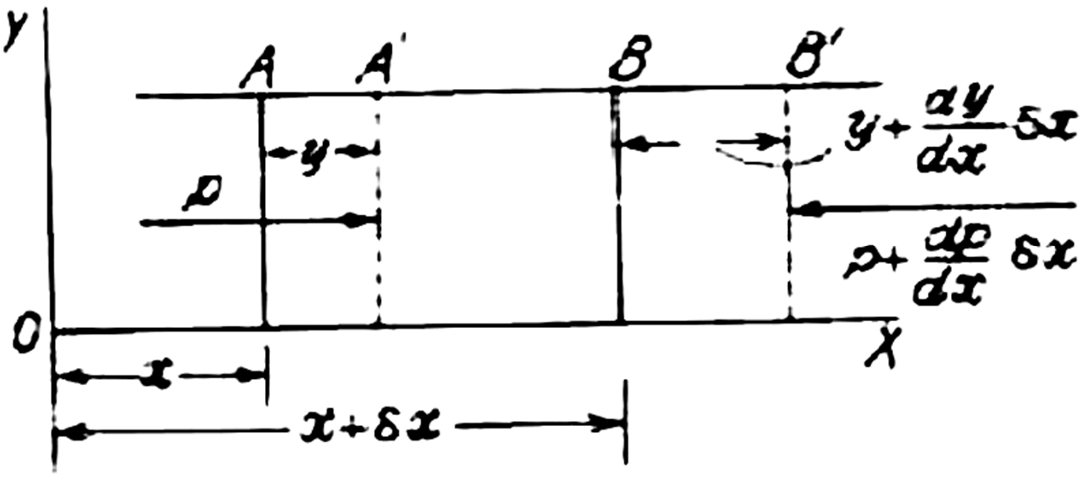
B.Sc. SEMESTER – I
PHYSICS COURSE : US01CPHY01
UNIT – 3 : SOUND

INTRODUCTION TO TRANSVERSE AND LONGITUDINAL WAVES

- ***Longitudinal Waves*** : The longitudinal waves are such that when they pass through any medium, the particles of the medium oscillate about their mean position in the direction of propagation of the wave.
- ***Transverse Waves*** : The transverse waves are such that when they pass through any medium, the particles of the medium oscillate about their mean position in the direction perpendicular to the direction of propagation of the wave.

VELOCITY OF LONGITUDINAL WAVES IN GASEOUS MEDIUM

- Let's consider a tube of unit cross-section area having length L lying along x – axis as shown in the figure below.



- Also let's consider two cross-sections A and B of the tube perpendicular to the axis of the tube having a separation δx between them.
- When a wave passes through the tube, the planes A and B are displaced and acquires positions A' and B'.
- AA' and BB' represent the displacements of the particles at the planes A and B respectively.
- If the displacement at A is 'y', then the displacement at B is given by [y +(dy/dx) δx].

- Thus the wave produces a change in the volume of the gas contained within the volume of the tube between the planes A and B.
- Since the tube is having a unit cross section area, the ***original volume*** of the gas between A and B is

  = cross section area x original length

  = 1 · [(x+δx)-x] = δx
- The volume of the gas confined between the planes A' and B' is the **new volume** and is given by the equation

  New Volume = cross section area x new length

  = 1 x new length

$$= \left[(x+\delta x)+\left(y+\frac{dy}{dx}.\,\delta x\right)\right]-[x+y]=\left(\delta x+\frac{dy}{dx}.\,\delta x\right)$$

then the **increase in volume** = new volume – original volume

$$\therefore \text{ Increase in volume} = \left(\delta x+\frac{dy}{dx}.\,\delta x\right)-\delta x=\frac{dy}{dx}.\,\delta x$$

- $$\text{Now volume strain} = \frac{\text{increase in volume}}{\text{original volume}}$$

$$=\frac{\frac{dy}{dx}.\,\delta x}{\delta x}=\frac{dy}{dx}$$

- Now if the pressure increase on the molecules at A is 'p' then the pressure increase on the molecules at B is

  = [p + (dp/dx) δx]
- These two pressures will act on the sample of the gas confined between the planes A' and B'.
- This pressure will constitute a restoring force on the sample of the gas between the two planes. So the Bulk Modulus (K) of the gas is defined as

$$K=\frac{\text{Stress}}{\text{Strain}}=\frac{-p}{(dy/dx)}$$

- Where the negative sign indicates the increase in the pressure with the decrease in volume. We can write,

$$p = -K\frac{dy}{dx}$$

- The restoring force is also given by

$$\frac{dp}{dx}.\delta x = \frac{d}{dx}\left(-K\frac{dy}{dx}.\delta x\right)$$

$$= -K\frac{d^2y}{dx^2}.\delta x$$

- This force can also be given using the Newton's Second Law of motion as F = ma, where mass 'm' is defined as

$$= \textbf{Volume} \times \textbf{density} = \delta x \times 1 \times \rho = \rho \,.\, \delta x$$

Acceleration from B' to A' $= -d^2y/dt^2$

$\therefore$ **Resultant force from B' to A'**

$$= \textbf{mass} \times \textbf{acceleration}$$

$$= \rho\,\delta x \times (-d^2y/dt^2)$$

$$= \rho\,.\,\delta x\,.\,\frac{d^2y}{dt^2}$$

Hence the equation of motion is

$$-\rho\,.\,\delta x\frac{d^2y}{dt^2} = -K\,.\,\frac{d^2y}{dx^2}\,.\,\delta x$$

or

$$\frac{d^2y}{dt^2} = \frac{K}{\rho}\,.\,\frac{d^2y}{dx^2}$$

Where ρ is the density of the medium.

- The differential equation for a progressive wave is given by the equation

$$\frac{d^2y}{dt^2} = v^2\frac{d^2y}{dx^2}$$

- Then comparing the last two equations we get the velocity of sound waves propagating in a medium to be

$V = \sqrt{(K/\rho)}$

- The above equation is the expression for the velocity of sound waves or the longitudinal waves in gaseous medium or in air.

CALCULATION OF VELOCITY OF SOUND IN AIR

NEWTON'S FORMULA FOR THE VELOCITY OF SOUND IN AIR

- Newton assumed that the phenomenon of propagation of sound in air is an isothermal process.
- He argued that the amount of heat generated in the region of compression is dissipated to the region of rarefaction and the temperature of the medium remains constant.
- Thus for a mass of a gas at pressure p and Volume V we can write the equation

$$pV = \text{Constant}$$

- Differentiating this equation we get

$$p\,dV + V\,dp = 0$$

$$\therefore \quad p = -\frac{dp}{(dV/V)}$$

$$= \frac{\text{Change in pressure}}{\text{Volume strain}}$$

$$= K$$

- Substituting this value of pressure in the velocity equation of the sound waves we get

$$v = \sqrt{\left(\frac{p}{\rho}\right)}$$

This is Newton's formula.

For air at 0°C,

$$p = 76 \times 13.6 \times 980 \text{ dynes/cm}^2$$

$$\text{and} \quad \rho = 0.00129 \text{ gm/c.c.}$$

$$\therefore \quad v = \sqrt{\left(\frac{76 \times 13.6 \times 980}{0.00129}\right)}$$

$$= 280 \text{ metres/sec.}$$

- However, this value is much lower than the experimentally observed value of velocity of sound, which is 332 m/s.

LAPLACE'S FORMULA(CORRECTION) FOR THE VELOCITY OF SOUND IN AIR

- Laplace assumed that the propagation of sound waves through air is not an isothermal process, but it is an adiabatic process.
- He made following arguments in favour of this assumptions:
  (a) Compression and rarefaction take place very rapidly
  (b) Distances between compression and rarefaction regions are very large.
  (c) Poor conductivity of air prevents the heat flow from region of compression to region of rarefaction.
- For an adiabatic process the relation between pressure and volume is

pV^{γ} = constant

Differentiating, $p\gamma V^{\gamma-1}dV + V^{\gamma}dp = 0$

$$p\gamma dV + V\,dp = 0$$

or $$p\gamma = -\frac{dp}{(dV/V)} = K$$

$\therefore$ $$v = \sqrt{\left(\frac{\gamma p}{\rho}\right)}$$

- The above equation is called Laplace's formula. Here γ is the specific heat ratio for the air. The value of γ for air is 1.41.
- The velocity of sound in air can therefore be obtained as

$$v = \sqrt{\left(\frac{1.41 \times 76 \times 13.6 \times 980}{0.00129}\right)}$$

$= 331.6$ metre/sec.

which is in good agreement with the experimental value.

EFFECT OF PRESSURE, TEMPERATURE AND HUMIDITY ON THE SPEED OF SOUND

<u>Effect of Pressure</u>

- If the pressure(p) on a gas changes, the volume(V) and density(ρ) of the gas also changes.
- If the temperature of the gas is constant then from Boyle's law we have

$$p \propto 1/V$$

- We know that the density $\rho \propto 1/V$
- Hence $p \propto \rho$, i.e., p/ρ = constant
- Then from Laplace's formula we can write

$$v = \sqrt{\left(\frac{\gamma p}{\rho}\right)} = \sqrt{\left(\frac{1.41p}{\rho}\right)} = \text{constant}$$

- Hence if the temperature of the gas remains constant, the speed of sound does not change with a change of pressure.

Effect of Temperature

- When the temperature of the gas changes, its density also changes without affecting the pressure.
- Due to this, the speed of sound also changes with temperature.
- Let ρ_o and ρ_t be the densities of the gas at 0°C and t°C respectively.
- The speed of sound at the temperature will be

$$v_0 = \sqrt{\left(\frac{\gamma p}{\rho_0}\right)} \text{ and } v_t = \sqrt{\left(\frac{\gamma p}{\rho_t}\right)}$$

$$\frac{v_t}{v_0} = \sqrt{\frac{\rho_0}{\rho_t}}$$

- According to Charle's law, $\rho_o = \rho_t\,(1-\alpha t)$, where α is the coefficient of expansion of the gas and is equal to 1/273 per °C.
- Hence,

$$\frac{v_t}{v_0} = \sqrt{\left[\frac{\rho_t\,(1+\alpha t)}{\rho_t}\right]} = \sqrt{(1+\alpha t)}$$

$$= \sqrt{\left(1+\frac{t}{273}\right)} = \sqrt{\left(\frac{273+t}{273}\right)}$$

$$= \sqrt{\left(\frac{T_t}{T_0}\right)}$$

Where T_t and T_0 are absolute temperatures.

- Thus the speed of sound is directly proportional to the square root of the absolute temperature.

Effect of Humidity

- If the temperature and pressure remains constant, the density of water vapour is less than that of air.
- Therefore, the presence of the moisture in the water vapour in the same volume of air lowers the density of the mixture.
- Let ρ and ρ' be the densities and γ and γ' be the ratios of the specific heats for dry and moist air respectively at the same pressure.
- Then the velocity of sound in dry air will be

$$v_d = \sqrt{\left(\frac{\gamma p}{\rho}\right)}$$

and velocity of the sound in moist air

$$v_m = \sqrt{\left(\frac{\gamma' p}{\rho'}\right)}$$

$$\therefore \quad \frac{v_m}{v_d} = \sqrt{\left(\frac{\gamma' p}{\gamma \rho'}\right)} = \sqrt{\left(\frac{p}{\rho'}\right)} \quad \left[\text{as } \frac{\gamma'}{\gamma} = 1 \text{ (nearly)}\right]$$

since $\rho > \rho'$ $\therefore$ $v_m > v_d$,

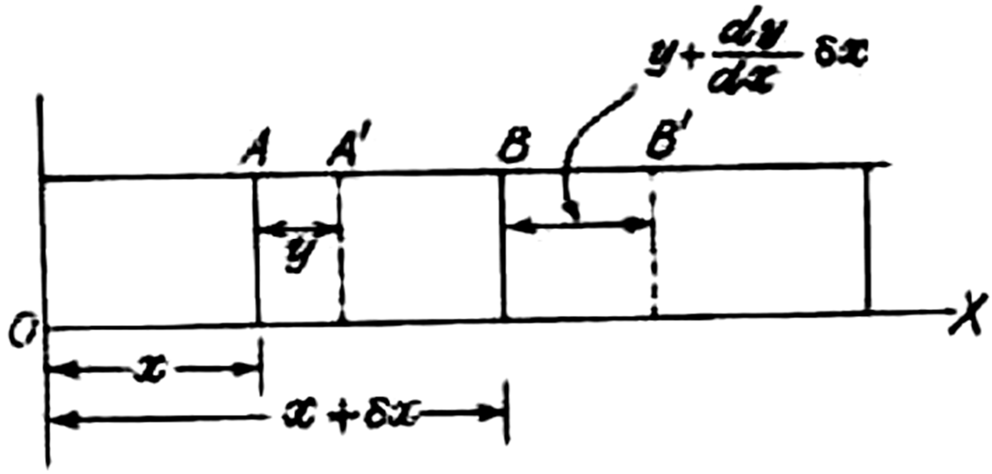
Thus the speed of sound in moist air is greater than in dry air.

Effect of Wind

- If the wind blows in the direction of sound, then the velocity of sound is increased.
- But if the wind blows in the opposite direction, the velocity of sound decreases.

VELOCITY OF SOUND IN METAL ROD(SOLID MEDIUM)

- Consider a solid rectangular metallic rod placed along the X axis.
- Suppose that A and B are the two planes of the rod at distance x and x+δx respectively, from the origin O, as shown in the figure.



- Also assume that a longitudinal wave is passing along the axis of the rod at a particular time t.
- The displacement of plane A is y and the displacement of plane B is [y + (dy/dx)δx] .

Hence increase in length of the rod

$$= \left(y + \frac{dy}{dx}\cdot\delta x\right) - y = \frac{dy}{dx}\cdot\delta x$$

Therefore longitudinal strain

$$= \frac{(dy/dx)\delta x}{\delta x} = \frac{dy}{dx}$$

- If Y is the Young Modulus of the material of the rod, the restoring force acting per unit area on the layer A' is given by

$$f = Y \times \frac{dy}{dx} \qquad \left[\because Y = \frac{\text{stress}}{\text{strain}} = \frac{f}{(dy/dx)}\right]$$

Similarly force acting on plane B' per unit area

$$f + df = Y\frac{d}{dx}\left(y + \frac{dy}{dx}\cdot\delta x\right) = Y\frac{dy}{dx} + Y\frac{d^2y}{dx^2}\cdot\delta x$$

Thus force acting on the rod of length δx

$$df = (f + df) - f$$

$$= Y\frac{dy}{dx} + Y\frac{d^2y}{dx^2}\cdot\delta x - Y\frac{dy}{dx}$$

$$= Y\frac{d^2y}{dx^2}\cdot\delta x \qquad \ldots(1)$$

According to Newton's Law.
Force = mass per unit area × acceleration

$$\therefore \qquad df = \rho.\delta x.\frac{d^2y}{dt^2} \qquad ...(2)$$

where ρ is the density of the material of the rod

$$\rho.\delta x.\frac{d^2y}{dt^2} = Y\frac{d^2y}{dx^2}.\delta x$$

$$\text{or} \qquad \frac{d^2y}{dt^2} = \frac{Y}{\rho}\frac{d^2y}{dx^2} \qquad ...(3)$$

Comparing it with characteristic differential equation of wave motion

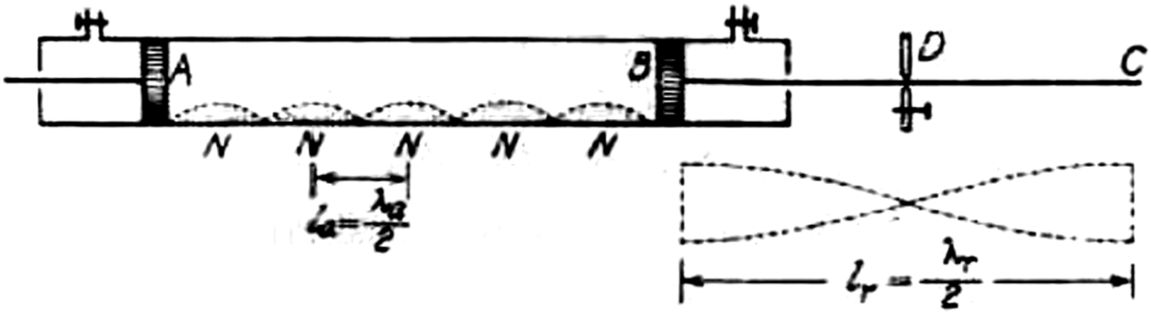
$$\frac{d^2y}{dt^2} = v^2\frac{d^2y}{dx^2}$$

$$\therefore \qquad v^2 = \frac{Y}{\rho} \text{ or } v = \sqrt{\left(\frac{Y}{\rho}\right)}. \qquad ...(4)$$

This is the required expression.

KUNDT'S TUBE

- Kundt devised an experimental method to study the velocities of sound in different materials.
- The method is used to determine the velocity of sound in solids in the form of rods and also in gases.



- As shown in the figure, the Kundt's tube consists of a horizontal glass tube about 1 meter long and 5 cm in diameter.
- At one end of the tube an adjustable piston A is fitted. The other end is closed by a loosely fitted cardboard cap B, which is firmly attached to a metal rod BC.
- The rod is clamped in the middle at D.

- Initially the tube is dried completely. Then a small amount of lycopodium powder is scattered in the gap AB of the tube.
- Then the DC part of the rod is rubbed with a resined cloth so the rod is set up in longitudinal vibrations with node in the middle and the antinodes at the ends.
- The disc B vibrates backward and forward putting the air column inside the tube in vibrations.
- The position of piston A is adjusted in such a way that the air column of the tube resounds loudly to the note produced by the rod.
- This is indicated by the violent motion of the powder at the various places along the tube.
- When the distance between A and B is an integral multiple of the wavelength of sound in air λ_a, the stationary wave pattern is formed inside the tube.
- The powder is gathered in small heaps at nodes and is displaced from antinodes.
- The distance between several of these heaps is measured and then the average distance between the two adjacent nodes is calculated.
- If la is the distance between the adjacent heaps then

  $l_a = \lambda_a/2$ or $\lambda_a = 2l_a$
- If l_r is the length of the rod and λ_r is the wavelength of sound waves in the rod, then

  $l_r = \lambda_r/2$ or $\lambda_r = 2\,l_r$
- If v_a and v_r are the velocities of sound in air and rod respectively, and n is the frequency of the sound emitted by the rod, then

  $v_a = n\,\lambda_a = n\,2l_a$ and $v_r = n\lambda_r = n\,2\,l_r$

$$\therefore \quad \frac{v_r}{v_a} = \frac{l_r}{l_a} \qquad ...(3)$$

$$i.e. \ \frac{\text{Velocity of sound in rod}}{\text{Velocity of sound in air}}$$

$$= \frac{\text{Length of the rod}}{\text{Distance between two consecutive nodes}}$$

$$\therefore \quad v_r = v_a \times \frac{l_r}{l_a} \qquad ...(4)$$

Thus measuring l_r, and l_a and knowing the velocity of sound in air, v_r *i.e.*, the velocity of sound in the rod can be calculated.

APPLICATIONS OF KUNDT'S TUBE

(1) Determination of Sound Velocities in Gases :

- The tube is filled with air and the experiment is performed to find out the value of the mean distance between the two adjacent nodes in air, i.e., l_a.
- Air is now replaced by the gas in which we want to measure the velocity of sound. Again the distance between the two adjacent nodes in gas, i.e., l_g is measured.
- In both the cases air and gas columns vibrate with the same frequency, hence

$$v_a = n\,\lambda_a = n\,.\,2\,l_a \quad \text{or} \quad n = \frac{v_a}{2\,l_a}$$

$$\text{and} \qquad v_g = n\,\lambda_g = n\,.\,2\,l_g$$

$$\therefore \qquad v_g = \frac{v_a}{2\,l_a} \times 2\,l_g = v_a \cdot \frac{l_g}{l_a}$$

Thus knowing the value of v_a, l_g and l_a, the value of v_g can be calculated.

(2) Comparison of Velocity of Sound in Different Gases :

- The tube is filled with gas 1 and the mean distance between the adjacent nodes, i.e., l_{g1} is measured.
- Then the tube is filled with gas 2 and again the mean distance between the adjacent nodes, i.e., l_{g2} is measured.
- If v_{g1} and v_{g2} are the velocities of sound in gases 1 and 2 respectively, then

$$v_{g1} = n\lambda_{g1} = n \cdot 2 l_{g1}$$

and

$$v_{g2} = n\lambda_{g2} = n \cdot 2 l_{g2}$$

$$\therefore \quad \frac{v_{g1}}{v_{g2}} = \frac{l_{g1}}{l_{g2}}$$

- Thus, we can compare the velocity of sound in two different gases.

(3) Determination of Velocity of Sound in Liquids :

- To determine the velocity of sound in a liquid, the Kundt's tube is filled with the experimental liquid.
- The lycopodium powder is replaced by the iron filings.

(4) Determination of Young's Modulus of the Rod :

- If we know the velocity of sound in the rod, the Young's modulus Y of the material of the rod can be determined using the formula

$$v_r = \sqrt{\left(\frac{Y}{\rho}\right)} \quad \text{or} \quad Y = \rho v_r^2$$

where ρ is the density of the material of the rod.

(5) Determination of Ratio of Specific Heat of Gases :

- The velocity of sound in a gas is given by the equation

$$v_g = \sqrt{\left(\frac{\gamma p}{\rho_g}\right)}$$

- Where ρg is the density of the gas, p is the pressure and γ is the ratio of the two specific heats of the gas.
- The value of vg is calculated with the help of Kundt's tube.
- Knowing the pressure and density of the gas the value of γ can be calculated.

SOLVED NUMERICALS

EXAMPLE 1. *Show that the velocity of sound in a gas is given by $v = \sqrt{\gamma R T}$, where R is gas constant for one gm, γ is ratio of specific heats and T, the absolute temperature.*

Solution : We know that

$$v = \sqrt{\left(\frac{\gamma p}{\rho}\right)} \quad \ldots(1)$$

where p is the pressure and ρ is the density.

For a perfect gas $pV = RT$ for one mole of gas.

Here R is the gas constant per gram of gas and T is the absolute temperature. For one gram of a gas

$$V = \frac{\text{mass}}{\text{density}} = \frac{1}{\rho}$$

$$\frac{p}{\rho} = RT$$

From eqs. (1) and (2), we have

$$v = \sqrt{\gamma R T}$$

EXAMPLE 3. *At what temperature will the speed of sound in air become double of its value at 0°C.*

Solution : We know that $\frac{v_t}{v_0} = \left(\frac{T}{T_0}\right)^{1/2}$

Here $v_t = 2v_0$ and $T_0 = 273°K$

$$\therefore \frac{v_t}{v_0} = \frac{2v_0}{v_0} = \left(\frac{T}{273}\right)^{1/2} \text{ or } 4 = \frac{T}{273}$$

or $T = 273 \times 4 = 1092°K$

$\therefore$ T in °C $= 1092 - 273 = 819°C$.

EXAMPLE 11. *A metal rod 150 cm long is fixed at the centre. When it vibrates longitudinally, the frequency is found to be 1200. Calculate the Young's modulus of the meterial of the rod. Its density is 8 gram cm^{-3}.*

Solution : Here $\lambda_r/2 = 150$ or $\lambda_r = 300$,

$n = 1200$ vibs/sec.

$\therefore \quad v_r = n\,\lambda_r = 1200 \times 300 = 360000$ cm/sec.

Again $v_r = \sqrt{\left(\frac{Y}{\rho}\right)}$ or $Y = r \times v_r^2$

$\therefore \quad Y = 8 \times (360000)^2 = 10.37 \times 10^{11}$ **dynes/cm^2.**

EXAMPLE 14. *In Kundt's tube containing air when a rod clamped in the middle is set into vibration, the distance between the dust heaps is 3.46 cm and when the tube is filled with a gas this distance is 3.16 cm. Compare the velocities of sound in the air and in the gas.*

Solution : We know that

$$\frac{v_a}{v_g} = \frac{l_a}{l_g} = \frac{3.46 \text{ cm}}{3.16 \text{ cm}} = 1.095$$

$$\therefore \quad v_a : v_g = 1.095 : 1$$

EXAMPLE 15. *Stationary waves are produced in a Kundt's tube filled with air by vibrating one metre long steel rod tied at middle. If the frequency of steel rod be 2480 per sec. and distance between the heaps of the powder in the tube be 6.9 cms find speed of sound in (i) steel rod, and (ii) air.*

Solution : (*i*) If l_r be the length of steel rod, then

$$l_r = \frac{\lambda_r}{2} \quad \text{or} \quad \lambda_r = 2\,l_r,$$

Speed of sound in steel rod is given by

$v_r = nl_r = n.2l_r$

$= 2480 \times 2 \times 1 = 4960$ m/sec.

(ii) If l_a be the distance between two consecutive nodes, then

$$l_a = 6.9 \text{ cms} = 0.069 \text{ metres}$$

and $$\lambda_a = 2 \times l_a = 2 \times 0.069 \text{ metre}$$

Speed of sound in air is given by

$$v_a = n \cdot \lambda_a = 2480 \times 2 \times 0.069$$

$$= 342.24 \text{ m/sec.}$$

MULTIPLE CHOICE QUESTIONS

1. Velocity of sound waves in a gas is proportional to
   (a) The square root of isothermal elasticity of the medium
   (b) The square root of the adiabatic elasticity of the medium
   (c) The reciprocal of the isothermal elasticity of the medium
   (d) The adiabatic elasticity of the medium

2. Velocity of sound in air at a given temperature
   (a) Increases with increase in pressure
   (b) Decreases with increase in pressure
   (c) Is independent of pressure
   (d) Increases at low pressures and decreases at high pressures

3. At what temperature, the velocity of sound in air is double its value at 0 °C
   (a) 1092 °C **(b) 819 °C** (c) 546 °C (d) 273 °C

4. The velocity of sound will be greatest in
   (a) water (b) air (c) vacuum **(d) metal**

5. Under similar conditions of temperature and pressure, the velocity of sound will be maximum in
   (a) nitrogen (b) oxygen **(c) hydrogen** (d) carbon dioxide

6. When the wind is blowing in the same direction in which the sound is travelling, the velocity of sound
   (a) increases (b) decreases (c) no change (d) may increase or decrease

7. The velocity of sound in a gas

(a) Increases by 0.61m when temperature rises by 1 °C

(b) Decreases by 0.61m when temperature rises by 1 °C

(c) Depends upon the pressure of the gas

(d) Depends upon the coefficient of shearing of the gas

8. The reason for introducing Laplace's correction in the expression for the velocity of sound in a gaseous medium is

(a) No change in the temperature of the medium during the propagation of sound through it

(b) No change in the heat content of the medium during the propagation of sound through it

(c) Changes in the pressure of the gas due to the compression and rarefactions

(d) Change in the volume of the gas

9. The ______ waves are such that when they pass through any medium, the particles of the medium oscillate about their mean position in the direction of propagation of the wave.

(a) longitudinal (b) transverse (c) stationary (d) progressive

10. The ______ waves are such that when they pass through any medium, the particles of the medium oscillate about their mean position in the direction perpendicular to the direction of propagation of the wave.

(a)longitudinal **(b) transverse** (c) stationary (d) progressive

11. Laplace formula for the velocity is

(a) $v = \sqrt{\frac{\gamma p}{\rho}}$ **(b)** $v = \sqrt{\left(\frac{p}{\rho\gamma}\right)}$ (c) $v = \sqrt{\frac{p\rho}{\gamma}}$ (d) $v = \sqrt{\left(\frac{\rho\gamma}{p}\right)}$

12 **The speed of sound in air at N.T.P. is 300 m/s. If air pressure becomes four times, then the speed of sound will be**

(a)150 m/s (b) 300 m/s (c) 600 m/s (d)1200 m/s

13 Velocity of sound is measured in Hydrogen and Oxygen gases at a given temperature. The ratio of two velocities will be $\left(\frac{v_H}{v_O}\right)$

(a) 32 : 1 (b) 1 :4 (c) 4 : 1 (d) 1 : 1

14 The value of specific heats for air is

(a) 1.21 (b) 1.31 (c) 1.41 (d) 1.51.

15 According to Newton correction, the propagation of sound waves is

(a) an isothermal process (b) an adiabatic process (c) an isobaric process (d) isochoric process

16 According to Laplace correction, the propagation of sound waves is

(a) an isothermal process (b) an adiabatic process (c) an isobaric process (d) isochoric process

17 According to Newton's formula the velocity of sound in air is

(i) 280 m/s, (ii) 332 m/s, (iii) 331.6 m/s, (iv) 350 m/s.

18 According to Laplace's corrections the velocity of sound in air is

(i) 280 m/s, (ii) 332 m/s, (iii) 331.6 m/s, (iv) 350 m/s.

19 In Kundt's tube experiment small heaps of powder are created at

(a) nodes (b) antinodes (c) at two ends of the tube (d) outside the tube.

20 The temperature at which the speed of sound in air becomes double of its value at 27 ^{o}C is

(a) 54 ^{o}C (b) 327 ^{o}C (c) 927 ^{o}C (d) -123 ^{o}C

1	**(b)**	**2**	**(c)**	**3**	**(b)**	**4**	**(d)**	**5**	**(c)**
6	**(a)**	**7**	**(a)**	**8**	**(b)**	**9**	**(a)**	**10**	**(b)**
11	**(a)**	**12**	**(b)**	**13**	**(c)**	**14**	**(a)**	**15**	**(a)**
16	**(b)**	**17**	**(a)**	**18**	**(c)**	**19**	**(a)**	**20**	**()**

SHORT QUESTIONS

1. Write the formulae for the velocity of sound in gaseous and solid medium.
2. Explain the effect of pressure on the velocity of sound in air.
3. Explain the effect of wind on the velocity of sound in air.
4. Explain briefly how the velocity of sound in a liquid can be measured using the Kundt's Tube method.
5. Explain how Kundt's Tube method can be applied to determine the Young's modulus of a metal rod.
6. Discuss how Kundt's Tube method can be used to determine the specific heat ratio of a gas.
7. Define : Longitudinal Waves and Transverse Waves.
8. Enlist the four factors which affect the velocity of sound in air.
9. Enlist any four applications of Kundt's Tube.

LONG QUESTIONS

1. Derive the formula for the velocity of longitudinal(sound) waves in a gaseous medium (air) with the help of necessary diagrams and equations.
2. Calculate the velocity of sound in air using Newton's formula and also discuss the Laplace's correction to Newton's formula.
3. Write a note on Newton's formula for the velocity of sound in air.
4. Write a note on Laplace's correction to Newton's formula for the velocity of sound.
5. What are the factors which affect the velocity of sound in air? Discuss them in detail.
6. Discuss the effect of pressure and temperature on the velocity of sound in air.
7. Discuss the effect of humidity and temperature on the velocity of sound in air.
8. Discuss the effect of humidity on the velocity of sound in air.
9. Derive the formula for the velocity of sound in a metal rod(solid medium) with the help of necessary diagrams and equations.
10. Discuss the Kundt's Tube method of determination of velocity of sound in a metal rod and derive the necessary equations.
11. Write a note on applications of Kundt's Tube.