\frac{1}{f}) = \lambda$

or $V = f\lambda$

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Therefo e,

Wave velocity (V) = Frequency (f) x Wavelength (λ)

Question 6

Describe a simple experiment to determine the speed of sound in air. What approximation is made in the method described by you?

Answer

The fact that light travels in air about a million times faster than sound, can be used to determine the speed of sound in air.

Experiment —

Choose two places A and B at high altitudes facing facing each other, at a distance d apart (say, about 1 km), in still iair. The distance d is noted. At each place, there is an observer with a gun and a stop watch. First the observer at place A fires the gun, while the observer at place B starts his stop watch immediately on seeing the flash of fire at A and stops it when he hears the sound of fire. The observer at B by his watch thus finds the time interval t_1 taken by the sound to travel from A to B.

Now the observer at place B fires the gun. The observer at A starts his stop watch when

he sees the flash of fire at B and stops when he hears the sound of fire. Thus, the observer A by his watch finds the time interval t_2 taken by sound to travel from B to A.

The average of the two time intervals is t = $\frac{t_1 + t_2}{2}$. This is the time taken by sound to travel the distance d between the places A and B.

The speed of sound is calculated by using the formula —

$$V = \frac{\text{Distance}}{\text{Time}} = \frac{d}{t} \text{ m s}^{-1}$$

In the experiment the speed of sound determined is not very accurate because of the personal error of the two observers and the variation in temperature and humidity of air in between the places A and B.

Exercise 8(A) — Numericals

Question 1

The heart of a man beats 75 times a minute. What is it's (a) frequency and (b) time period?

Answer

(a) Given,

Heart beats 75 times a minute

Converting minute into seconds, we get,

1 min = 60 s

As, frequency (f) is the number of times the heart beats in a second

Therefore, we get,

$$\mathrm{f} = \frac{75}{60}$$

$$\mathrm{f} = 1.25\ \mathrm{s}^{-1}$$

Hence, **Frequency = 1.25 s^{-1}**

(b) Time period t = $\frac{1}{\mathrm{f}}$

Substituting the values, we get,

$$\mathrm{t} = \frac{1}{1.25}$$

$$\mathrm{t} = 0.8\ s$$

Hence, **t = 0.8 s**

Question 2

The time period of a simple pendulum is 2 s. Find it's frequency.

Answer

Given,

time (t) = 2 s

frequency = ?

As,

Frequency (f) = $\frac{1}{t}$

Substituting the values, we get,

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

$$f = 0.5 \text{ Hz}$$

Hence, **f = 0.5 Hz**

Question 3

The separation between two consecutive crests in a transverse wave is 100 m. If wave velocity is 20 m s^{-1}, find the frequency of wave.

Answer

Given,

wavelength (λ) = 100 m

wave velocity (V)= 20 m s^{-1}

Frequency (f) = ?

As we know,

Wave velocity (V) = Frequency (f) x Wavelength (λ)

Substituting the values, we get,

$$20 = f \times 100$$

$$\Rightarrow f = \frac{20}{}$$

$$f = 0.2\ \text{Hz}$$

Hence, **f = 0.2 Hz**

Question 4

A longitudinal wave travels at a speed of 0.3 m s^{-1} and the frequency of a wave is 20 Hz. Find the separation between the two consecutive compressions.

Answer

Given,

Wave velocity (V)= 0.3 m s^{-1}

frequency (f) = 20 Hz

wavelength (λ) = ?

As we know,

Wave velocity (V) = Frequency (f) x Wavelength (λ)

Substituting the values, we get,

$$0.3 = 20 \times \lambda$$
$$\Rightarrow \lambda = \frac{0.3}{20}$$
$$\Rightarrow \lambda = \frac{3}{200}$$
$$\Rightarrow \lambda = 1.5 \times 10^{-2}\ \text{m}$$

Hence, **the separation between the two consecutive compressions which is the wave length = 1.5 x 10^{-2} m (or 1.5 cm)**

Question 5

A source of wave produces 40 crests and 40 troughs in 0.4 s. What is the frequency of the wave?

Answer

Given,

One crest and one trough make one wave, hence there are 40 waves.

time (t) = 0.4 s

frequency f = ?

Frequency is the number of waves per second,

$$f = \frac{40}{0.4}$$

$$\Rightarrow f = 100 \text{ Hz}$$

Hence,

Frequency of the wave = 100 Hz

Question 6

An observer A fires a gun and another observer B at a distance 1650 m away from A hears it's sound. If the speed of sound is 330

m s^{-1}, find the time when B will hear the sound after firing by A.

Answer

Given,

Distance between A and B = 1650 m

Speed (V)= 330 m s^{-1}

time t = ?

$$V = \frac{\text{Distance (d)}}{\text{Time (t)}}$$

Substituting the values, we get,

$$330 = \frac{1650}{t}$$
$$\Rightarrow t = \frac{1650}{330}$$
$$\Rightarrow t = 5\ s$$

Therefore, **the time when B will hear the sound after firing by A = 5 s.**

Question 7

The time interval between a lightning flash and the first sound of thunder is 5 s. If the speed of sound in air is 330 m s^{-1} , find the distance of flash from the observer.

Answer

Given,

Time interval (t) = 5 s

Speed (V) = 330 m s^{-1}

distance (d) = ?

$$V = \frac{\text{Distance (d)}}{\text{Time (t)}}$$

Substituting the values, we get,

$$330 = \frac{d}{5}$$

$$\Rightarrow d = 330 \times 5$$

$$\Rightarrow d = 1650 \text{ m}$$

Therefore, **the distance of flash from the observer = 1650 s.**

Question 8

A boy fires a gun and another boy at a distance hears the sound of fire 2.5 s after seeing the flash. If speed of sound in air is 340 m s^{-1} , find the distance between the boys.

Answer

Given,

Time (t)= 2.5 s

Speed of sound (V) = 340 m s^{-1}

Distance (d) = ?

$$V = \frac{\text{Distance (d)}}{\text{Time (t)}}$$

Substituting the values, we get,

$$340 = \frac{d}{2.5}$$

$$\Rightarrow d = 340 \times 2.5$$

$$\Rightarrow d = 850 \text{ m}$$

Therefore, **the distance between the boys = 850 m.**

Question 9

An observer sitting in line of two tanks, watches the flashes of two tanks firing at each other at the same time, but he hears the sounds of two shots 2s and 3.5s after seeing the flashes. If distance between the two tanks is 510 m, find the speed of sound.

Answer

Given,

Time taken to hear the sound of tank 1 = 2 s

Time taken to hear the sound of tank 2 = 3.5 s

Time interval = 3.5 – 2 = 1.5 s

Distance between two tanks = 510 m

Velocity (V) = ?

$$V = \frac{\text{Distance (d)}}{\text{Time (t)}}$$

Substituting the values, we get,

$$V = \frac{510}{1.5}$$

$$\Rightarrow V = 340 \text{ m s}^{-1}$$

Therefore, **the speed of sound = 340 m s^{-1} .**

Question 10

How long will sound take to travel in (a) an iron rail and (b) air, both 3.3 km in length? Take speed of sound in air to be 330 m s^{-1} and in iron to be 5280 m s^{-1} .

Answer

(a) Given,

Length of the iron rail = 3.3 km

Converting km to m, we get,

1 km = 1000 m

Therefore, 3.3 km = 1000 x 3.3 = 3300 m

Speed of the sound in iron (V) = 5280 m s^{-1}

t = ?

$$V = \frac{\text{Distance (d)}}{\text{Time (t)}}$$

$$5280 = \frac{3300}{\mathrm{t}}$$

$$\Rightarrow \mathrm{t} = \frac{3300}{5280}$$

$$\Rightarrow \mathrm{t} = 0.625 \text{ s}$$

Therefore, **the time taken by sound to travel in iron rail = 0.625 s**

(b) Speed of sound in air = 330 m s^{-1}

Substituting the values in the above formula, we get,

$$330 = \frac{3300}{t}$$

$$\Rightarrow t = \frac{3300}{330}$$

$$\Rightarrow t = 10 \text{ s}$$

Therefore, **the time taken by sound to travel in air = 10 s**

Question 11

Assuming the speed of sound in air equal to 340 m s^{-1} and in water equal to 1360 m s^{-1} , find the time taken to travel a distance 1700 m by sound in (i) air and (ii) water.

Answer

(i) Given,

Speed of sound in air (V_a) = 340 m s^{-1}

Speed of sound in water (V_w) = 1360 m s^{-1}

Distance (d) = 1700 m

t = ?

$$V = \frac{\text{Distance (d)}}{\text{Time (t)}}$$

Substituting the values for air, we get,

$$340 = \frac{1700}{t}$$
$$\Rightarrow t = \frac{1700}{340}$$
$$\Rightarrow t = 5 \text{ s}$$

Therefore, **the time taken by sound to travel in air = 5 s**

(ii) Substituting the values for water, we get,

$$1360 = \frac{1700}{t}$$
$$\Rightarrow t = \frac{1700}{1360}$$
$$\Rightarrow t = 1.25 \text{ s}$$

Therefore, **the time taken by sound to travel in air = 1.25 s**

Exercise 8(B) — Multiple Choice Type

Question 1(i)

A man can hear a sound of frequency :

1. 1 Hz
2. 1000 Hz
3. 200 Hz
4. 5 MHz

Answer

1000 Hz

Reason — The audible range of frequency for humans is **20 Hz to 20 kHz**. Hence, a man can hear the sound of frequency **1000 Hz.**

Question 1(ii)

The speed of ultrasound in air is :

1. the same as audible sound
2. less than audible sound
3. more than audible sound
4. equal to the speed of light

Answer

the same as audible sound

Reason — The speed of ultrasound in air is the same as audible sound i.e. 330 m s^{-1} .

Question 1(iii)

Echo-cardiography is used to obtain the image of

1. lungs

2. liver
3 heart
4. kidney

Answer

heart

Reason — Echo-cardiography is used to obtain the image of heart.

Question 1(iv)

Elephants produce ..... sound :

1. ultrasonic
2. infrasonic
3. supersonic
4. none of the above

Answer

infrasonic

Reason — Elephants and whales can produce infrasonic sounds of frequencies less than 20 Hz.

Question 1(v)

..... can hear the highest frequency range of sound.

1. Whales
2. Dogs

3. Cats
4. Bats

Answer

Bats

Reason — Bats can hear the highest frequency range of sound of 100 kHz.

Question 1(vi)

Choose the correct statement :

1. Ultrasonic waves travel faster than supersonic waves.
2. Sonic waves travel faster than supersonic waves.
3. Sonic waves travel faster than ultrasonic waves.
4. Sonic and ultrasonic waves travel with the same speed.

Answer

Sonic and ultrasonic waves travel with the same speed.

Reason — Sonic and ultrasonic waves travel with the same speed of 330 m s^{-1} .

Question 1(vii)

The sound of frequency less than 20 Hz is called :

1. supersonic
2. infrasonic
3. ultrasonic
4. ultrasound

Answer

infrasonic

Reason — The sound of frequency in the range 20 Hz to 20 kHz is called the sonic or audible sound; the sound of frequency less than 20 Hz is called infrasonic and greater than 20 kHz is called ultrasonic.

Question 1(viii)

The properties of ultrasound that make it useful, are:

1. High power and high speed
2. High power and good directivity
3. High frequency and high speed
4. High frequency and bending around the objects

Answer

High power and good directivity

Reason — Properties of ultrasound that make it useful to us are:

1. The energy carried by ultrasound is very high.
2. The ultrasound can travel along a well defined straight path. It does not bend appreciably at the edges of an obstacle because of it's small wavelength (i.e., it has high directivity).

Question 1(ix)

Sonar makes use of:

1. Infrasonic sound
2. Ultrasound
3. Supersonic sound
4. Light

Answer

Ultrasound

Reason — In SONAR (abbreviated form of sound navigation and ranging), to detect and find the distance of objects under water, ultrasound is used.

Exercise 8(B) — Assertion Reason Type

Question 2(i)

Assertion (A) : Sound waves cannot travel through vacuum.

S S

Rea on (R) : Sound travels in the form of longitudinal waves.

1. both A and R are true and R is the correct explanation of A
2. both A and R are true and R is not the correct explanation of A
3. assertion is false but reason is true
4. assertion is true but reason is false

Answer

both A and R are true and R is the correct explanation of A

Explanation

Assertion (A) is true because sound needs a material medium (solid, liquid, or gas) to propagate and in vacuum, there are no particles to transmit the vibrations — so sound cannot travel.

Reason (R) is true because in most media (especially air), sound propagates as longitudinal waves, where particles oscillate parallel to the direction of wave propagation.

Question 2(ii)

Assertion (A) : The speed of sound is maximum in gases when compared with speed in solids.

s

Rea on (R) : The speed of ound in a medium depends on the density of medium.

1. both A and R are true and R is the correct explanation of A
2. both A and R are true and R is not the correct explanation of A
3. assertion is false but reason is true
4. assertion is true but reason is false

Answer

assertion is false but reason is true

Explanation

Assertion (A) is false because the speed of sound is different in different media. The speed of sound is more in solids, less in liquids and least in gases since solids are much more elastic than liquids and gases.

Reason (R) is true because the speed of sound in a medium depends on the following two factors :

(i) the elasticity E of the medium, and

(ii) the density p of the medium.

The speed of sound in a medium is given by the relation :

$$V = \sqrt{\frac{E}{\rho}}$$

S S

Que tion 2(iii)

Assertion (A) : Sound travels faster in humid air than in dry air.

Reason (R) : The increase of moisture in air tends to decrease the density of air.

1. both A and R are true and R is the correct explanation of A
2. both A and R are true and R is not the correct explanation of A
3. assertion is false but reason is true
4. assertion is true but reason is false

Answer

both A and R are true and R is the correct explanation of A

Explanation

Assertion (A) is true because the speed of sound in air increases with the increase in humidity in air due to decrease in density of air.

Reason (R) is true because the density of water vapour is about 5/8th times the density of dry air at ordinary temperature, therefore the increase of moisture in air tends to decrease the density of air.

e s

As lower density du to moi ture increases the speed of sound so reason correctly explains the assertion

Question 2(iv)

Assertion (A) : Two persons on the surface of moon can not talk to each other.

Reason (R) : The speed of sound decreases with the decrease in temperature.

1. both A and R are true and R is the correct explanation of A
2. both A and R are true and R is not the correct explanation of A
3. assertion is false but reason is true
4. assertion is true but reason is false

Answer

both A and R are true and R is not the correct explanation of A

Explanation

Assertion (A) is true because sound requires a material medium so sound cannot travel in vacuum and since on the moon, there is no medium, therefore, one can not hear the sound produced by others.

Reason (R) is true because with the decrease in temperature, the density of gas increases

e s

and consequently the speed of sound decreases and vice versa. In fact, the speed of sound is directly proportional to the square root of temperature of the medium i.e., $V \propto \sqrt{T}$ where T is the temperature of the gas on the Kelvin scale.

While it's true that sound travels slower at lower temperature, this is not the reason why people can't talk on the Moon so, here reason does not justify the assertion.

Question 2(v)

Assertion (A) : The speed of ultrasound waves is higher than supersonic waves.

Reason (R) : Supersonic is used for objects travelling with speed greater than speed of sound in air.

1. both A and R are true and R is the correct explanation of A
2. both A and R are true and R is not the correct explanation of A
3. assertion is false but reason is true
4. assertion is true but reason is false

Answer

assertion is false but reason is true

Explanation

Assertion (A) is fals becau e ultrasound refers to sound waves with frequencies above 20,000 Hz, but they still travel at the speed of sound in a given medium while supersonic refers to objects moving faster than the speed of sound in air. So, the ultrasound does not have a speed higher than "supersonic"; in fact, supersonic objects exceed the speed of sound, while ultrasound is still sound, just at high frequency.

Reason (R) is true because supersonic word is used for objects which travel with a speed greater than the speed of sound in air (i.e., 330 m/s or Mach 1).

Exercise 8(B) — Very Short Answer Type

Question 1

What do you mean by the audible range of frequency?

Answer

The **range of frequency within which the sound can be heard by a human being** is called the audible range of frequency.

Question 2

What is the audible range of frequency for humans?

e

Answer

The audible range of frequency for humans is **20 Hz to 20 kHz**.

Question 3

For which range of frequencies are the human ears most sensitive?

Answer

The human ears are most sensitive in the range **2000 Hz to 3000 Hz**, where it can hear even a very feeble sound.

Question 4

Which has a higher frequency — ultrasonic sound or infrasonic sound?

Answer

Ultrasonic sound has higher frequency.

Question 5

Complete the following sentences —

(a) An average person can hear sounds of frequencies in the range ..... to .....

(b) Ultrasound is of frequency .....

(c) Infrasonic sound is of frequency .....

(d) Bats can produc and hear ..... sound.

(e) Elephants produce ..... sound.

Answer

(a) An average person can hear sound of frequencies in the range ***20 Hz*** to ***20 kHz***

(b) Ultrasound is of frequency ***above 20 kHz***

(c) Infrasonic sound is of frequency ***below 20 Hz***

(d) Bats can produce and hear ***ultrasonic*** sound

(e) Elephants produce ***infrasonic*** sound

Question 6

Name the sounds of the frequencies given below —

(a) 10 Hz

(b) 100 Hz

(c) 1000 Hz

(d) 40 kHz

Answer

(a) 10 Hz → **Infrasonic sound**.

(b) 100 Hz → **Audible sound**.

e

(c) 1000 Hz → **Audible sound**.

(d) 40 Hz → **Ultrasonic sound**.

Question 7

What is ultrasound?

Answer

The **sound of frequency range of above 20 kHz** is called ultrasound.

Question 8

State the approximate speed of ultrasound in air.

Answer

The approximate speed of ultrasound in air is **330 m s^{-1}** .

Exercise 8(B) — Short Answer Type

Question 1

Can you hear the sound produced due to vibrations of a seconds' pendulum? Give reason.

Answer

No, we cannot hear the sound produced due to vibrations of a seconds' pendulum because the frequency of sound produced due to vibrations of a seconds' pendulum is 0.5 Hz

which is an infrasonic sound and human ears cannot hear infrasonic sound.

Question 2

State two properties of ultrasound that make it useful to us.

Answer

Properties of ultrasound that make it useful to us are —

1. The **energy carried by ultrasound is very high**.
2. The ultrasound can travel along a well defined straight path. It does not bend appreciably at the edges of an obstacle because of it's small wavelength (i.e., it has **high directivity**).

Question 3

State two applications of ultrasound.

Answer

The applications of ultrasound are as follows —

1. Ultrasound is used in surgery to remove cataract and in kidney to break the small stones into fine grains.
2. Ultrasound is used for drilling holes or making cuts of desired shapes in

materials like glass.

Exercise 8(B) — Long Answer Type

Question 1

Differentiate between infrasonic, sonic, ultrasonic and supersonic sounds.

Answer

Infrasonic sounds	Sonic sounds	Ultrasonic sounds
The sound of frequency less than 20 Hz is called infrasonic sound.	The sound of frequency in the range 20 Hz to 20 kHz is called the sonic or audible sound.	The sound of frequency greater than 20 kHz is called ultrasonic sound.
Infrasonic sound is produced by some animals (e.g. Elephants,	Sonic sounds are within the range of human hearing. Day to day sounds that we hear	Ultrasonic sounds are used in medical imaging, industrial testing and

Infrasonic sounds	Sonic sounds	Ultrasonic sounds
Whales) and certain industrial processes.	like speech, music, and environmental noises are examples of sonic sounds.	cleaning processes. Some animal such as bats and dolphins produce ultrasonic sound for communicati and navigation.

Question 2

Explain how do bats locate the obstacles and prey in their way.

Answer

Bats avoid obstacles in their path by producing and hearing the ultrasound. They produce ultrasound which returns after striking an obstacle in their way. By hearing the reflected sound, they judge the direction of the obstacle in their way and from the time interval (when they produce ultrasound and then receive them back), they judge the distance of the obstacle.

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