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$$\boxed{v = \sqrt{\frac{T}{\mu}}}$$

ρ = density of string.

A = Crossectional area.

l = length of String

$$\mu = \frac{m}{l} = \frac{\rho A l}{l}$$

$$(\mu = \rho A)$$

$$\boxed{v = \sqrt{\frac{T}{\rho A}}}$$

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Velocity of sound wave in a medium (Fluid)

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

B = Bulk Modulus of the medium

ρ = density of the medium

$$\boxed{B = -\frac{dP}{\left(\frac{dV}{V}\right)}}$$

Velocity of Sound in Solid

$$\boxed{v = \sqrt{\frac{Y}{\rho}}}$$

Y = Young's Modulus.

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Velocity of Sound in air

According to Newton

↳ Compression and rarefraction is an isothermal process

$$B_{isothermal} = P.$$

$$v_{sound} = \sqrt{\frac{P}{\rho}}$$

LAPLACE CORRECTION

According to Laplace Compression & rarefraction occur very suddenl so system doesn't get enough time to intract with surrounding so Adiabatic process.

According to Laplace

$$PV^{\gamma} = C$$

$$B = \gamma P.$$

$$\boxed{v = \sqrt{\frac{\gamma P}{\rho}}}$$

$$\gamma_{air} = 1.4$$

$$PV = nRT$$

$$PV = \frac{m}{M} RT$$

$$P = \frac{m}{V}\left(\frac{RT}{M}\right)$$

$$P = \rho \frac{RT}{M}$$

$$\left(\frac{P}{\rho} = \frac{RT}{M}\right)$$

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

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

if T Costant then the ratio $\frac{P}{\rho}$ is Constant

$$\boxed{v \propto \sqrt{T}}$$

let, v_0 be Velocity at $0^\circ c$ and v be the velocity of sound at $t^\circ c$

$$\frac{v}{v_0} = \sqrt{\frac{273+t}{273}} \Rightarrow v = v_0\left(1+\frac{t}{273}\right)^{\frac{1}{2}}$$

$^\circ C$

$\frac{t}{273} << 1$

$$** \boxed{v = v_0\left(1+\frac{t}{546}\right)}$$

** Velocity of Sound depends on humidity.

Speed of sound increases with humidity provided pressure must be constant.

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Characteristics of Sound.

* pitch → Differentiate Male voice, female voice or any other.
  — Higher the pitch, quality of sound is good.
* frequency → Higher the frequency higher is the pitch.

* loudness & Intensity →

decible

$$\boxed{\beta = 10 \log\left(\frac{I}{I_0}\right)}$$

I_0 = Refrance intensity
$10^{-12}\ W/m^2$

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If intensity is increased by a factor of 20. by how many decible sound level increases.

$$\beta = 10 \log\left(\frac{I}{I_0}\right)$$

$$I_1 = 20 I$$

$$\beta_1 = 10 \log\left(\frac{20 I}{I_0}\right)$$

$$\beta_1 - \beta = 10 \log\left(\frac{20 I}{I_0}\right) - 10 \log\left(\frac{I}{I_0}\right)$$

$$= 10\left[\log\left(\frac{20 \cancel{I}}{\cancel{I_0}} \times \frac{\cancel{I_0}}{\cancel{I}}\right)\right]$$

$$= 10 \log(20)$$

$$\beta_1 = \beta + 10 \log(20)$$

$$\simeq \underline{13\,dB}$$

decible $\rightarrow$ (dB)

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Superposition principle.

$$y_1 = f_1\left(t - \frac{x}{v}\right)$$

$$y_2 = f_2\left(t - \frac{x}{v}\right)$$

$$y_R = y_1 + y_2$$

$$= f_1\left(t - \frac{x}{v}\right) + f_2\left(t - \frac{x}{v}\right)$$

INTERFERANCE

$$y_1 = A_1 \sin(kx - \omega t)$$

$$y_2 = A_2 \sin[k(x + \Delta x) - \omega t]$$

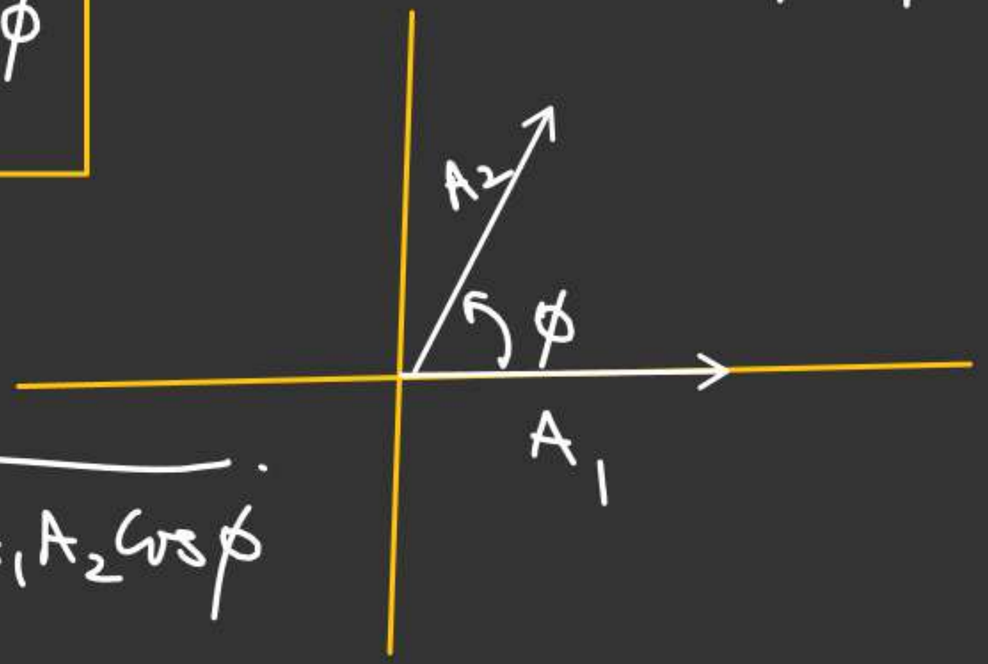
$$y_2 = A_2 \sin[kx - \omega t + \underbrace{k\Delta x}_{\phi}]$$

$$k\Delta x = \Delta\phi$$

$$\Delta\phi = \phi - 0$$

$$\boxed{\frac{2\pi}{\lambda} \cdot \Delta x = \Delta\phi}$$

$$y_R = y_1 + y_2$$



$$A_R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

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$$A_R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

Constructive

$\cos\phi = +1$

$\phi = 2n\pi$

$\Delta x = n\lambda$

Destructive

$\cos\phi = -1$

$\phi = (2n-1)\pi$

$\Delta x = (2n-1)\dfrac{\lambda}{2}$

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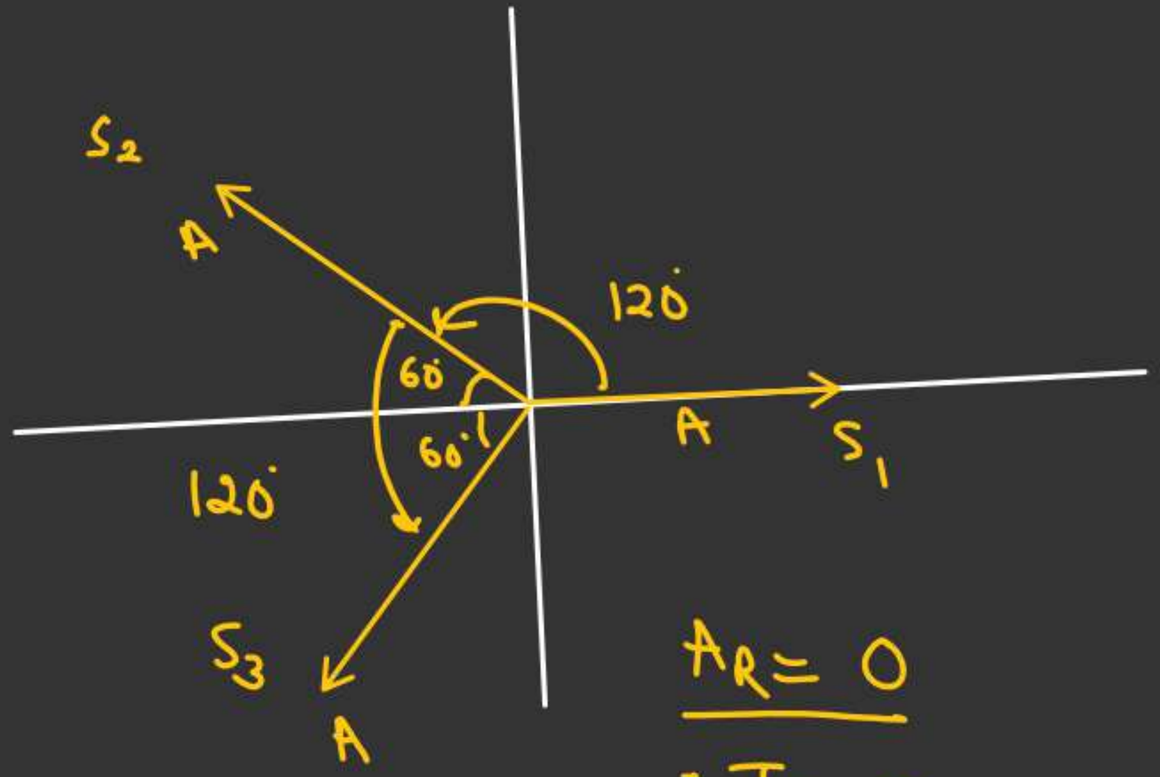
Q4. S_1, S_2 & S_3 are soures of sound of equal intensity. At P, the wave coming from S_2 is 120° ahead in phase of that from S_1. Also, the wave coming from S_3 is 120° ahead of that from S_2. What will be the resultant intensity of sound at P.

$S_1S_2 = S_2S_3$.

$[I \propto A^2]$



$A_R = 0$

$\therefore I_R = 0$.

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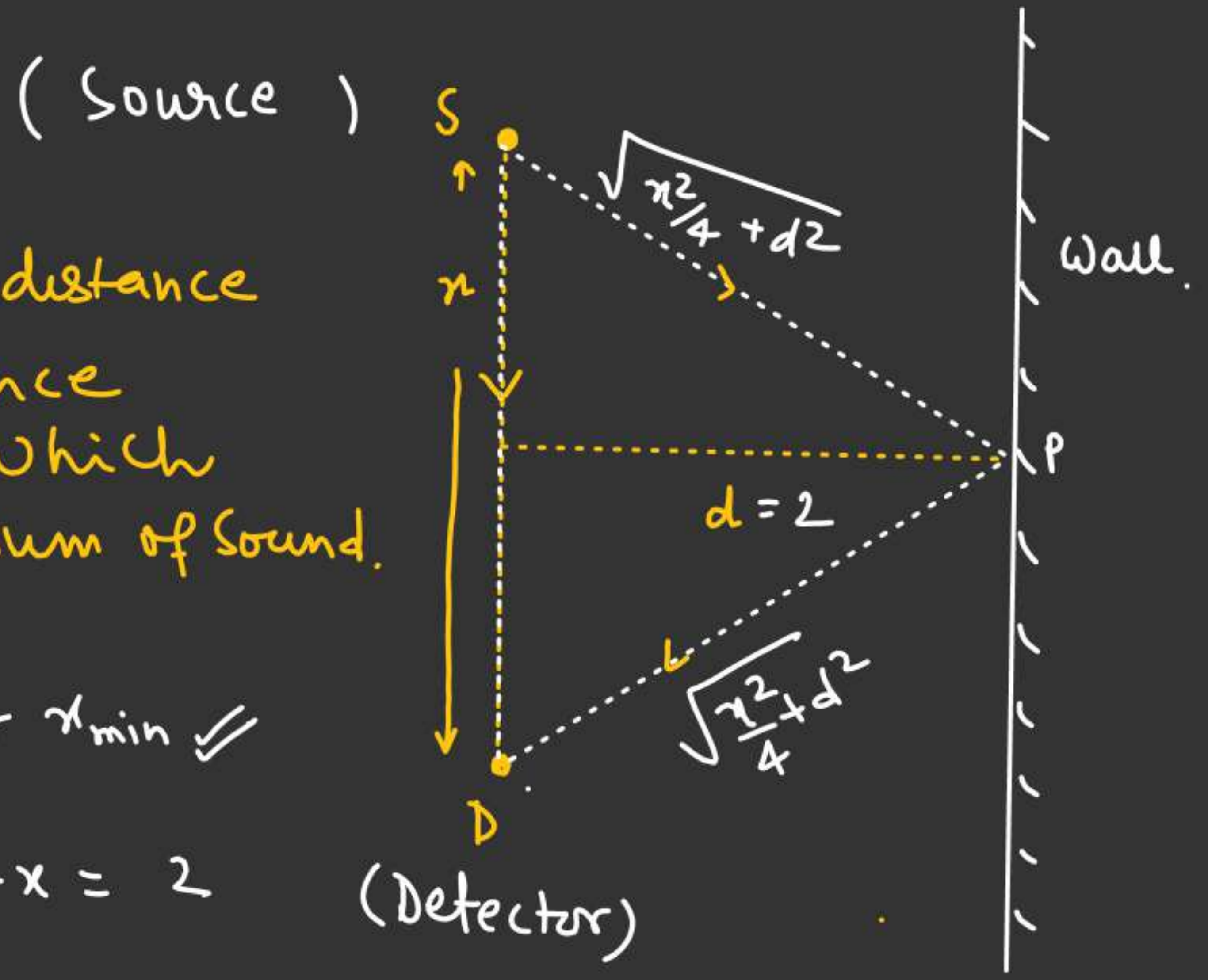
\# A Source emitting sound of frequency 180 Hz is placed in front of a wall at a distance of 2m from wall. A detector is also placed in front of wall at the same distance from it. Find the min. distance b/w source and detector for which detector detects a maximum of sound. Speed of sound in air = $360\ m s^{-1}$.

$v = f\lambda$

$$\lambda = \frac{v}{f} = \frac{360}{180} = 2.$$



For maxima

$$\Delta x = n\lambda$$

$$\Delta x = (SP + PD) - SD$$

$$= 2\sqrt{d^2 + \frac{x^2}{4}} - x$$

$n = 1$ for x_{min}

$$2\sqrt{d^2 + \frac{x^2}{4}} - x = 2$$

$$2\sqrt{d^2 + \frac{x^2}{4}} = (2 + x)$$

$$4\left(d^2 + \frac{x^2}{4}\right) = 4 + x^2 + 4x$$

$$4d^2 = 4 + 4x$$

$$16 - 4 = 4x$$

$$x = 3$$

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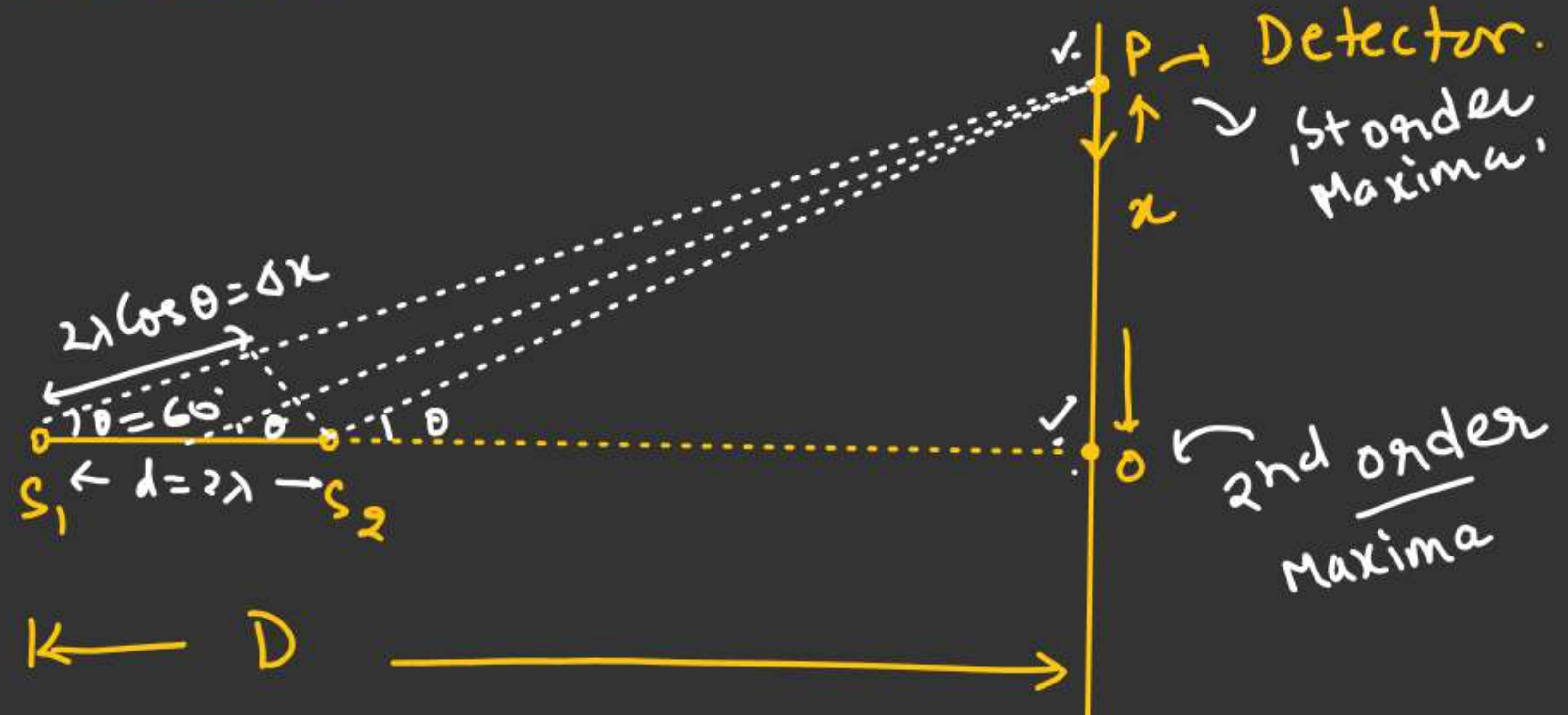
Q. Two coherent sound source.
Sound detected by detector moving perpendicular to line joining $S_1 S_2$.
Find distance b/w P & O so that intensity at P and O is same.

$D >> \lambda$.



At O.

$\Delta x = 2\lambda$

$\Delta x = n\lambda$

$n = 2 \Rightarrow 2^{nd}$ order Maxima

At P

$2\lambda\cos\theta = n\lambda$

n_{max} at $\theta = 0$ ie at O.

At P. $n = 1$

$2\lambda\cos\theta = \lambda$

$\cos\theta = \frac{1}{2}$

$\theta = 60°$

$\tan 60° = \frac{x}{D} \Rightarrow x = D\tan 60°$

$= \sqrt{3}D$