PRAYAS

JEE 2025

ATDB.uno

| Lecture- 09 | Physics |

Waves

By- Saleem Ahmed Sir

Topics *to be covered*

1 Open Organ Pipe, Close Organ Pipe

2 Beats

3 Resonance Column Tube

4

Q Ends of Streached wire of length L are fixed at $x=0$ and $x=L$

In one experiment $y_1 = A \sin \dfrac{\pi x}{L} \sin \omega t$ and total Energy is E_1

In another exp $y_2 = A \sin \dfrac{2\pi x}{L} \sin 2\omega t$ and total Energy is E_2
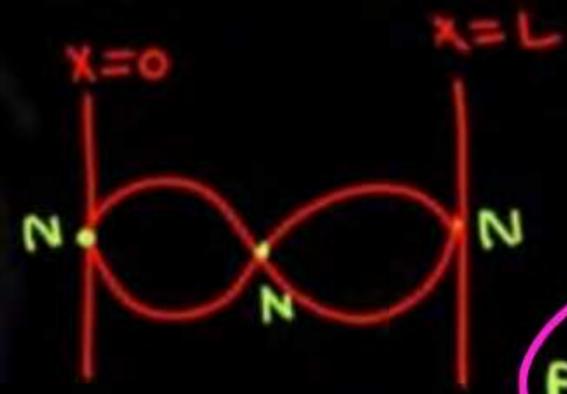
Find $\dfrac{E_1}{E_2} = ?$

Sol

2nd

$x=0 \qquad x=L$

N • N

N

JEE 2005

$$K = \dfrac{\pi}{L} = \dfrac{2\pi}{\lambda}$$

$$\lambda = 2$$

$$E_2 = 2 \times \dfrac{1}{8} \mu_2 A_2^2 \omega_2^2 \lambda_2$$

N

N

$x=0$

$x=L$

$$E_1 = \dfrac{1}{8} \mu A_1^2 \omega_1^2 \lambda_1$$

$$K = \dfrac{2\pi}{L} = \dfrac{2\pi}{\lambda}$$

$$\boxed{\lambda = L}$$

Correction

$$\dfrac{E_1}{E_2} = \dfrac{1}{2}\dfrac{\omega_1^2}{\omega_2^2} \cdot \dfrac{\lambda_1}{\lambda_2} = \left(\dfrac{\omega}{2\omega}\right)^2 \cdot \left(\dfrac{2L}{L}\right)\dfrac{1}{2} = \dfrac{1}{2} \times \dfrac{1}{2} = \dfrac{1}{4}$$
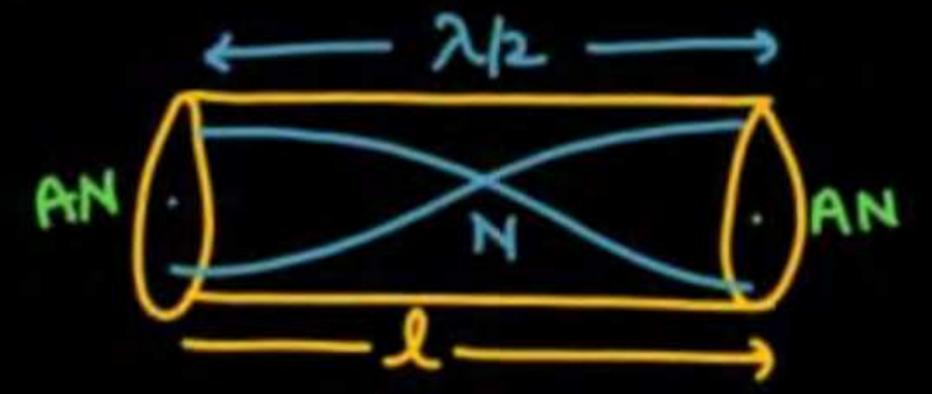
open organ pipe

F·M

$$l = \frac{\lambda}{2} \qquad \lambda = 2l$$
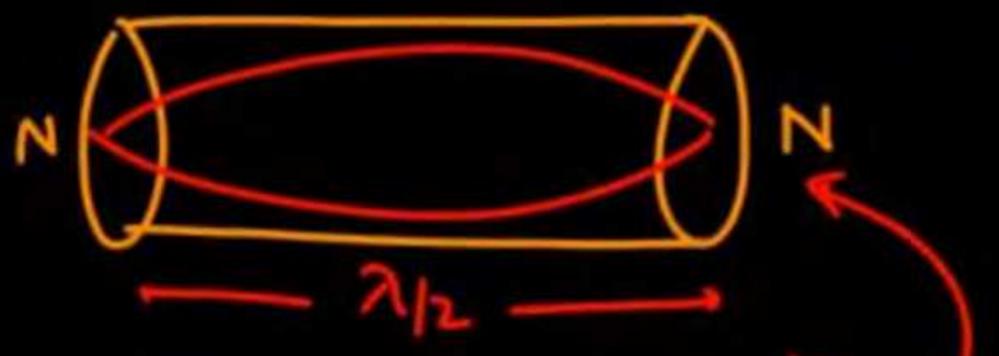
$$f_0 = \frac{V}{\lambda} = \frac{V}{2l}$$

$$v = \sqrt{\frac{\gamma RT}{m}}$$

$$\boxed{f_0 = \frac{1}{2l}\sqrt{\frac{\gamma RT}{m}}}$$

$\lambda/2$

AN   N   AN

l

Displacement
है माप

Fundamental mode

N   N

$\lambda/2$

Pressure का Node है

Preume

ATDB.uno

2nd harmonic / 1st overtone

$\lambda = \ell$

$f = \dfrac{V}{\lambda} = \dfrac{V}{\ell} = 2\dfrac{V}{2\ell}$

$f = 2\dfrac{V}{2\ell} \equiv$ 2nd harmonic / 1st overtone

AN ··· N ·· N ·· AN

ℓ

λ
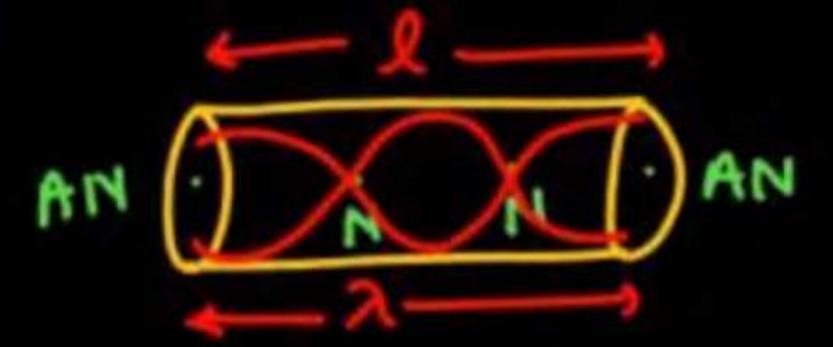
3rd harmonic (2nd overtone)

$f = \dfrac{V}{\lambda} = 3\left(\dfrac{V}{2\ell}\right)$

AN N N N

ℓ

$\dfrac{3\lambda}{2}$

$\ell = \dfrac{3\lambda}{2} \qquad \lambda = \dfrac{2\ell}{3}$

Result

$f_0 = \dfrac{V}{2\ell} \qquad V = \sqrt{\dfrac{YRT}{m}}$
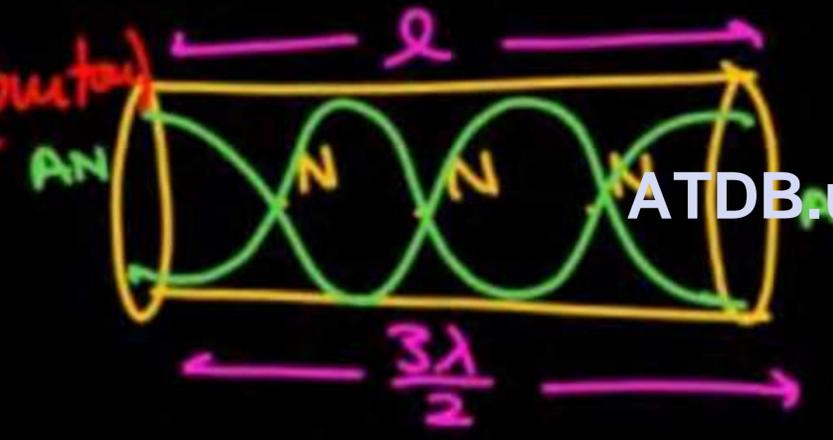
$f_2 = 2\dfrac{V}{2\ell}$

n^{th} harmonic $\quad f_n = \dfrac{nV}{2\ell}$

$\qquad \longrightarrow (n-1)$ overtone

ATDB.uno

one end closed

Fundamental mode

$$\lambda = 4\ell$$

$$f_0 = \frac{v}{\lambda} = \frac{V}{4\ell}$$

$$\frac{\lambda}{4}$$

$$\ell = \lambda/4$$
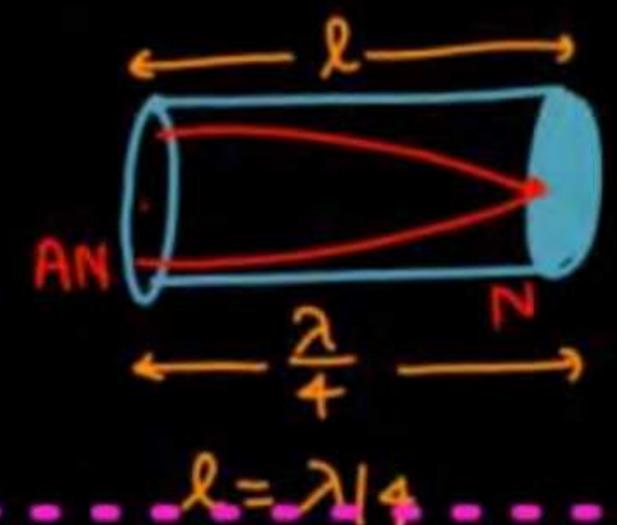
3rd harmonic / 1st overtone

$$\ell = \frac{3\lambda}{4}, \quad \lambda = \frac{4\ell}{3}$$

$$f = \frac{V}{\lambda} = \frac{V}{4\ell} \times 3$$

$$f = 3\left(\frac{V}{4\ell}\right) \equiv \left(3^{rd} \text{ harmonic}\right)$$

$$\frac{3\lambda}{4}$$

$$\ell = \frac{3\lambda}{4}$$
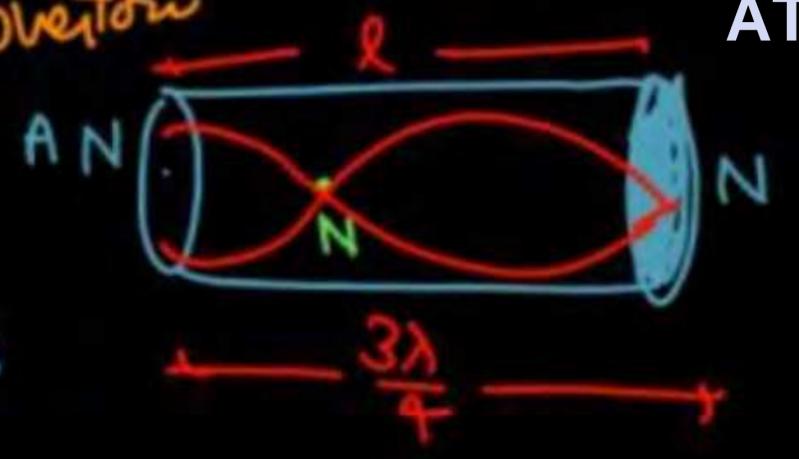
5th harmonic / 2nd overtone

$$\frac{5\lambda}{4}$$

$$\ell = \frac{5\lambda}{4} \qquad \lambda = \frac{4\ell}{5}$$
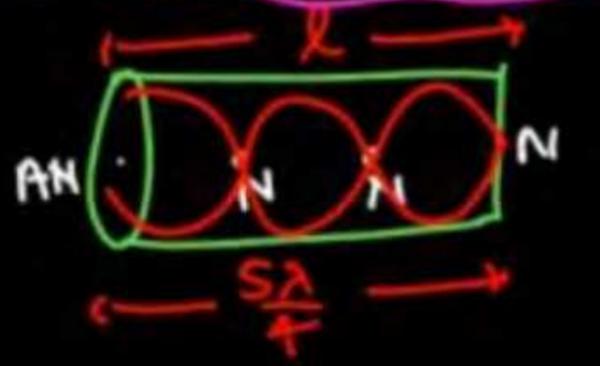
$$f = 5\frac{V}{4\ell} = 5^{th} (\text{harmonic})$$

Result

$$f_0 = \frac{V}{4\ell}$$

$$f = (\text{odd})\frac{V}{4\ell}$$

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

$$\boxed{f = (2n+1)\frac{V}{4\ell}}$$

n^{th} overtone
$(2n+1)$ harmonic

open organ pipe (Both end open)

$$f_0 = \frac{V}{2\ell}$$

$$v = \sqrt{\frac{\gamma RT}{m}}$$

$$f_n = n\frac{V}{2\ell} \qquad n^{th} \text{ harmonic}$$
$$(n-1) \text{ overtone}$$

$$v = \sqrt{\frac{T}{\mu}}$$
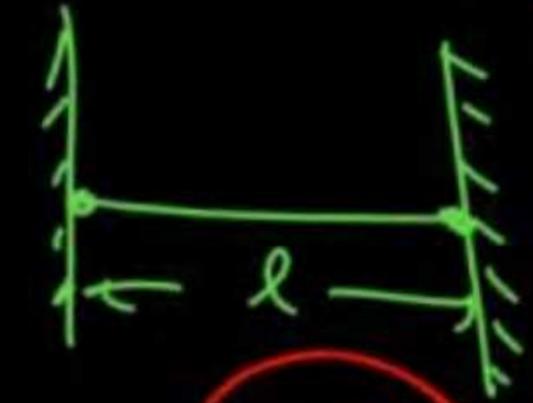
String fix
At both
end
Same

COP closed organ pipe (one end closed)
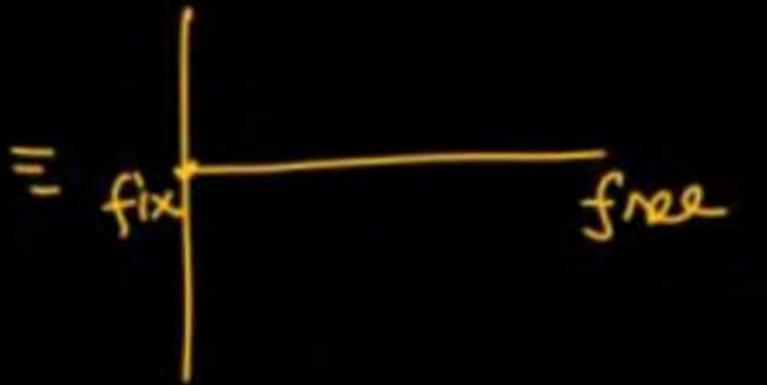
$$f_0 = \frac{V}{4\ell}$$

fix   free

$$n^{th} \text{ overton} \equiv (2n+1) \text{ harm}$$
$$2^{nd} \text{ overtn} = 5^{th} \text{ harm}$$
$$3^{rd} \text{ out} = 7^{th} \text{ harm}$$

$$5^{th} \text{ harmonic} = f_5 = \frac{5V}{4\ell}$$
$$9^{th} \quad '' \quad = f_9 = \frac{9V}{4\ell}$$

$$(2n+1)^{th}$$

$$\Rightarrow f = (2n+1)\frac{V}{4\ell} \quad (n^{th} \text{ overtn})$$

String free at both
end

ATDB.uno

Q Third overtone of a closed organ pipe is in Unison with forth harmonic of an open organ pipe. find ratio of their length.

$$f_{7\,(COP)} = f_4\,(OOP)$$

$$7\,\frac{V}{4\ell_1} = 4\cdot\frac{V}{2\ell_2}$$

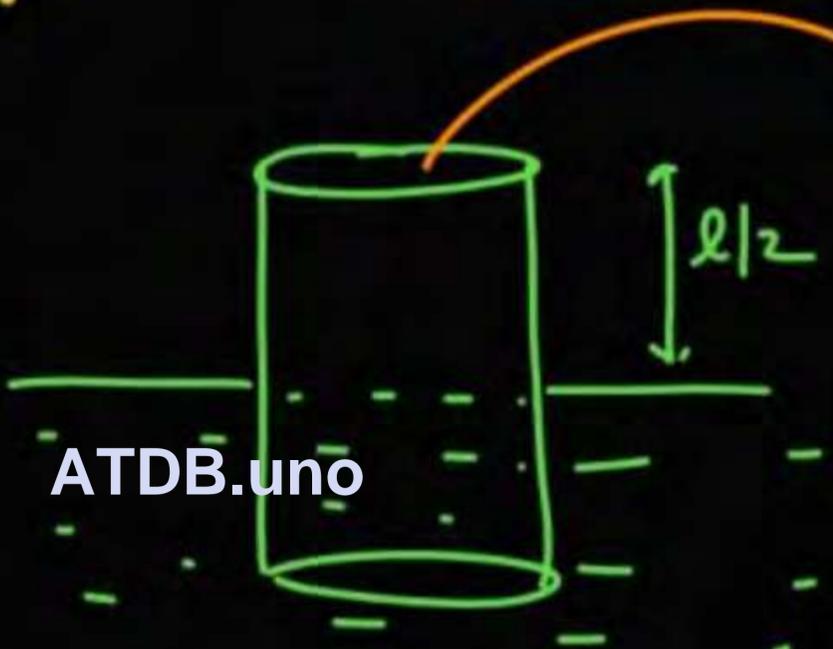$$\boxed{\frac{\ell_2}{\ell_1} = \frac{8}{7}}$$

ATDB.uno

Q Cylindrical tube open at both end has fundamental freq f in air Tube is dipped vertically into water so that half of it is in the water. Fundamental freq of aircolumn is now?

$$f_0 = \frac{V}{2\ell}$$

$$\ell/2$$

$$f_0' = \frac{V}{4L} = \frac{V}{4\frac{\ell}{2}}$$

$$f_0' = \frac{V}{2\ell}$$

$$\left(f_0 \equiv \longrightarrow \text{Same} \right)$$

Q For a closed organ pipe if O_2 gas is filled fundamental mode

frequency is f_0. at $50°c$ $\qquad$ $f_0 = \dfrac{V_0}{4\ell} = \sqrt{\dfrac{\gamma_1 RT}{m_1}} \cdot \dfrac{1}{4\ell}$

① find fundamental mode freq if gas is replaced by $N_2 \Rightarrow f' = \sqrt{\dfrac{\gamma_1 RT}{m_2}} \dfrac{1}{4\ell}$

② 5th harmonic if gas is replaced by $N_2 \Rightarrow f_5' = 5 \dfrac{V_0'}{4\ell}$

※ ④ 10th harmonic at $100°c$ if gas is He.

$f_5' = 5 \cdot \sqrt{\dfrac{\gamma_1 RT}{M_{N_2}}} \cdot \dfrac{1}{4\ell}$

ATDB.uno

$\dfrac{(F \cdot m)_{O_2}}{(Fm)_{N_2}} = \dfrac{(f_0)_{O_2}}{(f_0)_{N_2}} = \sqrt{\dfrac{M_{O_2}}{M_{N_2}}}$

④ $O_2 \Rightarrow f_0 = \sqrt{\dfrac{7}{5} \cdot \dfrac{R \cdot (273+50)}{32}}$

$f' = 10 \sqrt{\dfrac{5}{3} \cdot \dfrac{R(273+100)}{4}}$

End correction

$$l + x = \frac{\lambda}{4}$$

$$x = \cdot 6\, r$$

$\longrightarrow$ radius of tube

• AN

$\updownarrow x$ (end correction)

x

l

N

AN

$\updownarrow x$

l

$\updownarrow x$

AN

$$l + x + x = \frac{\lambda}{2}$$

$$x = \cdot 6\, r$$
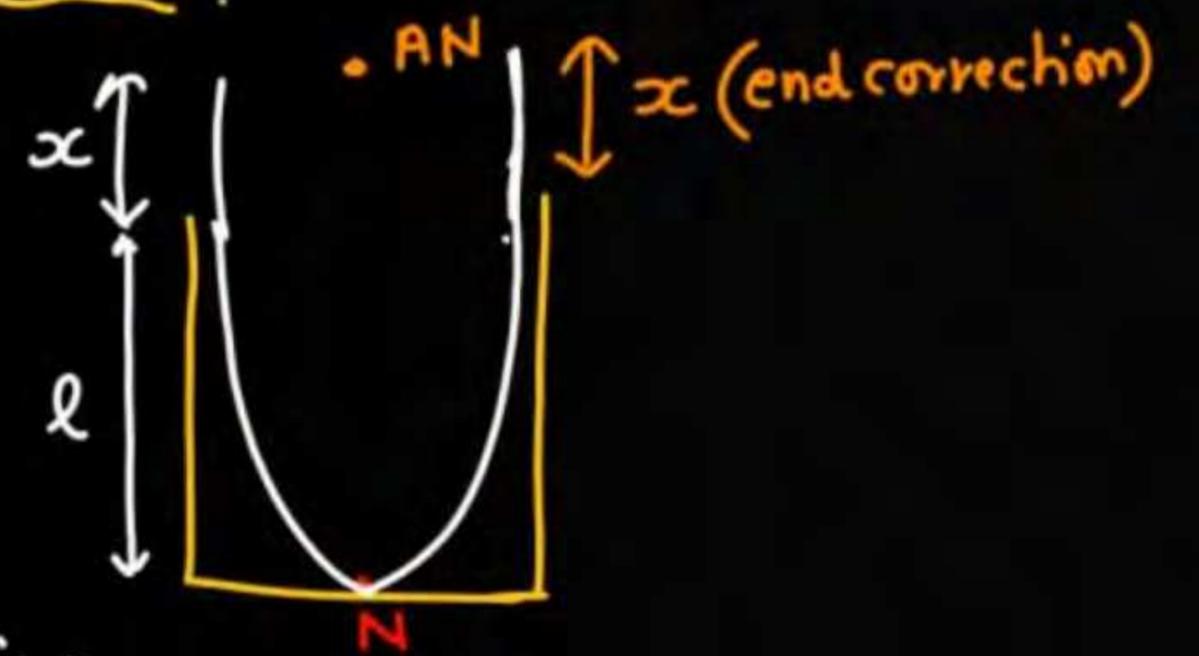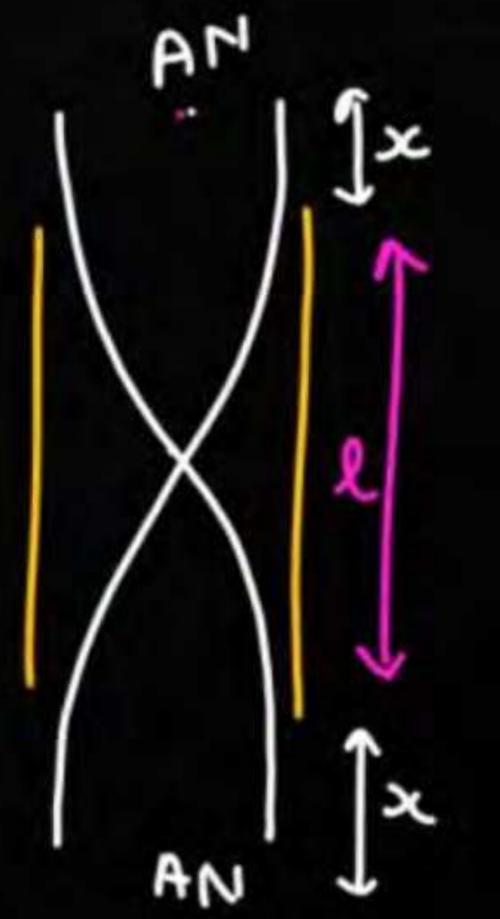
ATDB.uno

Resonance Column tube

— to find speed of sound

f_0

AN

$\uparrow x$

l_1 1st resonatin length

AN

$\uparrow x$

$l_2 \rightarrow$ 2nd resonatin length

N

N

N

N
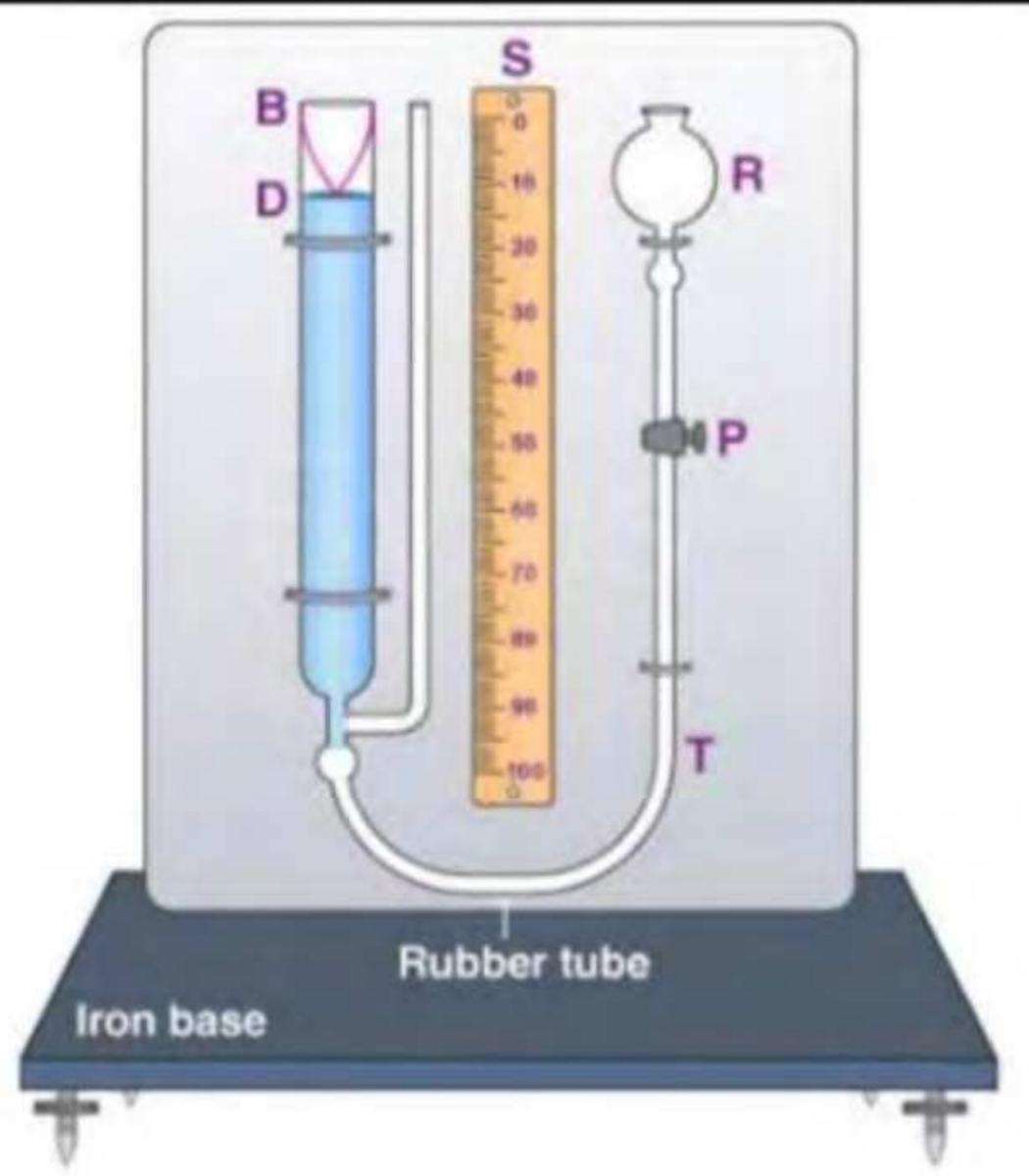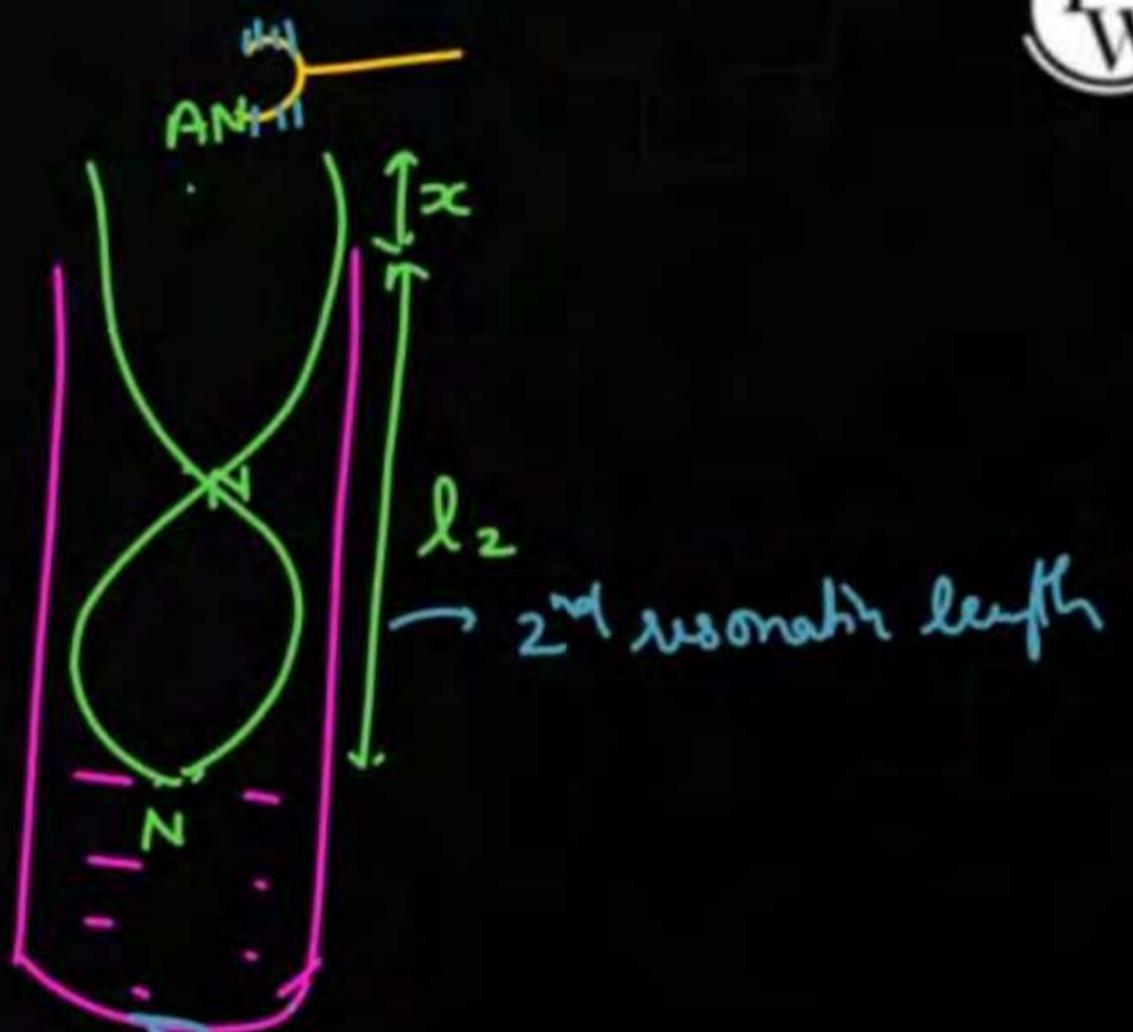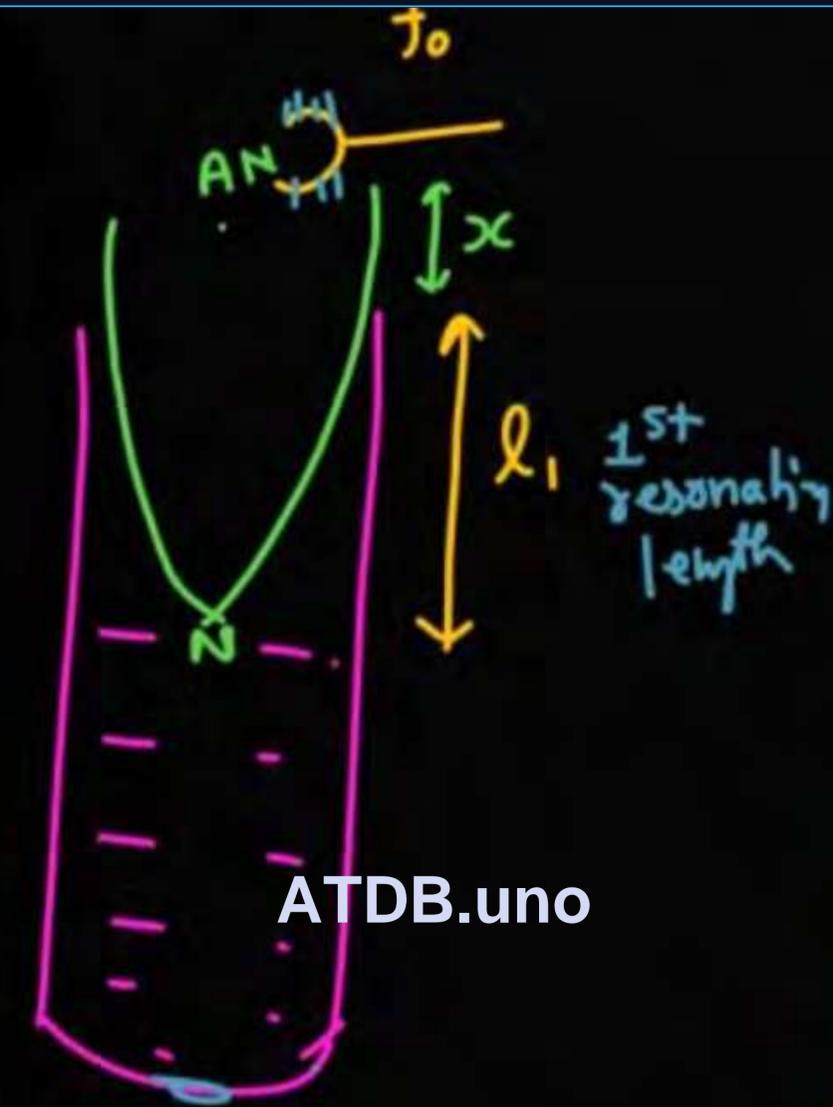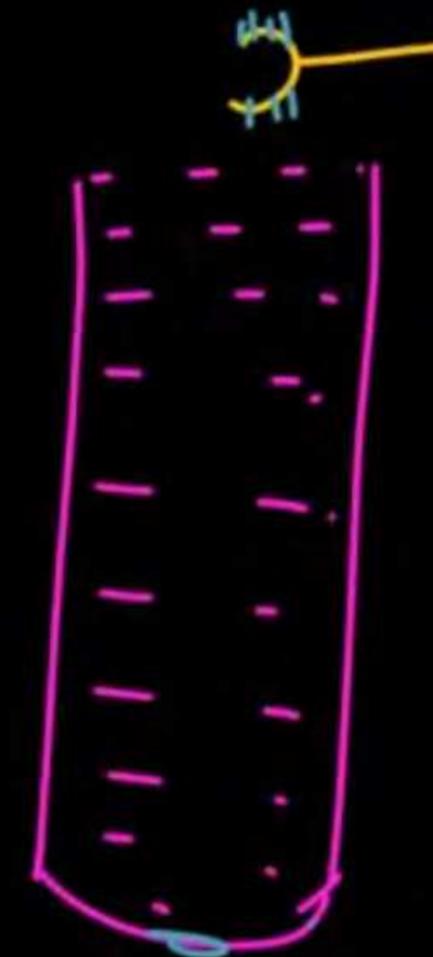
3rd Resonatin length $= l_3$

$$l_3 + x = \frac{5\lambda}{4}$$

$$l_1 + x = \frac{\lambda}{4} - \text{①}$$

$$l_2 + x = \frac{3\lambda}{4} - \text{②}$$

$$l_2 - l_1 = \frac{\lambda}{2} \Rightarrow \boxed{\lambda = 2(l_2 - l_1)} \qquad \boxed{v_{sow} = f_0 \lambda}$$

Q. In a resonance column tube exp if 1st resonating length is 40 c·m

2nd resonating length is observed at 122 cm. find

① end correction, diameter of tube

③ third resonating length

$l_1 = 40$

$l_2 = 122$

① $40 + x = \dfrac{\lambda}{4}$

$122 + x = \dfrac{3\lambda}{4}$

$$\dfrac{82}{} = \dfrac{\lambda}{2}$$

$\boxed{\lambda = 164}$

$\boxed{v_\omega = f_0 \lambda}$

$40 + x = \dfrac{164}{4}$

$\boxed{x = 1 \text{ cm}}$

$x = .6r$

③ $l_3 + x = \dfrac{5\lambda}{4}$

$l_3 + 1 = \dfrac{5 \times 164}{4}$

$l_3 = \checkmark$

ATDB.uno

$$\gamma = \frac{C_p}{C_v} = 1 + \frac{2}{f}$$

$$\text{monoat} = f = 3 \Rightarrow \gamma = \frac{5}{3}$$

$$\text{diat} \quad f = 5 \Rightarrow \gamma = \frac{7}{5}$$

ATDB.uno

with a monoatomic gas of molar mass M_A. Pipe B is open at one end and closed at the other end, and is filled with a diatomic gas of molar mass M_B. Both gases are at the same temperature. **[JEE 2002]**

(a) If the frequency of the second harmonic of the fundamental mode in pipe A is equal to the frequency of the third harmonic of the fundamental mode in pipe B, determine the value of M_A/M_B.

(b) Now the open end of pipe B is also closed (so that the pipe is closed at both ends). Find the ratio of the fundamental frequency in pipe A to that in pipe B.
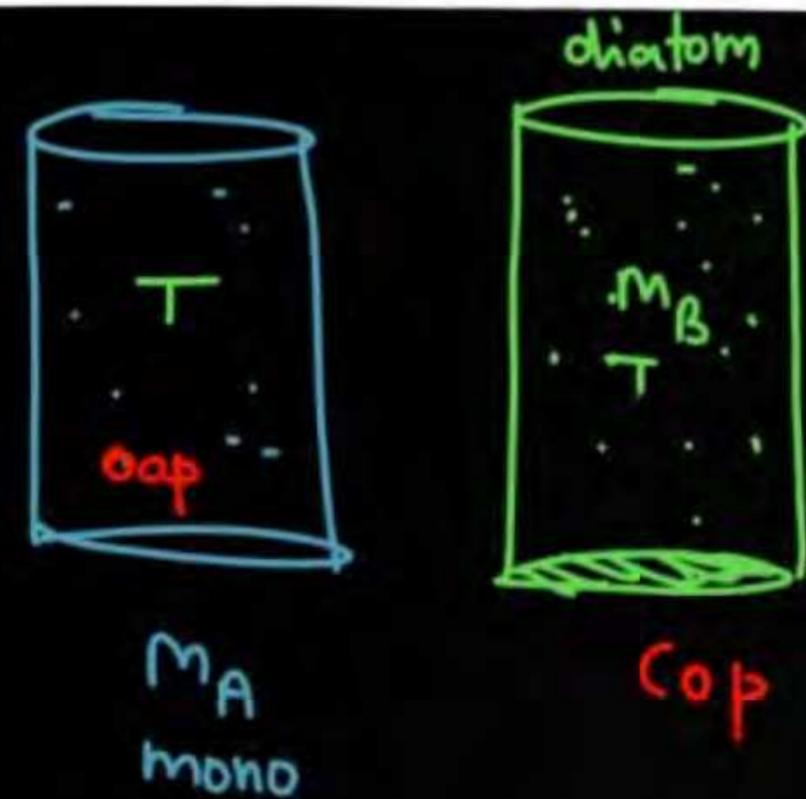
diatom

(a)

$$2 \times \frac{V_1}{2\ell} = 3\frac{V_2}{4\ell}$$

mono $\qquad$ diato

$$v = \sqrt{\frac{\gamma RT}{m}}$$

T

Oap

M_B

T

M_A

mono

Cop

$$\frac{2\sqrt{\frac{5}{3}\cdot\frac{R\cdot T}{m_A}}}{2\ell} = \frac{3}{4\ell}\sqrt{\frac{7}{5}\frac{RT}{m_B}}$$

$$\frac{\lambda}{2} = \ell$$

$$f = \frac{v}{\lambda} = \frac{v}{2\ell}$$

ℓ

close
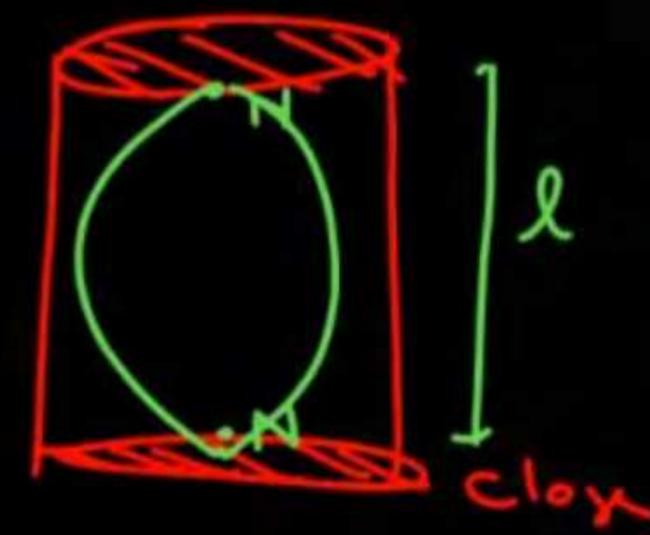
A tube of a certain diameter and of length 48 cm is open at both ends. Its fundamental frequency of resonance is found to be 320 Hz. The velocity of sound in air is 320m/sec. Estimate the diameter of the tube. **[IIT-1980]**

$f_0 = 320$

$V_{Sou} = 320$

$V = f\lambda$
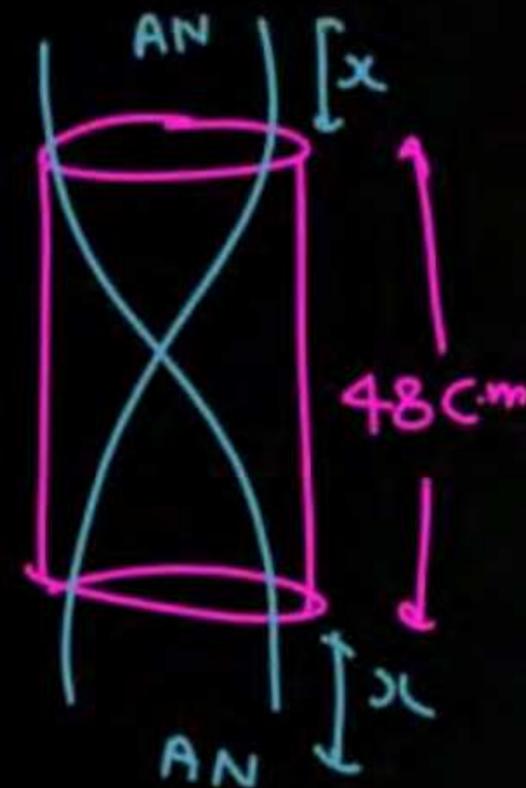
$\lambda = 1m = 100\,cm$

$x + 48 + x = \dfrac{\lambda}{2}$

$2x + 48 = \dfrac{100}{2} = 50\,cm$

$x = 1\,cm = .6r$

$r = \dfrac{10}{6}\,cm$

$diameter = 2r = \dfrac{20}{6}$

$= 3.33\,cm$

The equation of a longitudinal standing wave due to superposition of the progressive waves produced by two sources of sound is s = – 20 sin 10 πx sin 100 πt where s is the displacement from mean position measured in mm ; x is in meters and t in seconds. The specific gravity of the medium is 10^{-3}. Find

(a) wavelength, frequency and velocity of the progressive waves.

(b) Bulk modulus of the medium and the pressure amplitude of the progressive waves.

(c) minimum distance between pressure antinode and the displacement antinode.

$\rho_w = 10^3 \, kg/m^3$

$\Delta P_0 = B S_0 K$

$= \lambda/4$

dio plan Node

$$K = 10\pi = \frac{2\pi}{\lambda}$$

$$\omega = 100\pi = 2\pi f$$

$$V_\omega = \frac{\omega}{K} = \sqrt{\frac{B}{\rho}}$$

$$f = 50$$

$$B = V_\omega^2 \cdot \rho$$

The equation of a longitudinal standing wave due to superposition of the progressive waves produced by two sources of sound is $s = -20 \sin 10\pi x \sin 100\pi t$ where s is the displacement from mean position measured in mm ; x is in meters and t in seconds. The specific gravity of the medium is 10^{-3}. Find

(a) wavelength, frequency and velocity of the progressive waves.

(b) Bulk modulus of the medium and the pressure amplitude of the progressive waves.

(c) minimum distance between pressure antinode and the displacement antinode.

① $A = 10 \, mm \quad \omega = 100\pi = 2\pi f \qquad \boxed{f = 50}$

$S_0 = 10 \, mm \qquad k = 10\pi = \dfrac{2\pi}{\lambda}$

$$\lambda = \dfrac{1}{5}$$

② $v = \sqrt{\dfrac{B}{\rho}}$

$$B = \rho v^2 = (10^{-3} \times 1000) \times 10^2 = 100$$

$$P_0 = B S_0 k = 100 \times 10 \times 10^{-3} . \times 10\pi = 10\pi \, P_a$$

The first overtone of a pipe closed at one end resonates with the third harmonic of a string fixed at its ends. The ratio of the speed of sound to the speed of transverse wave travelling on the string is $2:1$. Find the ratio of the length of pipe to the length of string.

$$\frac{V_1}{V_2} = 2$$

COP 1st ownt

$$\frac{3V_1}{4L_1} = 3\frac{V_2}{2L_2}$$

$\cdot \text{lll}$
pipe

lll
Sdri-

Question

A bird is singing on a tree. A person approaches the tree and perceives that the intensity has increased by 10 dB. Find the ratio of initial and final separation between the man and the bird.

Ans : $\sqrt{10}$

Question

It is found that an increase in pressure of 100 kPa causes a certain volume of water to decrease by 5×10^{-3} percent of its original volume. Then the speed of sound in the water is about (density of water 10^3 kg/m³).

A 330 m/s

B 1414 m/s

C 1732 m/s

D 2500 m/s

hint

$$B = - \frac{\Delta P}{\Delta V / V}$$

$$v = \sqrt{\frac{B}{\rho}}$$

ATDB.uno

Question

A point source emits sound equally in all directions in a non-absorbing medium. Two points P and Q are at a distance of 9 meters and 25 meters respectively from the source. The ratio of the amplitudes of the waves at P and Q is :-

A 5 : 3

B 3 : 5

C 25 : 9

D 625 : 81

$$I \propto \frac{1}{r^2}$$

$$I \propto A^2$$

$$A^2 \propto \frac{1}{r^2}$$

$$A \propto \frac{1}{r}$$

S

P

Q

9m

25m
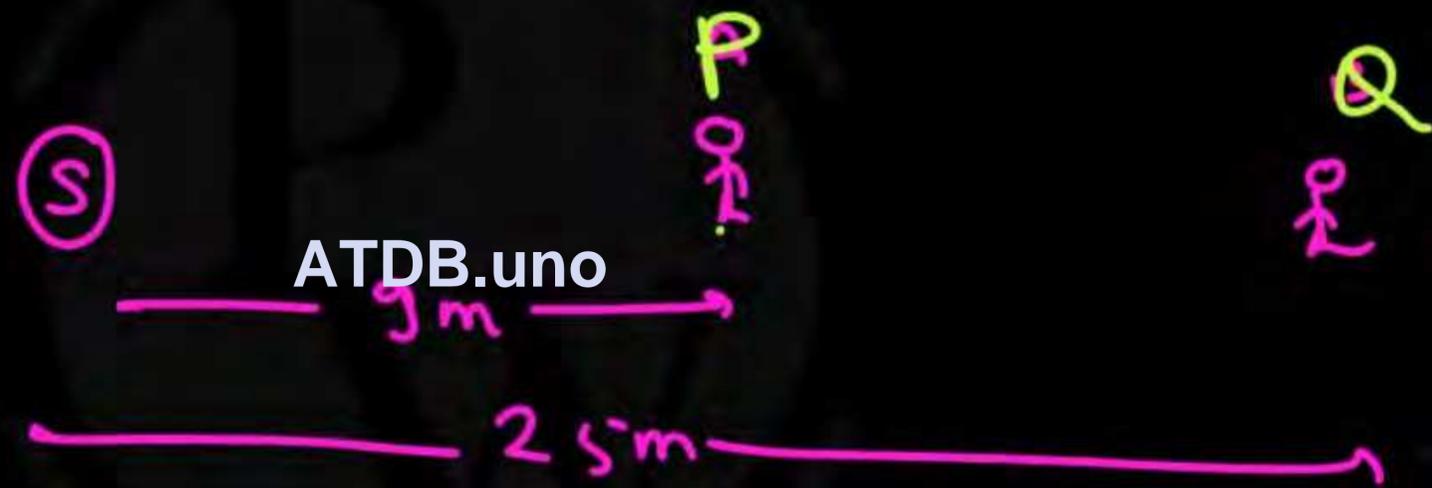
Ans : (C)

Question

A point source emits sound equally in all directions in a non-absorbing medium. Two points P and Q are at a distance of 9 meters and 25 meters respectively from the source. The ratio of the amplitudes of the waves at P and Q is :-

A   5 : 3

B   3 : 5

C   25 : 9

D   625 : 81

$$I \propto A^2$$

$$I \propto \frac{1}{r^2}$$

$$A \propto \frac{1}{r}$$

Ans : (C)

Question

The equation of a longitudinal standing wave due to superposition of the progressive waves produced by two sources of sound is s = –20 sin10πx sin100πt where s is the displacement from mean position measured in mm ; x is in meters and t in seconds. The specific gravity of the medium is 10^{-3}. Find

(a) wavelength, frequency and velocity of the progressive waves.

(b) Bulk modulus of the medium and the pressure amplitude of the progressive waves.

(c) minimum distance between pressure antinode and the displacement antinode

Ans : (a) 1/5 m, 50 Hz, 10 m/s; (b) 100 Pa, 10 π Pa, (c) 1/20 m

In a mixture of gases, the average number of degrees of freedom per molecule is 6. The rms speed of the molecules of the gas is c. Find the velocity of sound in the gas.

Hw

Ans : 2c/3

Question

The first overtone of a pipe closed at one end resonates with the third harmonic of a string fixed at its ends. The ratio of the speed of sound to the speed of transverse wave travelling on the string is 2 : 1. Find the ratio of the length of pipe to the length of string.

Repeat

ATDB.uno

Ans : 1 : 1

Question (H/W)

An open organ pipe filled with air has a fundamental frequency 500Hz. The first harmonic of another organ pipe closed at one end and filled with carbon dioxide has the same frequency as that of the first harmonic of the open organ pipe. Calculate the length of each pipe. Assume that the velocity of sound in air and in carbondioxide to be 330 and 264 m/s respectively.

$V_1 = 330$

$V_2 = 264$

$$f_0 = 500 = \frac{V_1}{2\ell_1}$$

$$\frac{V_2}{4L_2} = \frac{V_1}{2\ell_1}$$

Ans : 33 cm and 13.2 cm

ATDB.uno

ATDB.uno | Studyprayas ⓘ FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFZ
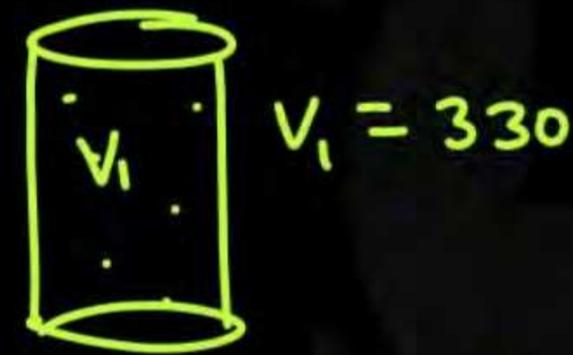
Question

Hlw

A sound wave has a wavelength of 3.0 m. The distance from a compression center to the adjacent rarefaction center is :-

A   0.75 m

B   1.5 m

C   3.0 m

D   need to know wave speed

Ans : (B)

Question

The fig.(i) shows the graphical representation of the air molecules in a tube of air (length = L) at atmospheric pressure on the absolute pressure P(x) graph. Which one of the following pictures corresponds to the absolute pressure P(x) graph of fig. (ii).
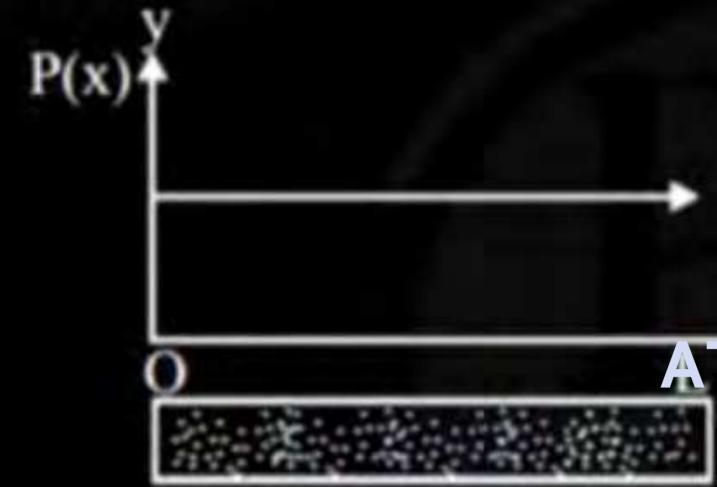
Figure (i)
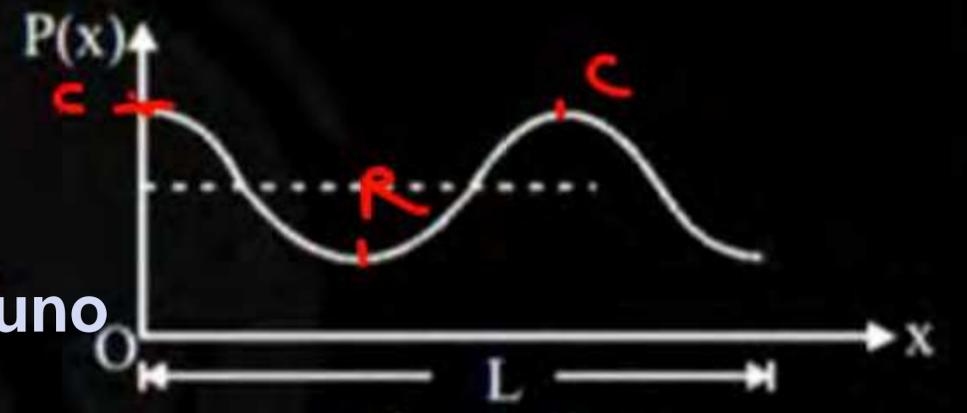
Figure (ii)

A
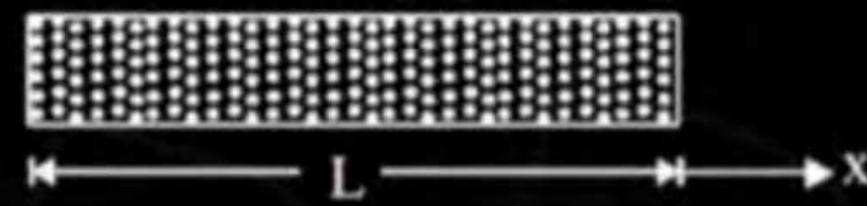
B
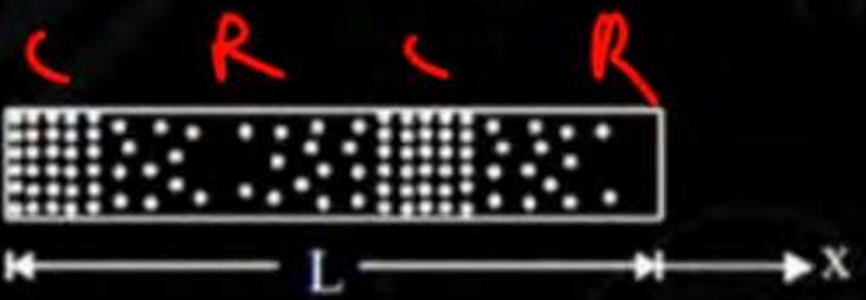
C
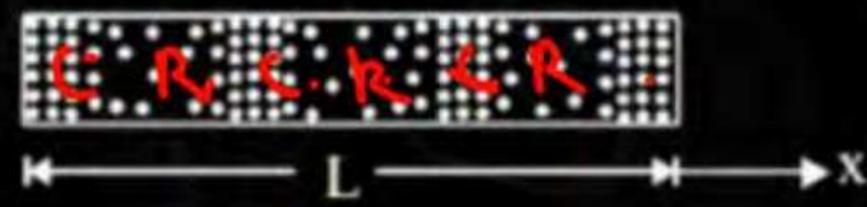
D
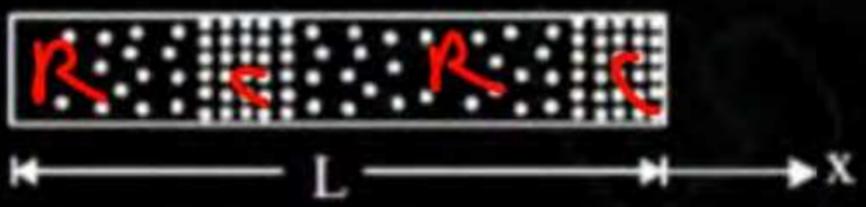
Ans : (*)

Question

Jm fvrt

Two monatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate container kept at the same temperature. The ratio of the speed of sound in gas 1 to that in gas 2 is given by

[JEE 2000 (Scr)]

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

(A) $\sqrt{\dfrac{m_1}{m_2}}$

(B) $\sqrt{\dfrac{m_2}{m_1}}$

(C) $\dfrac{m_1}{m_2}$

(D) $\dfrac{m_2}{m_1}$

Ans : (B)

ATDB.uno

ATDB.uno | Studyprayas ☆ FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFz

Question

note / copy

(P W)

The speed of longitudinal wave is 100 times the speed of transverse wave in a taut brass wire. If the Young's modulus of brass is 1.0×10^{11} N/m^2, the stress in wire is:-

A) 1.0×10^7 N/m^2

B) 1.0×10^6 N/m^2

C) 1.0×10^5 N/m^2

D) 1.0×10^8 N/m^2

$v_{longitudenal} = 100 \ v_{transverse\ wave}$

$$\sqrt{\frac{Y}{\rho}} = 100 \sqrt{\frac{T}{\mu}} = 100 \sqrt{\frac{T}{\rho A}}$$

ATDB.uno

$$\sqrt{\frac{Y}{\rho}} = 100 \sqrt{\frac{T}{\rho A}}$$

$Y = 10^4 \ (Stress)$

Sh

Ans : (A)

Question

The speed of longitudinal wave is 100 times the speed of transverse wave in a taut brass wire. If the Young's modulus of brass is $1.0 \times 10^{11} \, N/m^2$, the stress in wire is:-

(A) $1.0 \times 10^7 \, N/m^2$

(B) $1.0 \times 10^6 \, N/m^2$

(C) $1.0 \times 10^5 \, N/m^2$

(D) $1.0 \times 10^8 \, N/m^2$

$$v_{longitudinal} = \sqrt{\frac{Y}{\rho}} = 100 \, v_{transverse}$$

$$\sqrt{\frac{Y}{\rho}} = 100 \sqrt{\frac{T}{\rho A}}$$

$$\sqrt{Y} = 100 \sqrt{\frac{T}{A}}$$

$$Stress = \frac{T}{A} = \frac{Y}{10^4}$$

Ans : (A)

Question

A microphone is connected to an oscilloscope. The diagram shows the trace on the screen when the microphone receives a pure note. Which trace can be obtained when a musical instrument produces a note of the same pitch but of a different quality ?

A

B

C

D

Ans : (B)

Question

Which of the figures, shows the pressure difference from regular atmospheric pressure for an organ pipe of length L closed at one end, corresponds to the 1st overtone for the pipe?

A

B
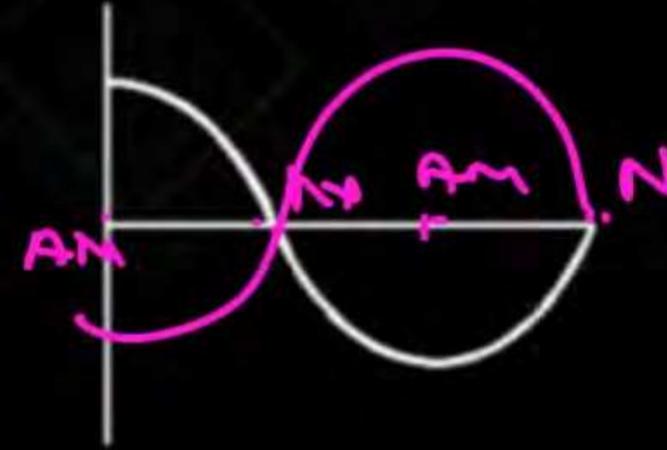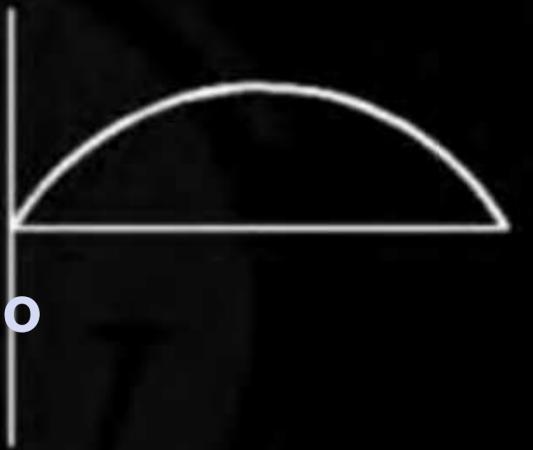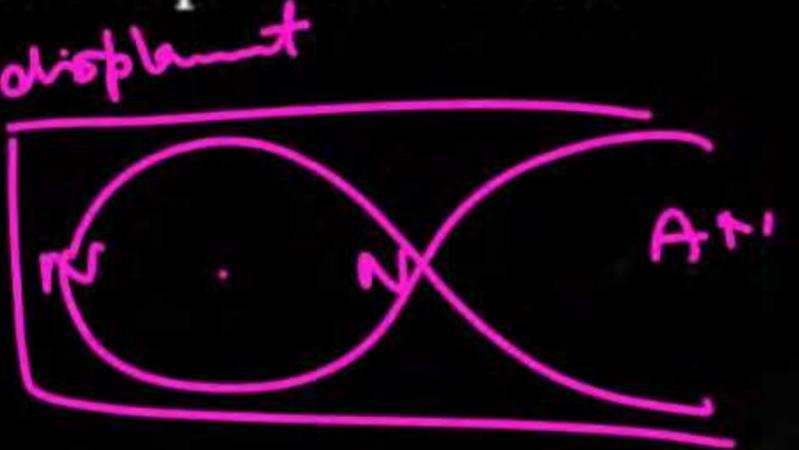
C
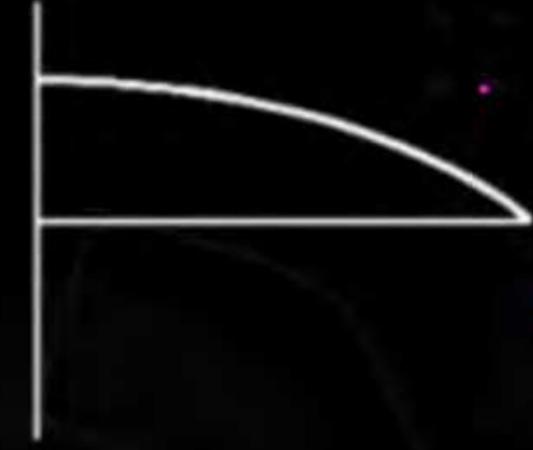
D
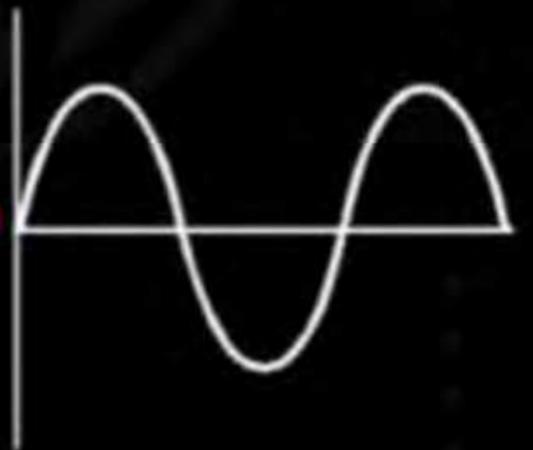
Ans : (A)

Question $H|w$

In an organ pipe whose one end is at $x = 0$, the pressure is expressed by $p = p_0 \cos \dfrac{3\pi x}{2} \sin 300\pi t$ where x is in meter and t in sec. The organ pipe can be

A closed at one end, open at another with length = 0.5 m

B open at both ends, length = 1m

C closed at both ends, length = 2m

D closed at one end, open at another with length = $\dfrac{2}{3}$m

Ans : (C)

ATDB.uno z

ATDB PDFz

ATDB.uno | Studyprayas ô FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFz

Question H/w

If l_1 and l_2 are the lengths of air column for the first and second resonance when a tuning fork of frequency n is sounded on a resonance tube, then the distance of the displacement antinode from the top end of the resonance tube is:

A $\quad 2(l_2 - l_1)$

B $\quad \dfrac{1}{2}(2l_1 - l_2)$

C $\quad \dfrac{l_2 - 3l_1}{2}$

D $\quad \dfrac{l_2 - l_1}{2}$

Ans : (C)

Question

H/ω

A sound absorber attenuates the sound level by 20 dB. The intensity decreases by a factor of-

[AIEEE - 2007]

(A) 1000

(B) 10000

(C) 10

(D) 100

Ans : (D)

ATDB.uno z

ATDB.uno | Studyprayas ∂ FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFz

Question

Column-I shows four systems, each of the same length L, for producing standing waves. The lowest possible natural frequency of a system is called its fundamental frequency, whose wavelength is denoted as λ_f. Match each system with statements given in Column-II describing the nature and wavelength of the standing waves.

[JEE 2011]

Column-I

(A) Pipe closed at one end

(B) Pipe open at both ends

(C) Stretched wire clamped at both ends

(D) Stretched wire clamped at both ends and at mid-point
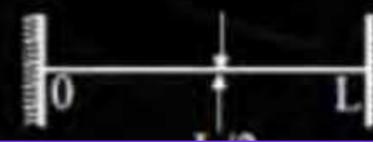
Column-II

(P) Longitudinal waves

(Q) Transverse Waves

(R) $\lambda_f = L$

(S) $\lambda_f = 2L$

(T) $\lambda_f = 4L$

Ans : (A) P,T (B) P,S (C) Q,S (D) Q,R

Beat

when two sound wave of same amplitude and different frequency superimpose then intensity at any point in space varies periodically wrt time. This effect is called Beat.

$$Beat = |f_1 - f_2|$$

$$f_1 = 500$$
$$f_2 = 503$$

$$Beat = 503 - 500 = 3$$

$$T.F \Rightarrow wax \Rightarrow freq \downarrow$$

$$T-F \Rightarrow phila \Rightarrow freq \uparrow$$

ATDB.uno

Q. Consider a T.F (tuning fork) A of frequency 100 Hz. when sounded with T.F B produce 6 beats. If some wax is loaded on B beat frequency increases. Find initial freq. of T.F. B.

$f_B = 106$

⑥

⑤ → 105

$f_A = 100$ → ④ → 104

⑦ ⑥

⑧

$f_B = 94$

93

92

$\underline{Ans}$ ㊹
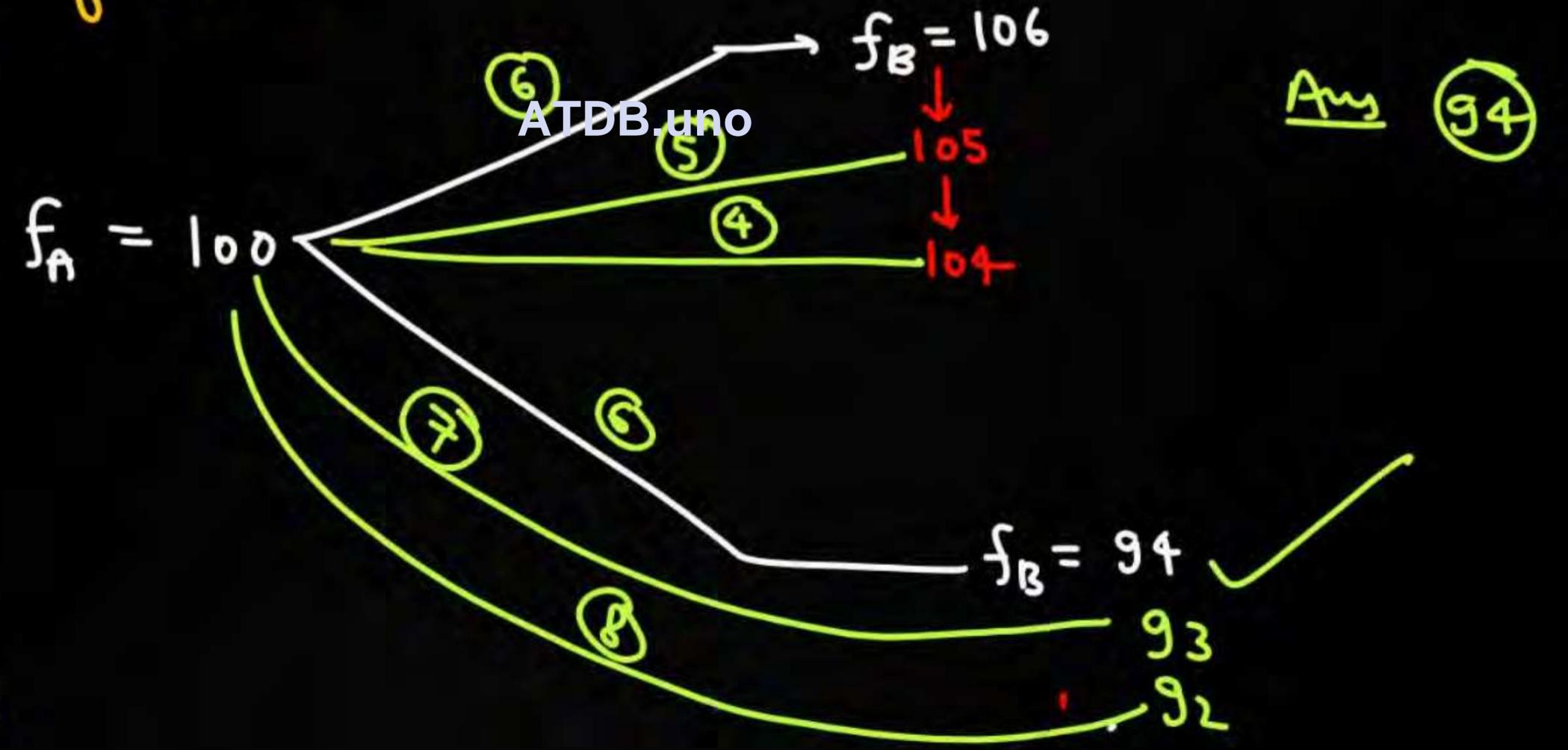
Q. Consider a T.F (tuning fork) A of frequency 500 Hz when sounded with T.F B produce 6 beats. If some wax is loaded on A beat frequency decreases to ④. find freq. of T.F. B.

Sol^n

$$f_A = 500$$

$$f_B = 506$$

$$f_B = 494$$

Avg

$$f_A = 500$$
⑥
⑤
④
⑧

$$500 \downarrow 499 \downarrow 498 \downarrow 497$$
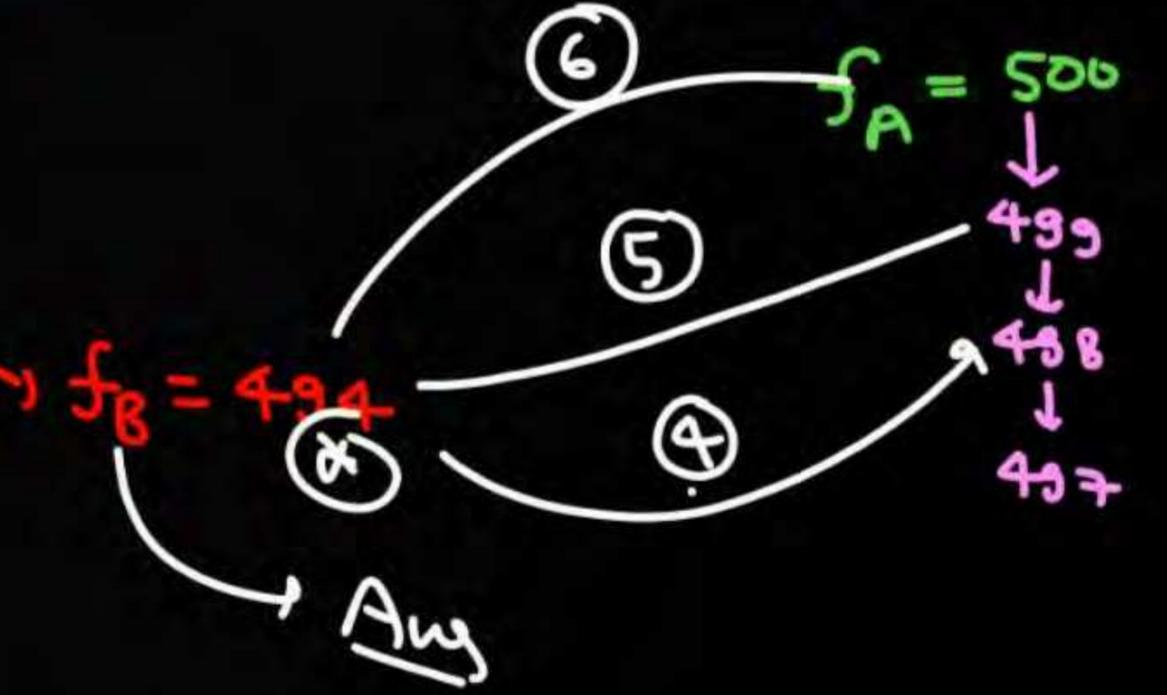
Q   Find velocity of sound in gas where two waves of wavelength
50 cm & 50.4 cm produce 6 beats per second.

$v = f\lambda$

$f = \dfrac{v}{\lambda}$

$f_1 - f_2 = 6$

$\dfrac{v}{\cdot 50} - \dfrac{v}{\cdot 504} = 6$

ATDB.uno

$v = \checkmark$

f_1 f_2

Q An COP & OOP of same length produce 2 beats when they are set into viberation Simultaneously in their fundamental mode. If the length of OOP is now halfed and that of COP is doubled no. of beat produce will be?

$$f_1 - f_2 = 2$$

$$\left| \frac{V}{4\ell} - \frac{V}{2\ell} \right| = 2$$

$$\frac{V}{4\ell} = 2$$

$$\boxed{\frac{V}{\ell} = 8}$$

$$\frac{V}{2\left(\frac{\ell}{2}\right)} - \frac{V}{4(2\ell)} = \frac{V}{\ell} - \frac{V}{8\ell} = \frac{7V}{8\ell}$$

$$= \frac{7}{8} \times 8 = 7$$

Q_2

$$f_2 = 2\frac{V_1}{2\ell_1}$$

$$V_1 = \sqrt{T/\mu}$$

5th harmonic

$$V_2 = \sqrt{\frac{\gamma RT}{m}}$$
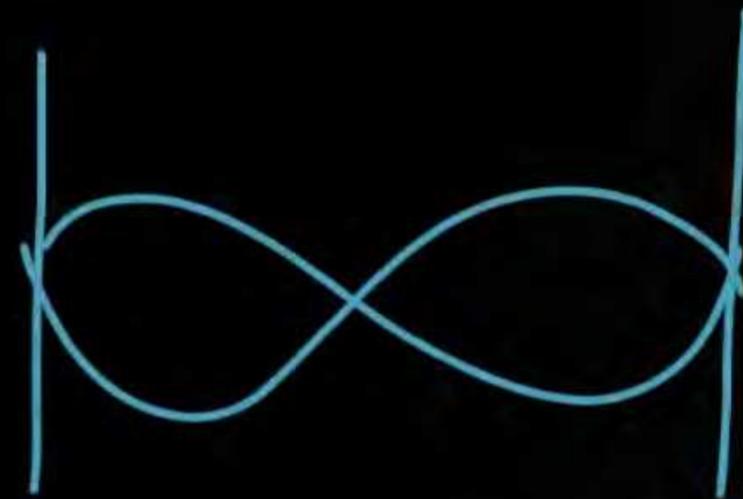
$$f_5 = 5\frac{V_2}{4\ell_2}$$

$$\left|\frac{2V_1}{2\ell_1} - \frac{5V_2}{4\ell_2}\right| = Beat$$

$$V_w = \frac{\omega}{K}$$

$$\langle I \rangle = \frac{1}{2} B S_0^2 \omega K = \frac{1}{2} \frac{\Delta P_0^2}{\rho V_w} - \frac{1}{2} \rho S_0^2 \omega^2 V_w$$

If two wave $\equiv$ same velocity $\Rightarrow$ $I \propto S_0^2 \omega^2$

Q If sound of intensity 8340×10^{6} watt/m^2 is passing through air. find S_0 if

$$f_{req} = 1000 \, Hz \qquad \rho_{air} = 1.2 \, Kg/m^3$$

$$V_{sound} = 330 \, m/s$$

Sol^n

$I = \checkmark$

$\omega = \checkmark$

$\rho = \checkmark$

$V_\omega = \checkmark$

$S_0 = ?$

$$\langle I \rangle = \frac{1}{2} \rho S_0^2 \omega^2 V_\omega$$

Given

$Q.$ Two sound wave $S_1 = 10\sin\left(100\pi t - 4\pi x\right)$

$S_2 = 20\sin\left(200\pi t + 2\pi a x\right)$

$I \propto S_0^2 \omega^2$

and

propagate in a medium with Same speed find

find a & ratio of Intensity

Sol^n

$$\frac{100\pi}{4\pi} = \frac{200\pi}{2\pi a}$$

$a = 4$

$I = \frac{1}{2} B S_0^2 \omega K$

$V_\omega = \frac{\omega}{K} \qquad K = \frac{\omega}{V_\omega}$

$I = \frac{1}{2} B S_0^2 \omega \cdot \frac{\omega}{V_\omega}$

$I \propto S_0^2 \omega^2$

$$\frac{I_1}{I_2} = \left(\frac{10}{20}\right)^2 \times \left(\frac{100\pi}{200\pi}\right)^2$$

ATDB.uno

ATDB.uno

ATDB.uno | Studyprayas ä FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDF z

ATDB.uno

QUESTION

A uniform thin rope of length 12 m and mass 6 kg hangs vertically from a rigid support and a block of mass 2 kg is attached to its free end. A transverse short wavetrain of wavelength 6 cm is produced at the lower end of the rope. What is the wavelength of the wavetrain (in cm) when it reaches the top of the rope?

$f \longrightarrow$ Same

$v = f \lambda$

[JEE Mains 2020]

ATDB.uno

(1) 9

(2) 12

(3) 6

(4) 3

Ans : (2)

QUESTION

A one meter long (both ends open) organ pipe is kept in a gas that has double the density of air at STP. Assuming the speed of sound in air at STP is 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is _____ Hz.

[JEE Mains 2020]

Ans : 106.00 to 107.20

ATDB.uno

ATDB.uno | Studyprayas | FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFZ

QUESTION

In a resonance tube experiment when the tube is filled with water up to height of 17.0 cm from bottom, it resonates with a given tuning fork. When the water level is raised the next resonance with the same tuning fork occurs at a height of 24.5 cm. If the velocity of sound in air is 330 m/s, the tuning fork frequency is: **[JEE Mains 2020]**

ATDB.uno

1   1100 Hz

2   3300 Hz

3   2200 Hz

4   550 Hz

Ans : (3)

ATDB.unoz

ATDB.uno | Studyprayas a FOR PERSONAL STUDY USE ONLY, DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFZ

QUESTION

Assume that the displacement(s) of air is proportional to the pressure difference (Δp) created by a sound wave. Displacement(s) further depends on the speed of sound (v), density of air (ρ) and the frequency (f). If $\Delta p \sim 10$ Pa, $v \sim 300$ m/s, $p \sim 1$ kg/m^3 and $f \sim 1000$Hz, then s will be the order of (take multiplicative constant to be 1).

[JEE Mains 2020]

ATDB.uno

1. 10 mm

2. $\dfrac{3}{100}$ mm

3. 1 m

4. $\dfrac{1}{10}$ mm

Ans : (2)

QUESTION

A student is performing the experiment of resonance column. The diameter of the column tube is 6 cm. The frequency of the tuning fork is 504 Hz. Speed of the sound at the given temperature is 336 m/s. The zero of the meter scale coincides with the top end of the resonance column tube. The reading of the water level in the column when the first resonance occurs is:

[JEE Mains 2021]

ATDB.uno

(1) 13 cm

(2) 16.6 cm

(3) 18.4 cm

(4) 14.8 cm

Ans : (4)

QUESTION

A tuning fork A of unknown frequency produces 5 beats/s with a fork of known frequency 340 Hz. When fork A is filed, the beat frequency decreases to 2 beats/s. What is the frequency of fork A?

[JEE Mains 2021]

1 342 Hz

ATDB.uno

2 345 Hz

3 335 Hz

4 338 Hz

Ans : (3)

ATDB.uno

ATDB.uno | Studyprayas à FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDF2

QUESTION

A closed organ pipe of length L and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open pipe is $\frac{x}{3} L \sqrt{\dfrac{\rho_1}{\rho_2}}$ where x is _____. (Round off to the Nearest Integer)

ATDB.uno

[JEE Mains 2021]

Ans : 4

ATDB.uno z

ATDB.uno | Studyprayas â FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFZ

QUESTION

A sound wave of frequency 245 Hz travels with the speed of 300 ms^{-1} along the positive x-axis. Each point of the wave moves to and for through a total distance of 6 cm. What will be the mathematical expression of this travelling wave?

[JEE Mains 2021]

1 $Y(x, t) = 0.03 [\sin 5.1 x - (0.2 \times 10^3)t]$

2 $Y(x, t) = 0.06 [\sin 5.1 x - (1.5 \times 10^3)t]$

3 $Y(x, t) = 0.06 [\sin 0.8 x - (0.5 \times 10^3)t]$

4 $Y(x, t) = 0.03 [\sin 5.1 x - (1.5 \times 10^3)t]$

Ans : (4)

ATDB.uno

ATDB.uno | Studyprayas â FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFZ

QUESTION

The amplitude of wave disturbance propagating in the positive x-direction is given by $y = \dfrac{1}{(1+x^2)}$ at time t = 0 and $y = \dfrac{1}{1+(x-2)^2}$ at t = 1s, where x and y are in meres. The shape of wave does not change during the propagation. The velocity of the wave will be _____ m/s.

[JEE Mains 2021]

ATDB.uno

Ans : 2

QUESTION

Two travelling waves produces a standing wave represented by equation, $y = 1.0$ mm $\cos(1.57$ cm$^{-1})$ x $\sin(78.5$ s$^{-1})$t. The node closest to the origin in the region x > 0 will be at x = _____ cm.

[JEE Mains 2021]

Ans : 1

ATDB.uno

ATDB.uno | Studyprayas FOR PERSONAL STUDY USE ONLY. DO NOT SHARE OR REDISTRIBUTE.

ATDB PDFZ

ATDB.uno | Unauthorised redistribution is strictly prohibited

QUESTION

A tuning fork is vibrating at 250 Hz. The length of the shortest closed organ pipe that will resonate with the tuning fork will be _____ cm. (Take speed of sound in air as 340 ms⁻¹).

[JEE Mains 2021]

Ans : 34

QUESTION

In the wave equation, $y = 0.5\sin\dfrac{2\pi}{\lambda}(400t - x)$ m the velocity of the wave will be:

[JEE Mains 2022]

1   200 m/s

2 $20\sqrt{2}$ m/s

3   400 m/s

4 $400\sqrt{2}$ m/s

Ans : (3)

QUESTION

The first overtone frequency of an open organ pipe is equal to the fundamental frequency of a closed organ pipe. If the length of the closed organ pipe is 20 cm. The length of the open organ pipe is _____ cm.

[JEE Mains 2022]

ATDB.uno

Ans : 80

QUESTION

An observer moves towards a stationary source of sound with a velocity equal to one-fifth of the velocity of sound. The percentage change in the frequency will be:

[JEE Mains 2022]

1. 20%

2. 10%

3. 5%

4. 0%

Ans : (1)

QUESTION

If a wave gets refracted into a denser medium, then which of the following is true?

[JEE Mains 2022]

1 wavelength speed and frequency decreases.

2 wavelength increases, speed decreases and frequency remains constant.

3 wavelength and speed decreases but frequency remains constant.

4 wavelength, speed and frequency increases.

Ans : (3)

QUESTION

The velocity of sound in a gas. in which two wavelengths 4.08 m and 4.16 m produce 40 beats in 12 s, will be:

[JEE Mains 2022]

1   2.82 ms⁻¹

2   175.5 ms⁻¹

3   353.6 ms⁻¹

4   707.2 ms⁻¹

Ans : (4)

QUESTION

A tuning fork of frequency 340 Hz resonates in the fundamental mode with an air column of length 125 cm in a cylindrical tube closed at one end. When water is slowly poured in it, the minimum height of water required for observing resonance once again is _____ cm. (Velocity of sound in air is 340 ms^{-1})

[JEE Mains 2022]

ATDB.uno

Ans : 50

QUESTION

(P W)

A longitudinal wave is represented by $x = 10\sin 2\pi\left(nt - \dfrac{x}{\lambda}\right)$ cm. The maximum particle velocity will be four times the wave velocity if the determined value of wavelength is equal to:

[JEE Mains 2022]

1 $\quad 2\pi$

2 $\quad 5\pi$

ATDB.uno

3 $\quad \pi$

4 $\quad \dfrac{5\pi}{2}$

Ans : (2)

QUESTION

In an experiment to determine the velocity of sound in air at room temperature using a resonance is observed when the air column has a length of 20.0 cm for a tuning fork of frequency 400 Hz is used. The velocity of the sound at room temperature is 336 ms^{-1}. The third resonance is observed when the air column has a length of _____ cm.

[JEE Mains 2022]

ATDB.uno

Ans : 104

QUESTION

A travelling wave is described by the equation $y(x, t) = [0.05 \sin (8x - 4t)]$m.
The velocity of the wave is : [all the quantities are in SI unit]

[24 January 2023 - Shift 1]

ATDB.uno

1. 4 ms^{-1}

2. 2 ms^{-1}

3. 0.5 ms^{-1}

4. 8 ms^{-1}

Ans : (3)

QUESTION

The distance between two consecutive points with phase difference of 60° in a wave of frequency 500 Hz is 6.0 m. The velocity with which wave is traveling is _____ km/s.

[25 January 2023 - Shift 1]

Ans : (18)

QUESTION

The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is:

[06 April 2023 - Shift 2]

1   1 : 2

2   4 : 1

3   1 : 4

4   1 : 1

Ans : (2)

QUESTION

An organ pipe 40 cm long is open at both ends. The speed of sound in air is 360 ms^{-1}. The frequency of the second harmonic is _____ Hz.

[08 April 2023 - Shift 1]

ATDB.uno

Ans : (900)

The equation of wave is given by $Y = 10^{-2}\sin 2\pi\left(160t - 0.5x + \dfrac{\pi}{4}\right)$, where x and Y are in m and t is s. The speed of the wave is _____ km h^{-1} **[11 April 2023 - Shift 1]**

Ans : (1152)

QUESTION

For a certain organ pipe, the first three resonance frequencies are in the ratio of 1 : 3 : 5 respectively. If the frequency of fifth harmonic is 405 Hz and the speed of sound in air is 324 ms^{-1} the length of the organ pipe is _____ m.

[12 April 2023 - Shift 1]

ATDB.uno

Ans : (1)

QUESTION

A closed organ pipe 150 cm long gives 7 beats per second with an open organ pipe of length 350 cm, both vibrating in fundamental mode. The velocity of sound is _____ m/s.

[27 Jan. 2024 - Shift 2]

ATDB.uno

Ans : (294)

QUESTION

In a closed organ pipe, the frequency of fundamental note is 30 Hz. A certain amount of water is now poured in the organ pipe so that the fundamental frequency is increased to 110 Hz. If the organ pipe has a cross-sectional area of 2 cm², the amount of water poured in the organ tube is _____ g. (Take speed of sound in air is 330 m/s).

[30 Jan. 2024 - Shift 1]

ATDB.uno

Ans : (400)

QUESTION

The fundamental frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. If length of the open pipe is 60 cm, the length of the closed pipe will be:

[31 Jan. 2024 - Shift 1]

1 60 cm

ATDB.uno

2 45 cm

3 30 cm

4 15 cm

Ans : (4)

QUESTION

The speed of sound in oxygen at S.T.P. will be approximately:
(Given, $R = 8.3 \, JK^{-1}$, $\gamma = 1.4$)

[31 Jan. 2024 - Shift 2]

1 310 m/s

2 333 m/s

ATDB.uno

3 341 m/s

4 325 m/s

Ans : (1)

QUESTION

Two open organ pipes of lengths 60 cm and 90 cm resonate at 6th and 5th harmonics respectively. The difference of frequencies for the given modes is _____ Hz. (Velocity of sound in air = 333 m/s).

[06 Apr. 2024 - Shift 2]

Ans : (740)

QUESTION

A closed and an open organ pipe have same lengths. If the ratio of frequencies of their seventh overtones is $\left(\dfrac{a-1}{a}\right)$ then the value of a is _____. **[08 Apr. 2024 - Shift 1]**

Ans : (16)

QUESTION

A plane progressive wave is given by $y = 2 \cos 2\pi(330t - x)$ m. The frequency of the wave is:

[08 Apr. 2024 - Shift 2]

1 330 Hz

2 660 Hz

3 340 Hz

4 165 Hz

Ans : (1)

Home work

- Ques an attached
- PYQ module Exercise. $\left(\text{Except doppler effect}\right)$

ATDB.uno