DPP – 1 (Sound Wave)

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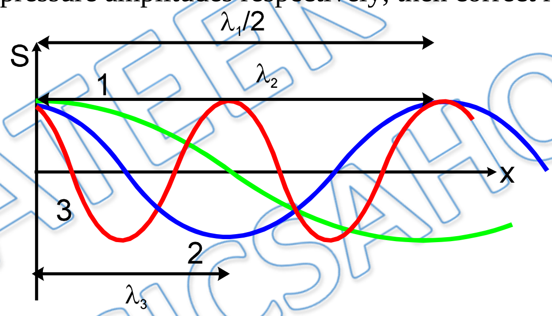
Q 1. **State True or false**

S_1: If pressure of a gas is increased keeping the temperature constant the speed of sound wave in the gas increases.

S_2: In a travelling sinusoidal sound wave the phase difference between displacement wave and pressure wave is $\frac{\pi}{2}$.

S_3 : At same temperature sound propagates with same speed in CO gas and N_2 gas (a) T F T (b) F T T (c) F F T (d) F T F

Q 2. Figure shown is a graph, at a certain time t, of the displacement function S(x,t) of three sound waves 1,2 and 3 as marked on the curves that travel along x–axis through air. If P_1, P_2 and P_3 represent their pressure amplitudes respectively, then correct relation between them is :

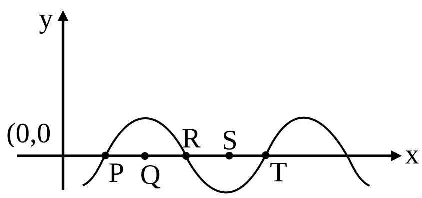


(a) $P_1 > P_2 > P_3$ (b) $P_3 > P_2 > P_1$ (c) $P_1 = P_2 = P_3$ (d) $P_2 > P_3 > P_1$

Q 3. The maximum pressure variation that the human ear can tolerate in loud sound is about 30 N/m^2. The corresponding maximum displacement amplitude for a sound wave in air having a frequency of 10^4 Hz is:(take velocity of sound in air as 300 m/s and density of air 1.5 kg/m^3)

(a) $\frac{2\pi}{3} \times 10^{-2}$ (b) $\frac{2\times10^{-4}}{\pi}$ (c) $\frac{\pi}{3} \times 10^{-2}$ (d) $\frac{10^{-4}}{30\pi}$

Q 4. The graph below shows displacement(y) versus distance (x) along the line of a transmission of a longitudinal wave at a given instant. The positive y-axis is displacement to the right and the negative y-axis is displacement to the left. The pressure maxima positions happen at the positions marked -



` (a) P (b) Q (c) R (d) S

Q 5. A sound wave of wavelength 40 cm travels in air. If the difference between the maximum and minimum pressures at a given point is $1.0 \times 10^{-3} N/m^2$, find the amplitude of vibration of the particles of the medium. The bulk modulus of air $1.4 \times 10^5 N/m^2$.
(a) 4.2×10^{-10}m. (b) 3.6×10^{-10} m (c) 1.4×10^{-10} m. (d) 2.2×10^{-10} m.

Q 6. The sensation of sound in human mind remains for 0.1 second. A man is clapping near a wall. Find minimum distance of wall from man to listen echo of clap? Velocity of sound in air is 330 m/ sec.
(a) 17m (b) 16m (c) 16.5m (d) 17.5m

Q 7. Two points A and B are separated by distance 960 m. Air temperature is varying linearly from A to B. Absolute temperature of B is 4 times that of A. Velocity of sound at A is 320m/sec. A sound is produced at A, Time taken by it to reach B is
(a) 1sec (b) 1.2 sec (c) 1.6sec (d) 2 sec

Q 8. The velocity of sound waves in an ideal gas at temperatures T_1 K and T_2 K are respectively v_1 and v_1. The rms velocity of gas molecules at these two temperatures are ω_1 and ω_2, respectively then –

(a) $\frac{v_1}{v_2} = \frac{\omega_1}{\omega_2}$ (b) $\frac{v_1}{v_2} = \sqrt{\gamma}\frac{\omega_1}{\omega_2}$ (c) $\frac{v_1}{v_2} = \sqrt{\frac{\gamma}{3}\frac{\omega_1}{\omega_2}}$ (d) $\frac{v_1}{v_2} = \sqrt{\frac{\omega_1}{\omega_2}}$

Q 9. Of the following properties of a sound wave, the one that is independent of the other is its -
(a) Amplitude (b) Velocity (c) Wavelength (d) Frequency

Q 10. Mark the correct statement
(a) According to Newtons formula velocity of sound in hydrogen is 4 times that in oxygen at same temperature.
(b) According to Laplace formula velocity of sound in hydrogen is 4 times that in oxygen at same temperature.
(c) According to Newtons formula velocity of sound in helium is $2\sqrt{2}$ times that in oxygen at same temperature.
(d) According to Laplace formula velocity of sound in helium is more than $2\sqrt{2}$ times that in oxygen at same temperature.

Q 11. Velocity of sound in air is
(a) Smaller at night due to low temperature at night.
(b) Greater at night due to low temperature at night
(c) Smaller at night due to low density of air at night.
(d) Greater at night due to low density of air at night.

Q 12. Two sound waves are moving in just opposite directions, first wave due east and second wave due west. At a given time instant a particle of first wave is at its one extreme position which is east of its mean position and at same time instant a particle of second wave is at its one extreme position which is west of its mean position. Phase difference between pressure variation at these two particles is
(a) 0 (b) π (c) $\frac{\pi}{2}$ (d) None of these

Q 13. Regarding speed of sound in gas match the following:

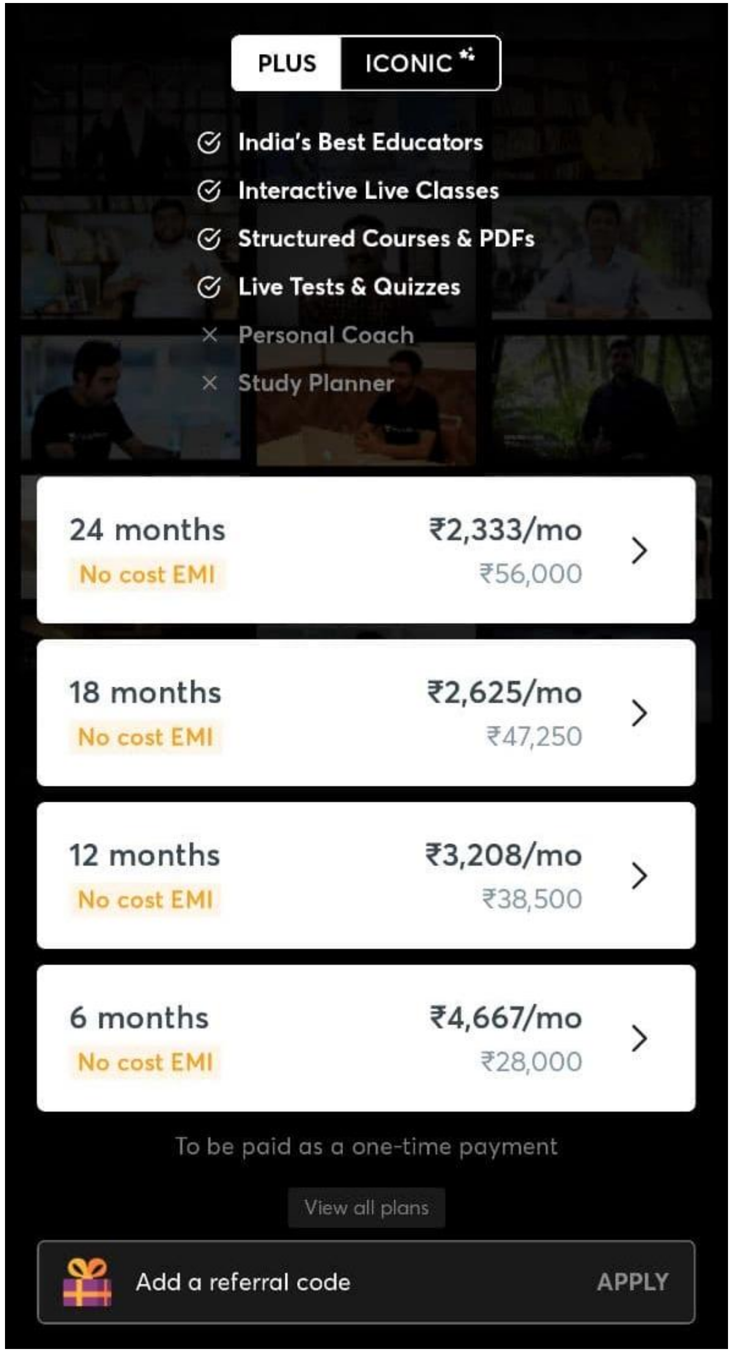
	Column-I		Column-II
(A)	Temperature of gas is	(P)	speed becomes

	made 4 times and pressure 2 times		$2\sqrt{2}$times
(B)	Only pressure is made 4 time without change in temperature	(Q)	speed becomes 2 times
(C)	Only temperature is changed to 4 times	(R)	speed remains unchanged
(D)	Molecular mass of the gas is made 4 times	(S)	speed remains half

Answer Key

Q.1 b	**Q.2 b**	**Q.3 d**	**Q.4 c**	**Q.5 d**
Q.6 c	**Q.7 d**	**Q.8 a**	**Q.9 b**	**Q.10 a, b, c, d**
Q.11 d	**Q.12 a**			

Q.13 A $\rightarrow$ Q ; B $\rightarrow$ R ; C $\rightarrow$ Q ; D $\rightarrow$ S



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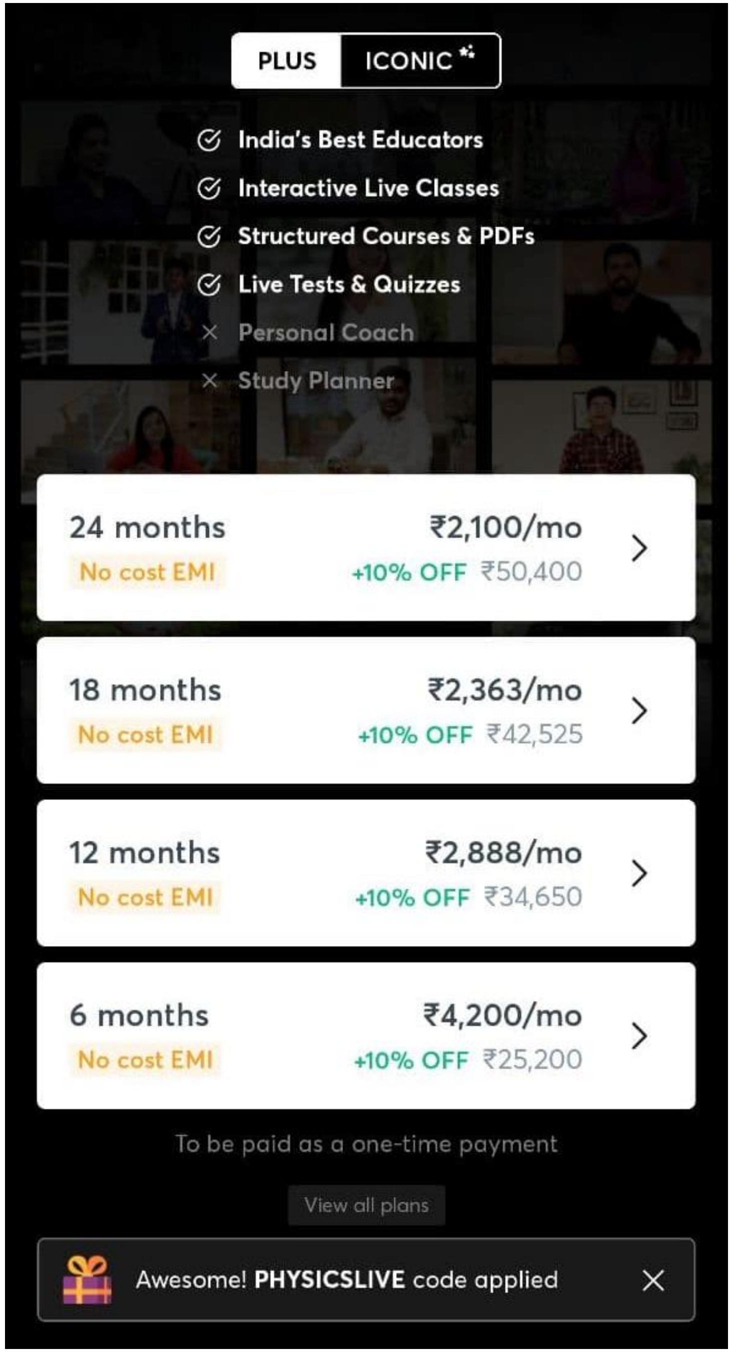

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Written Solution

DPP- 1 Sound : Displacement Wave, Pressure Wave

By Physicsaholics Team

Q1) State True or false

***S*₁**: If pressure of a gas is increased keeping the temperature constant the speed of sound wave in the gas increases.

***S*₂**: In a travelling sinusoidal sound wave the phase difference between displacement wave and pressure wave is $\frac{\pi}{2}$.

***S*₃** : At same temperature sound propagates with same speed in CO gas and N_2 gas

(a) T F T (b) F T T (c) F F T (d) F T F

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

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

Diatomic

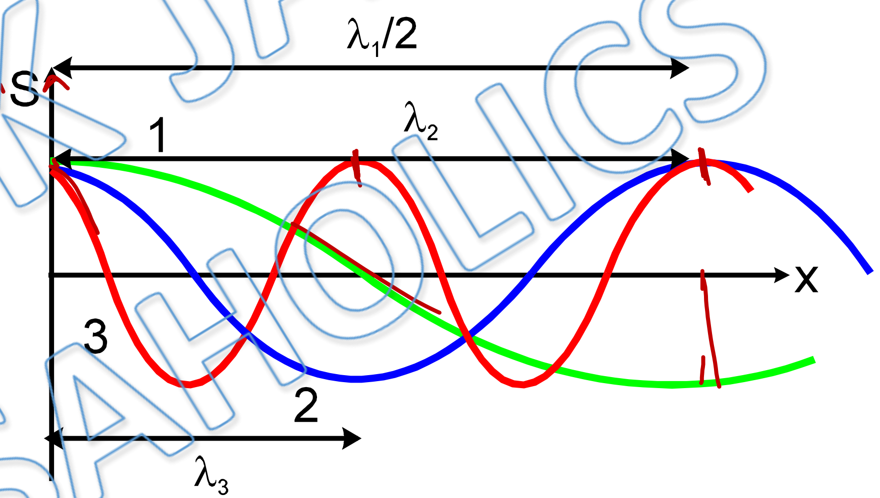
$M = 14 \times 2 = 28$

Diatomic

$M = 12 + 16 = 28$

Q2) Figure shown is a graph, at a certain time t, of the displacement function S(x,t) of three sound waves 1,2 and 3 as marked on the curves that travel along x–axis through air. If P_1, P_2 and P_3 represent their pressure amplitudes respectively, then correct relation between them is :

$S_0 \rightarrow$ Displacement Amplitude is same for all



(a) $P_1 > P_2 > P_3$

(b) $P_3 > P_2 > P_1$ ✓

(c) $P_1 = P_2 = P_3$

(d) $P_2 > P_3 > P_1$

$P_0 = BKS_0$

$P_0 = \frac{BS_0 \times 2\pi}{\lambda}$

Since $\lambda_3 < \lambda_2 < \lambda_1$

$P_3 > P_2 > P_1$

Q3) The maximum pressure variation that the human ear can tolerate in loud sound is about 30 N/m^2. The corresponding maximum displacement amplitude for a sound wave in air having a frequency of 10^4 Hz is:(take velocity of sound in air as 300 m/s and density of air 1.5 kg/m^3)

from mean pressure

$P_0 = 30$

$f = 10^4$

$v = 300$

$\rho = 1.5$

$P_0 = B k S_0$

$v = \sqrt{\frac{B}{\rho}} \Rightarrow B = \rho v^2$

$P_0 = \rho v^2 k S_0$

$P_0 = \rho v \omega S_0$

$S_0 = \frac{P_0}{\rho v \omega}$

$= \frac{30}{1.5 \times 300 \times 2\pi \times 10^4}$

$= \frac{10^{-4}}{30\pi}$

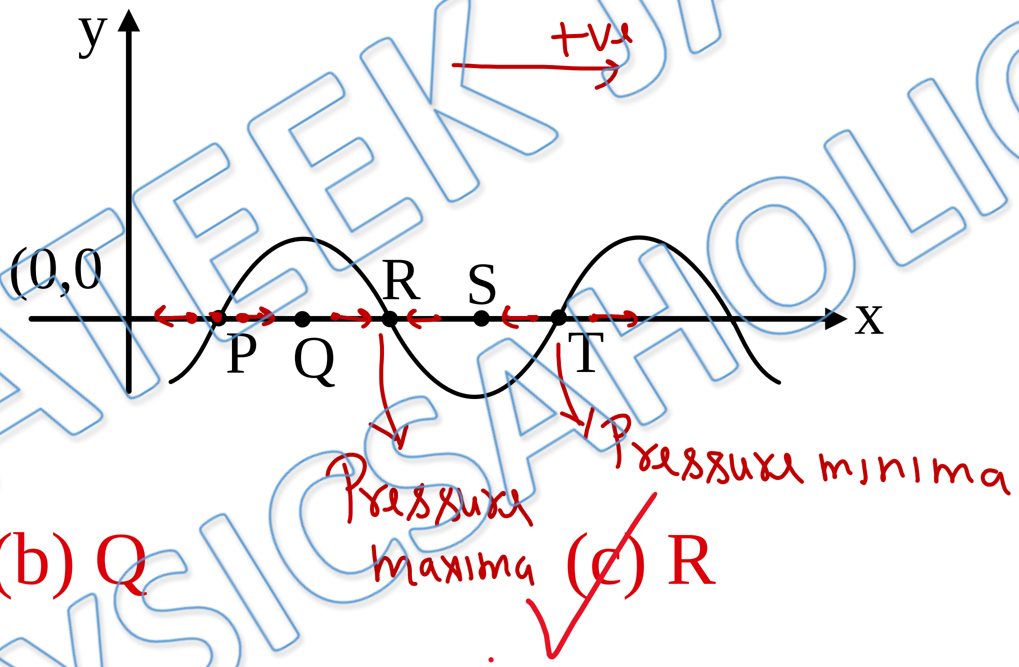
(a) $\frac{2\pi}{3} \times 10^{-2}$

(b) $\frac{2\times10^{-4}}{\pi}$

(c) $\frac{\pi}{3} \times 10^{-2}$

(d) $\frac{10^{-4}}{30\pi}$ ✓

Q4) The graph below shows displacement(y) versus distance (x) along the line of a transmission of a longitudinal wave at a given instant. The positive y-axis is displacement to the right and the negative y-axis is displacement to the left. The pressure maxima positions happen at the positions marked -



(a) P (b) Q (c) R (d) S

Q5) A sound wave of wavelength 40 cm travels in air. If the difference between the maximum and minimum pressures at a given point is $1.0 \times 10^{-3} \mathrm{N}/m^2$, find the amplitude of vibration of the particles of the medium. The bulk modulus of air $1.4 \times 10^5 \mathrm{N}/m^2$.

$2P_0 = 1 \times 10^{-3}$

$P_0 = .5 \times 10^{-3}$

$\lambda = 40\,cm = .4\,m$

$P_0 = BKS_0$

$.5 \times 10^{-3} = 1.4 \times 10^5 \times \frac{2\pi}{.4} S_0$

$S_0 = \frac{.5 \times .4}{2\pi \times 1.4} \times 10^{-8}\,m$

(a) 4.2×10^{-10} m.

(b) 3.6×10^{-10} m.

(c) 1.4×10^{-10} m.

(d) 2.2×10^{-10} m.

$S_0 = \frac{20}{2\pi \times 1.4} \times 10^{-10}\,m$

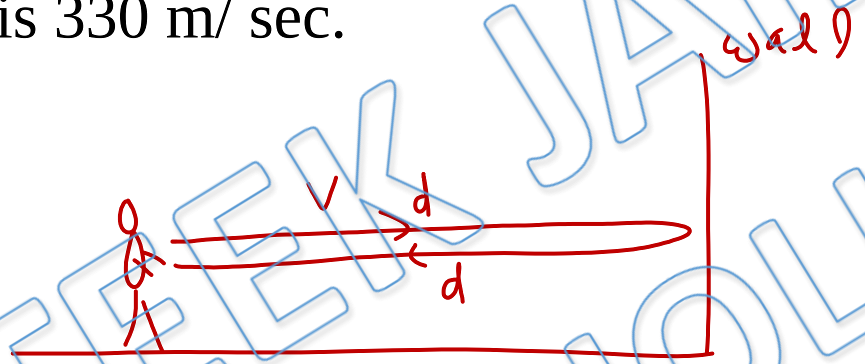
$= \frac{20}{3.14 \times 2.8} \times 10^{-10}\,m$

Q6) The sensation of sound in human mind remains for 0.1 second. A man is clapping near a wall. Find minimum distance of wall from man to listen echo of clap ? Velocity of sound in air is 330 m/ sec.

$t = \frac{2d}{V} > .1$

$2d > .1 \times 330$

$d > \frac{33}{2}$ m



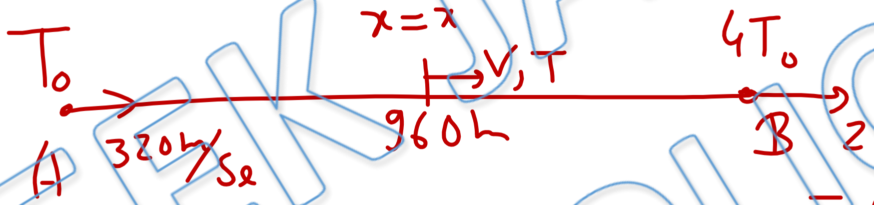
(a) 17m (b) 16m (c) 16.5m ✓ (d) 17.5m

Q7) Two points A and B are separated by distance 960 m. Air temperature is varying linearly from A to B. Absolute temperature of B is 4 times that of A. Velocity of sound at A is 320m/sec. A sound is produced at A, Time taken by it to reach B is

$$V = \sqrt{\frac{\gamma R T}{M}}$$

$$V^2 = \frac{\gamma R}{M} T$$

$$2V\frac{dV}{dx} = \frac{\gamma R}{M}\left(\frac{dT}{dx}\right) \rightarrow \text{Constant}$$



$V \propto \sqrt{T}$

(a) 1sec (b) 1.2 sec (c) 1.6sec (d) 2 sec ✓

acceleration of wave = Constant $\Rightarrow$ $x = \frac{u+v}{2} \times t$

$$960 = \frac{320+640}{2} \times t$$

$$t = 2\text{ Sec}$$

Q8) The velocity of sound waves in an ideal gas at temperatures T_1 K and T_2 K are respectively v_1 and v_1. The rms velocity of gas molecules at these two temperatures are ω_1 and ω_2, respectively then -

$$V = \sqrt{\frac{\gamma RT}{M}} \qquad \omega = \sqrt{\frac{3RT}{M}}$$

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}} \qquad \frac{\omega_1}{\omega_2} = \sqrt{\frac{T_1}{T_2}}$$

(a) $\frac{v_1}{v_2} = \frac{\omega_1}{\omega_2}$ ✓

(b) $\frac{v_1}{v_2} = \sqrt{\gamma}\frac{\omega_1}{\omega_2}$

(c) $\frac{v_1}{v_2} = \sqrt{\frac{\gamma}{3}\frac{\omega_1}{\omega_2}}$

(d) $\frac{v_1}{v_2} = \sqrt{\frac{\omega_1}{\omega_2}}$

Q9) Of the following properties of a sound wave, the one that is independent of the other is its -

(a) Amplitude (b) Velocity (c) Wavelength (d) Frequency

(Q10) Mark the correct statement

(a) According to Newtons formula velocity of sound in hydrogen is 4 times that in oxygen at same temperature.

(b) According to Laplace formula velocity of sound in hydrogen is 4 times that in oxygen at same temperature.

(c) According to Newtons formula velocity of sound in helium is $2\sqrt{2}$ times that in oxygen at same temperature.

(d) According to Laplace formula velocity of sound in helium is more than $2\sqrt{2}$ times that in oxygen at same temperature.

$$V = \sqrt{\frac{RT}{M}} \Rightarrow \frac{V_{H_2}}{V_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}} = \sqrt{\frac{32}{2}} = 4$$

$$V = \sqrt{\frac{\gamma RT}{M}}$$ Here γ is same for both

$$\frac{V_{He}}{V_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{He}}} = \sqrt{\frac{32}{4}} = 2\sqrt{2}$$

$$\frac{V_{He}}{V_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{He}}\frac{\gamma_{He}}{\gamma_{O_2}}} = 2\sqrt{2}\sqrt{\frac{\gamma_{He}}{\gamma_{O_2}}} = 2\sqrt{2}\sqrt{\frac{1.6}{1.4}}$$

Q11) Velocity of sound in air is

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

$P \rightarrow$ 1 atm

$\rho \rightarrow$ at night, humidity is high $\rightarrow$ low air density.

$$V = \sqrt{\frac{\gamma RT}{M}}$$

(a) Smaller at night due to low temperature at night.

(b) Greater at night due to low temperature at night

(c) Smaller at night due to low density of air at night.

(d) Greater at night due to low density of air at night. ✓

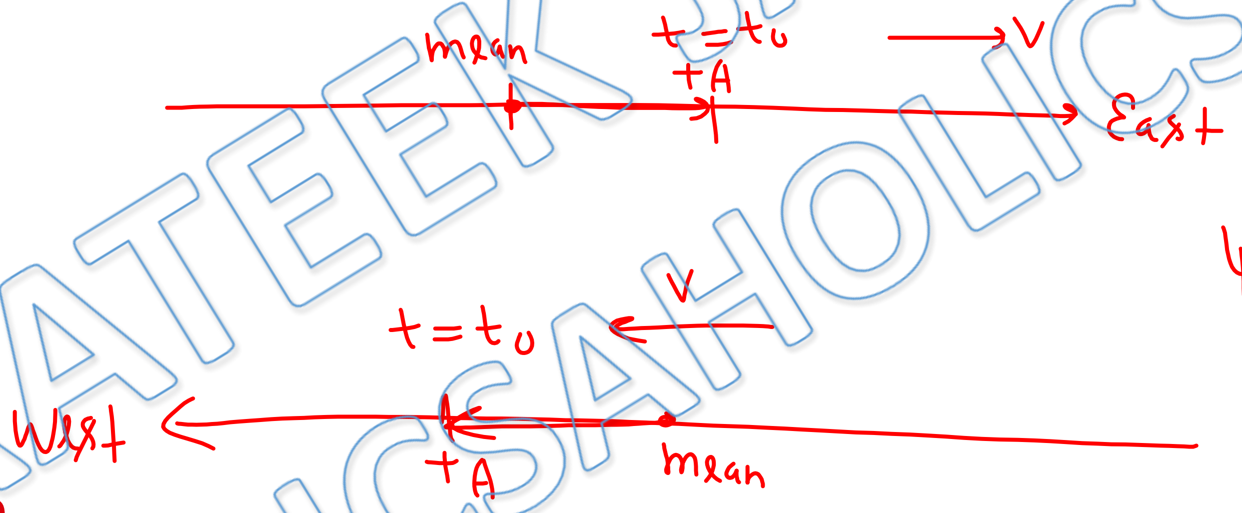
Q12) Two sound waves are moving in just opposite directions, first wave due east and second wave due west. At a given time instant a particle of first wave is at its one extreme position which is east of its mean position and at same time instant a particle of second wave is at its one extreme position which is west of its mean position. Phase difference between pressure variation at these two particles is

(a) 0

(b) π

(c) $\frac{\pi}{2}$

(d) None of these



East is +ve.

ψ of x = π/2

ψ of Pressure = π

ψ of x = π/2

ψ of pressure = π

Q13) Regarding speed of sound in gas match the following :

Column-I	**Column-II**
(A) Temperature of gas is made 4 times and pressure 2 times	(P) speed becomes $2\sqrt{2}$ times
(B) Only pressure is made 4 time without change in temperature	(Q) speed becomes 2 times
(C) Only temperature is changed to 4 times	(R) speed remains unchanged
(D) Molecular mass of the gas is made 4 times	(S) speed remains half

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