Exercise-8(A)

What causes sound?

Solution:

Sound is caused when a body vibrates.

1. **What is sound? How is it produced?**

Solution:

Sound is a form of energy that produces the sensation of hearing in our ears. Sound is produced by vibrations.

Example of sound production –

When a string is stretched by holding one end in mouth between the teeth and the other end in one hand, plucking the string by the other hand near the middle generates a vibration, causing sound to be produced.

2. **Complete the following sentence:**
Sound is produced by a ____________body.

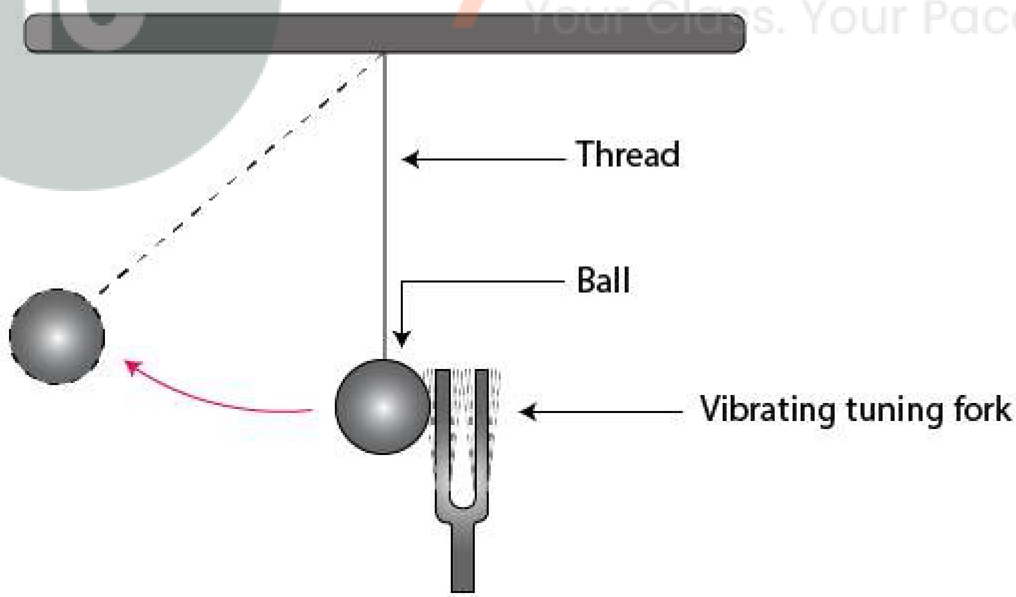
Solution:

Vibrating

3. **Describe a simple experiment which demonstrates that the sound produced by a tuning fork is due to vibrations of its arms.**

Solution:

Experiment to demonstrate that sound produced by a tuning fork is due to vibrations of the arms:



- Strike one arm of a tuning fork on a rubber pad and place it close to a tennis ball suspended by a thread
- Note that when the arm of the vibrating tuning fork is placed close to the ball, it jumps to and fro causing the sound of the vibrating tuning fork to be heard

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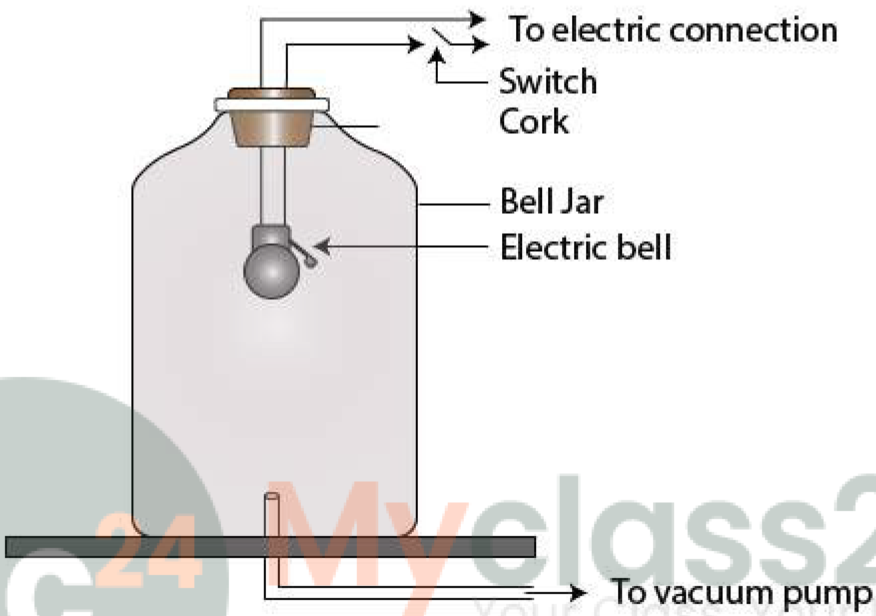
- When the arms stop vibrating, the ball becomes stationary, sound is not heard

4. **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.**

Solution:

Following is an experiment that demonstrates that a material medium is required for the propagation of sound:



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- Suspend an electric bell in a bell jar, which is connected to a vaccum pump as observed in the figure
- The circuit of the electric bell is completed, when the key is pressed
- The hammer of the electric bell is observed to strike the gong constantly, and the sound of the bell is heard
- Air is eventually withdrawn from the jar by starting the vaccum, keeping the key pressed still.
- Note that the loudness of sound keeps declining as the air is taken out from the bell jar, no sound is heard finally when the jar is completely void of air.
- The hammer of electric bell is still seen striking the gong constantly indicating that the gong is still vibrating, generating sound, but is not heard.

Explanation –

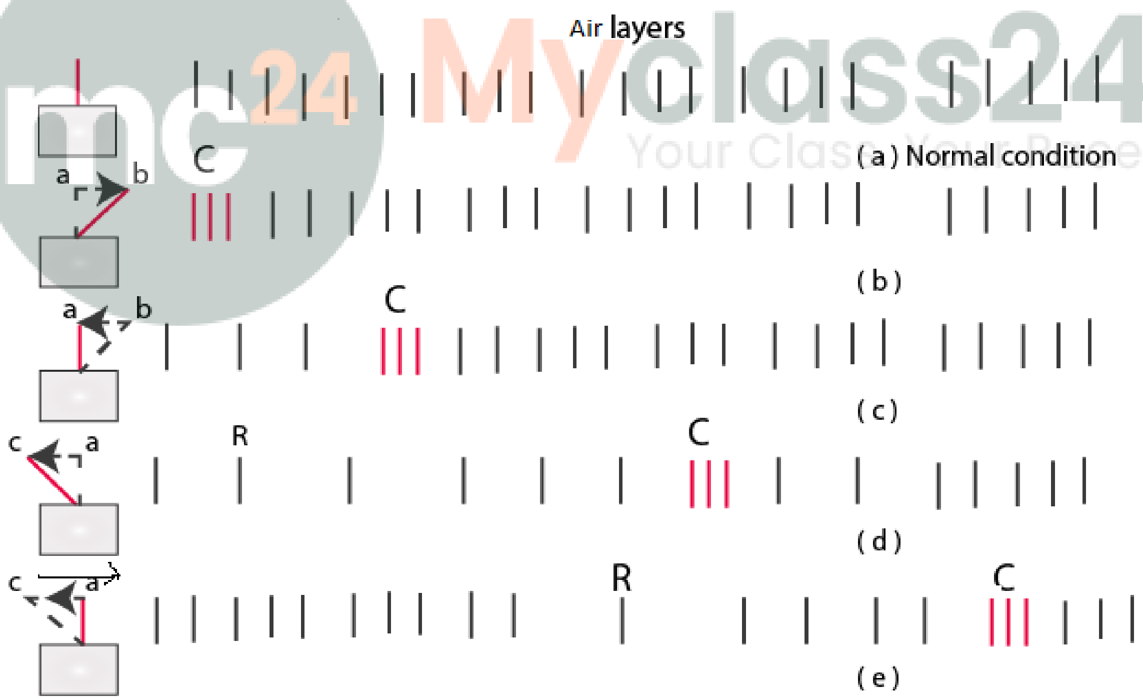
- When the hammer hits the gong, sound is produced due to vibration of the gong that travels through the air to the wall of the jar.
- It causes the walls to vibrate due to which the air outside the jar is also set in vibration, hence sound is heard by us
- When air is withdrawn from the jar, sound that is caused by the gong's vibrations cannot travel to the wall of the jar, hence wall could not vibrate and sound is not heard.

This demonstrates that sounds requires a material medium to propagate, and cannot travel through vaccum.

5. **There is no atmosphere on moon. Can you hear each other on the moon's surface?**
   Solution:
   No, we cannot hear each other on the surface of the moon. This is because of vaccum on moon. Sound requires a material medium to propagate.

6. **State three characteristics of the medium required for propagation of sound in a medium.**
   Solution:
   The three characteristics of the medium necessary for sound propagation in a medium are:
   - The medium is required to be elastic so that its particles may revert to their initial position after displacement on either side. In other words, the particles are capable of vibrating about their mean positions.
   - The medium must have inertia in order for the particles to store mechanical energy.
   - The medium should be frictionless such that there is no loss of energy in propagation of sound through it

7. **Explain with an example, the propagation of sound in a medium.**
   Solution:



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- A vertical metal strip with its lower end secured and upper end suspended free to vibrate as seen in figure is used.
- As observed in the figure, when the strip is moved from a to b, the air present in that area is compressed at point C.
- The particles present in this layer, compress the layer next to it, which in turn compresses the layer next to it and the process continues.
- Therefore, the disturbance advances in the form of compression while the particles are still intact in their original positions, without being displaced from their mean positions.
- As observed, when the strip reverts from b to a, after propelling the particles forward, the compression moves forward, the air particles near the strip bounce to their original position.
- When the strip moves from a to c as observed in the figure, it pushes the layer of air near it towards left, causing a low pressure space on the right side. The layers of air get rarefied, the region is known as rarefaction.
- As observed in the figure, when the strip reverts from C to its mean position A, the rarefaction R travels forward and air near the strip return to their normal positions.
- Hence, one full to and fro motion of the strip produces one compression and one rarefaction, generating one wave. This wave through which sound propagates in air is known as longitudinal wave.

8. 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.

Solution:

The disturbance

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

Solution:

The two kinds of waves in form of which sound travels in a medium are as follows:

- Transverse waves
- Longitudinal waves

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

Solution:

It is a wave in which the particles of a 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.

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

Solution:

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

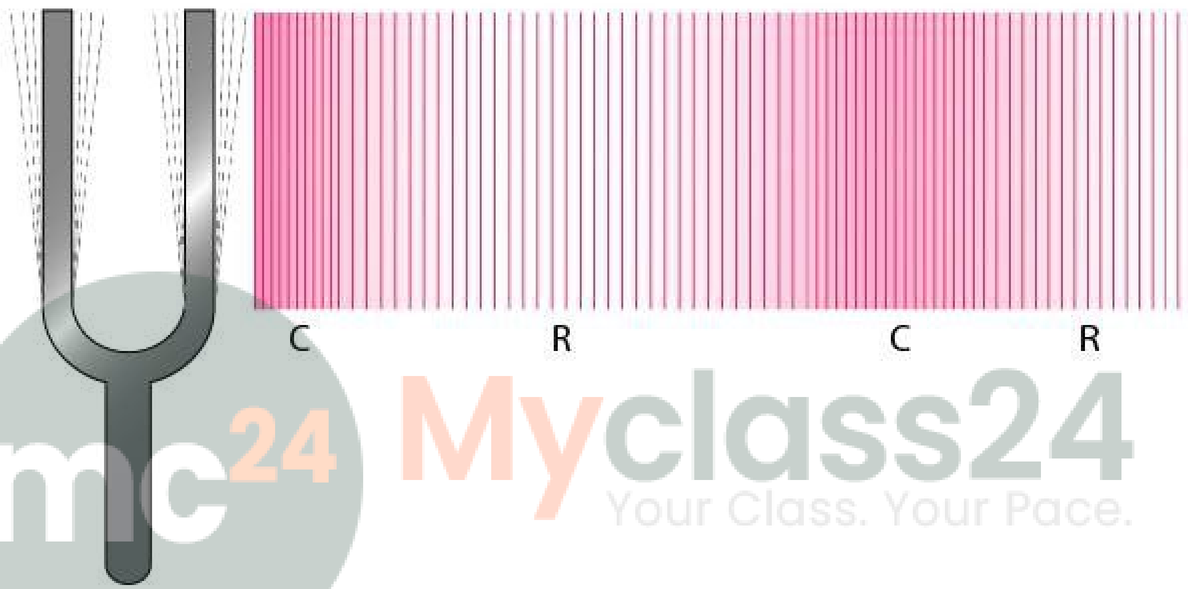
Transverse waves can only be produced in solids and on the surface of liquids. They cannot be produced inside liquids and in gases.

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

Solution:

Compression – When a vibrating object advances, it pushes and compresses the air that is in front of it, thus creating a region of high pressure, the region is called compression C as observed in the figure. The compression begins to drift away from the object that vibrates. When the vibrating object moves backwards, it creates an area of low pressure known as rarefaction as observed in the figure.

Rarefaction is the region of low density, wherein the particles of the medium move away from each other, compressions on the other hand, are the regions of high density where the particles of the medium are very close to each other.



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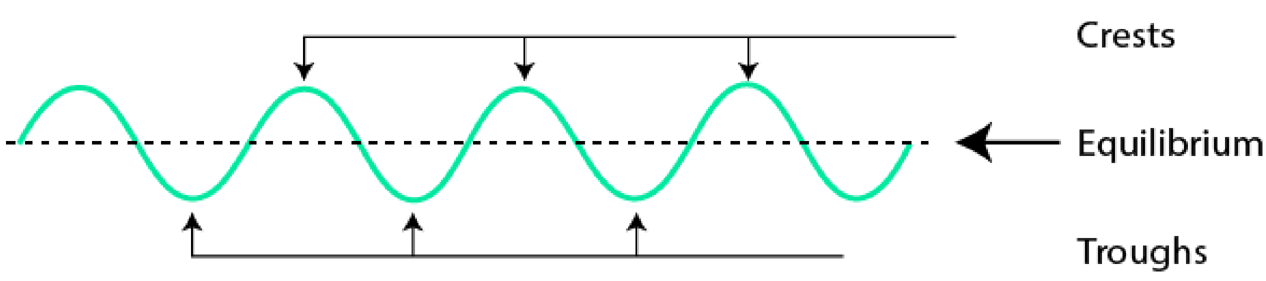
13. Explain the terms crest and trough in relation to a transverse wave.

Solution:

A transverse is composed of a crest and trough. Crest is the position of maximum upward displacement while trough is the position of maximum downward displacement.



Crests and Troughsin a transverse wave

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

Solution:

The following is the experiment:

When a stone is dropped in still water of a pond, the sound of a stone striking the water surface is heard, which is actually a disturbance produced in water at the point where the stone strikes it. The disturbance propagates radially outwards, in all directions in the form of circular waves on the water surface.

If a piece of cork is placed on the surface of water at a distance away from the point where the stone strikes it, it is observed that the cork does not move forward, but it vibrates up and down, the wave still moves ahead. It is because water particles begin to vibrate upwards and downwards at the same point where the stone strikes. These particles then transmit their energy to the adjacent particles causing them to revert to their mean positions.

Hence, particles do not move but only transfer energy to other particles.

15. Define the term amplitude of a wave. Write its S.I. unit.

Solution:

Amplitude of a wave can be defined as the maximum displacement of the particle of a medium on either side of its mean position when a wave passes through a medium. The S.I. unit of amplitude is metre (m).

16. What do you mean by the term frequency of a wave? State its S.I. unit.

Solution:

Frequency of a wave can be defined as the number of vibrations made by a particle of medium in one second. The S.I. unit of frequency is $(\text{second})^{-1}$ or hertz (Hz)

17. How is the frequency of a wave related to its time period?

Solution:

The relation is expressed as follows:

Frequency = 1/time period

18. Define the term wave velocity. Write its S.I. unit.

Solution:

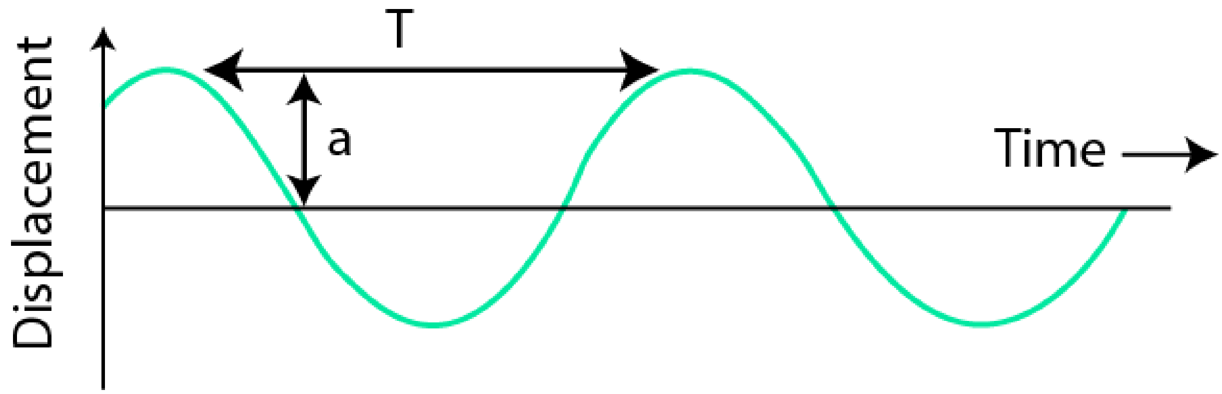
Wave velocity can be defined as the distance travelled by a wave in one second. It is also known as wave speed.

Its S.I. unit is metre per second ($m\ s^{-1}$)

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

Solution:

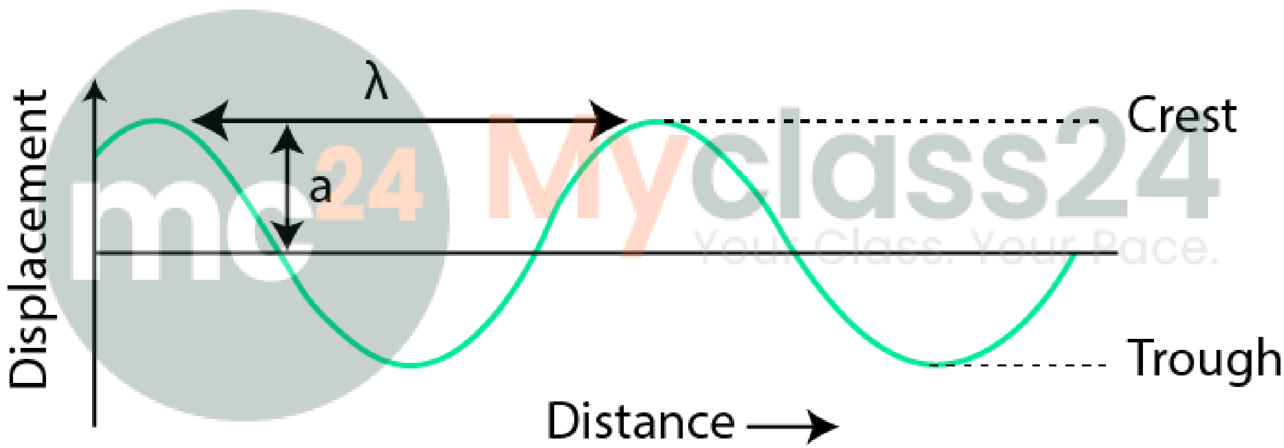
The displacement-time graph is as below:



20. 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

Solution:

The displacement-time graph is as shown below:



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

Solution:

They are related in the following way:

$$V = f\lambda$$

Where, V is the wave velocity, f is the frequency and λ is the wavelength

Derivation is as follows:

Let V be the wave velocity, T be the time period, f be the frequency, and λ be the wavelength

We know from the definition of wavelength,

Wavelength λ = distance covered by a wave in one unit of time period or in T seconds

= wave velocity x time period

$\lambda = V \times T$-------------------------------(i)

But, we know that, $T = 1/f$

Substituting this value of T in equation (i), we get;

$V \times (1/f) = \lambda$

$V = f\lambda$

Hence, wave velocity = frequency x wavelength

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

Solution:

The two properties of the medium on which the speed of the sound in it depends are as follows:

- Density
- Elasticity

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

Solution:

The speed of sound in solids, liquids and gases in ascending order is as follows:

$V_g < V_l < V_s$

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

Solution:

The speed is as follows:

(i) Light = 3×10^8 m/s

(ii) Sound in air = 330 m/s

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

Solution:

The speed of sound in air is 330 m/s

The speed of sound in water is 1450 m/s

The speed of sound in steel is 5100 m/s

Therefore, the comparison gives 1:4:15

26. Answer the following:

(i) Can sound travel in vaccum?

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

Solution:

(i) No, sound cannot travel in vaccum. As there are no particles in vaccum to propagate sound

(ii) The speed of sounds differs in different media. It is maximum in solids, comparatively lesser in liquids and the least in gases.

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

Solution:

It is because light travels much faster than sound. Speed of light is 3×10^8 m/s.

28. If you place your ear close to an iron railing which is tapped some distance away, you hear the

sound twice. Explain why?

Solution:

It is because sound travels faster in iron than in air. Hence, we first hear the sound through the iron rail and then we hear the sound through air.

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

(i) Who would hear the sound first: boat man or diver?

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

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

Solution:

(i) The sound of explosion would first be heard by the diver

(ii) The sound is first heard by the diver as sound travels faster in water than in air

(iii) 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

30. How do the following factors affect, if at all, the speed of sound in air:

(i) Frequency of air

(ii) Temperature of air

(iii) Pressure of air

(iv) Moisture in air?

Solution:

The following factors affect the speed of sound in the following means:

(i) Frequency of air – Speed of sound is not affected

(ii) Temperature of air – speed of sound increases with an increase in the temperature

(iii) Pressure of air – Speed of sound is not affected

(iv) Moisture in air – Speed of sound increases with an increase in the moisture level in air

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

Solution:

The speed of sound is affected in the following ways:

(i) Amplitude – speed of sound does not change with amplitude

(ii) Wavelength of sound wave – speed of sound does not change with the wavelength of sound wave

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

Solution:

The speed of sound is more in humid air compared to dry air. It is because the density of air decreases with an increase in moisture level and $V \propto (1/\sqrt{\rho})$.

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

Solution:

The speed of sound in air varies. It increases by 0.61 m/s for each 1°C rise in temperature.

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

Solution:

In order to calculate the speed of sound in air a simple experiment can be carried out.

Let a person stand at a known distance say 'd' meter from the cliff, and fire a pistol, start the stopwatch simultaneously. As soon as the person hears the echo, he stops the stopwatch.

Distance travelled by sound in time t seconds is 2d

Therefore, speed of sound = distance covered/time taken = 2d/t

The approximation that is made is that the speed of sound stays the same for the time when the experiment is taking place.

35. Complete the following sentences:

(a) Sound cannot travel through __________but 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

Solution:

(a) Vaccum, medium
(b) Do not move, moves ahead
(c) Rarefaction
(d) Trough
(e) Frequency

Multiple choice type:

1. **The correct statement is:**
   (a) Sound and light both require medium for propagation
   (b) Sound can travel in vaccum, but light cannot
   (c) Sound needs medium, but light does not need medium for its propagation
   (d) Sound and light both can travel in vaccum
   Solution:
   (c) Sound needs medium, but light does not need medium for its propagation

2. **The speed of sound in air at 0 ° is nearly:**
   (a) 1450 m/s
   (b) 450 m/s
   (c) 5100 m/s

(d) 330 m/s
Solution:
(d) 330 m/s

3. **Sound in air propagates in form of:**
(a) Longitudinal wave
(b) Transverse wave
(c) Both longitudinal and transverse wave
(d) Neither longitudinal nor transverse wave
Solution:
(a) Longitudinal wave

4. **The speed of light in air is:**
(a) 3×10^8 m/s
(b) 330 m/s
(c) 5100 m/s
(d) 3×10^{10} m/s
Solution:
(a) 3×10^8 m/s

Numericals:

1. **The heart of a man beats 75 times a minute. What is its (a) frequency and (b) time period?**
Solution:
Given: t = 75 minutes or 4500 seconds
Frequency = ? Time period = ?
(a) Frequency is the number of time the heart beats in a second
$F = 75/60 = 1.25 s^{-1}$
(b) Time period = 1/f
= 1/1.25
= 0.8s

2. **The time period of a simple pendulum is 2s. Find its frequency**.
Solution:
Given: t=2s, frequency = ?
Frequency = 1/t
= ½ = 0.5 Hz

3. **The separation between two consecutive crests in a transverse wave is 100m. If wave velocity is 20 m s^{-1}, find the frequency of wave.**
Solution:
Given: wave velocity = 20 m/s, wavelength = 100m
As we know,
Wave velocity = frequency x wavelength
⇨ Frequency = wave velocity / wavelength
⇨ Frequency = 20/100

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⇨ Frequency = 0.2Hz

4. **A longitudinal wave travels at a speed of 0.3 m/s and the frequency of a wave is 20Hz. Find the separation between the two consecutive compressions.**

Solution:

Given:

Wave velocity = 0.3 m/s, frequency = 20 Hz,

To find the wavelength (as wavelength is the separation between two consecutive compressions of a wave)

As we know,

Wave velocity = frequency x wavelength

Wavelength = wave velocity / frequency

= 0.3 / 20

= 1.5×10^{-2}m

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

Solution:

To find the frequency of the wave:

Frequency is the number of waves per second

$\therefore \text{Frequency} = 40/0.4 = 100\text{Hz}$

6. **An observer A fires a gun and another observer B at a distance 1650m away from A hears its sound. If the speed of sound is 330m/s, find the time when B will hear the sound after firing by A.**

Solution:

Distance between observer A and B = 1650m

Speed of sound = 330 m/s

Time at which the observer B hears the sound = distance covered/speed

= 1650/330

= 5s

7. **The time interval between a lightning flash and the first sound of thunder is 5s. If the speed of sound in air is 330 m/s, find the distance of flash from the observer.**

Solution:

Given: Speed of sound = 330 m/s

Time interval between lighting and thunder = 5s

Distance of flash from the observer = speed x time taken

= 330 x 5 = 1650 m

8. **A boy fires a gun and another boy at a distance hears the sound of fire 2.5s after seeing the flash. If speed of sound in air is 340m/s, find the distance between the boys.**

Solution:

Given: Speed of sound = 340 m/s

Time taken to hear the sound = 2.5s

Distance between the boy and the flash = speed x time taken

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= 340 x 2.5 = 850m

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 510m, find the speed of sound.

Solution:

Given:

Distance between tank A and B = 510m

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

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

Time taken by B to hear the sound of tank A = 3.5 – 2 = 1.5s

We know that,

Speed = distance /time

= 510 / 1.5

= 340m/s

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

Solution:

Given:

(a) Speed of the sound in iron = 5280m/s

Length of the iron rail = 3.3km or 3300m

∴ time taken for sound to travel in iron rod = distance/speed

= 3300/5280

= 0.625s

(b) Speed of sound in air = 330m/s

Time taken by sound to travel in iron rod = distance/speed

= 3300/330

= 10s

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

Solution:

Given:

Speed of sound in air = 340 m/s

Speed of sound in water = 1360 m/s

Distance covered = 1700m

(a) To find the time taken by sound to travel in air

Time taken = distance covered/speed

= 1700/340

= 5s

(b) To find the time taken by sound to travel in water

Time taken = distance covered/speed

= 1700/1360

= 1.25s