WAVES

(Transfer of energy by oscillation of Medium components)

waves

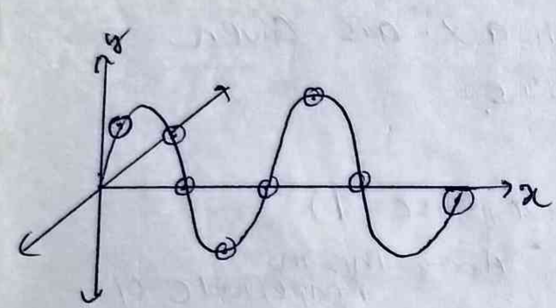
Mechanical waves

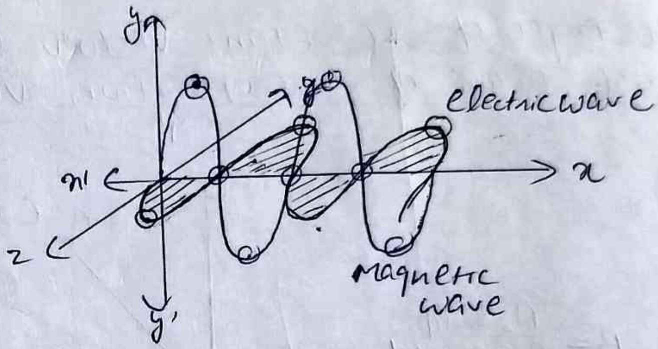
energy transfer takes place by oscillation of Physical Medium Particles

ex:- Sound, Spring, string!

Electromagnetic waves

energy transfer takes place by oscillation of electrifield and Magnetic field, light, x-rays etc!



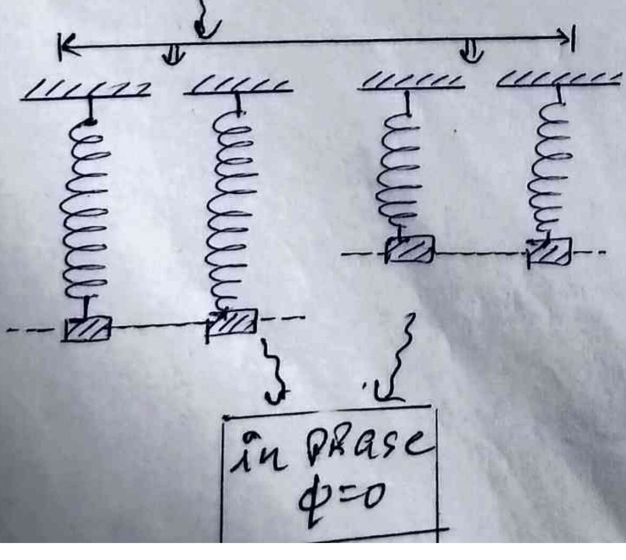


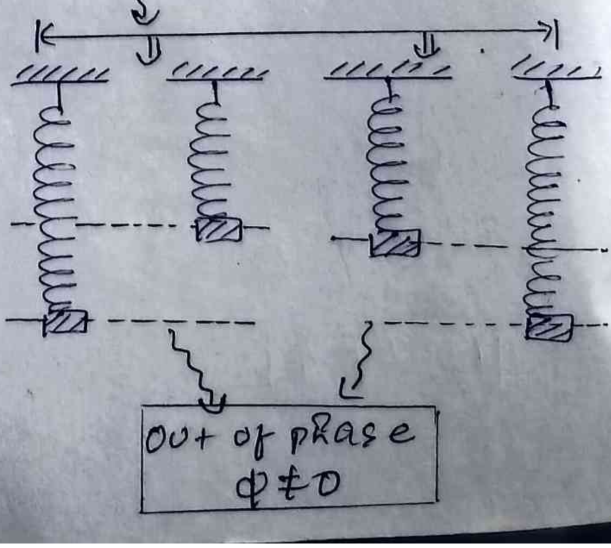
Transverse wave:-

> **longitudinal wave:-**
> Particle oscillate in direction of waves!

In Phase

Out of Phase

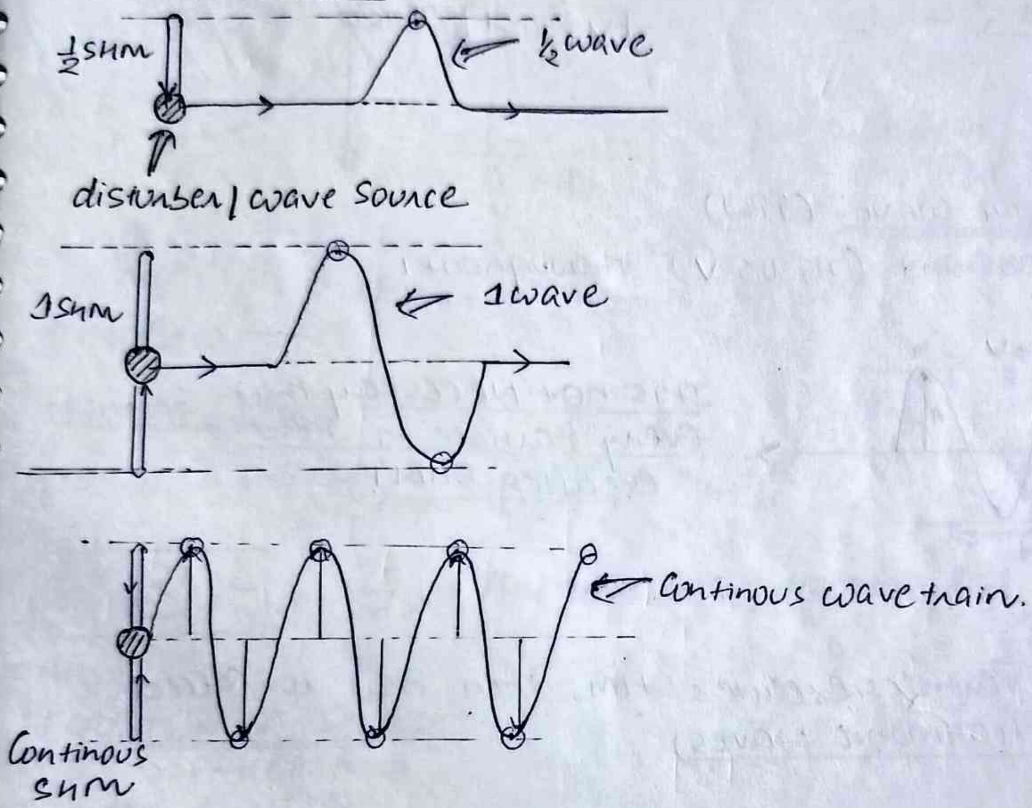




> CHARACTERSTICS OF MECHANICAL WAVE

→ Amplitude (A)
→ frequency (ν)
→ velocity (v)

KILLER VISUALIZATION :-



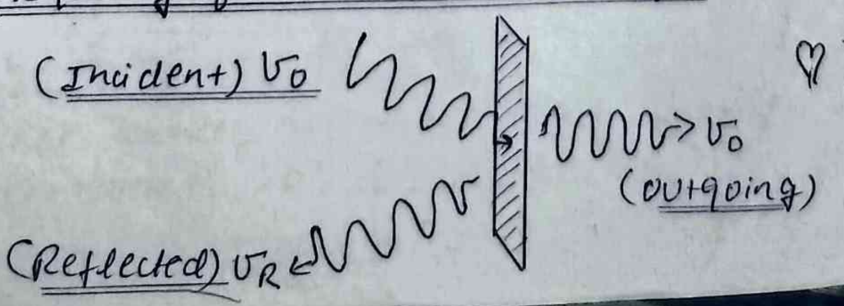
> AMPLITUDE :-

Max. displacement of Medium Particles during their Osillations from Mean Position.

> FREQUENCY :-

No. of Osillation of Medium Particles / unit time

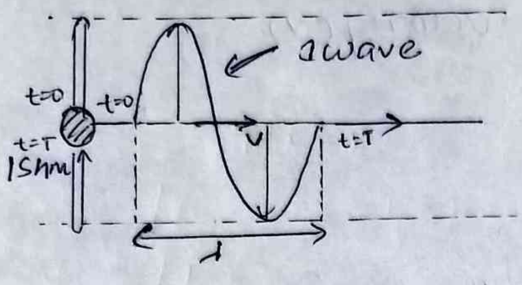
Frequency of wave never changes :-



$\boxed{\nu_I = \nu_0 = \nu_R}$

> VELOCITY OF WAVE (depend on Medium) :-

Speed with which energy is transferred through Medium!



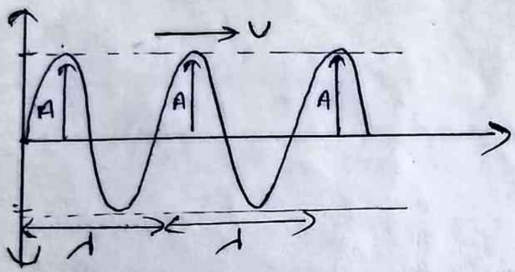
speed = $\frac{\text{distance}}{\text{time}}$

$v = \frac{\lambda}{T}$

$\boxed{v = \nu\lambda}$ :: GOLD

> PLANE PROGESSIVE WAVE :- (PPW)

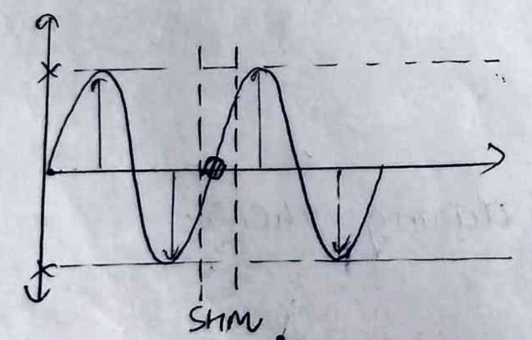
Wave having constant (A, ν, v) throughout!

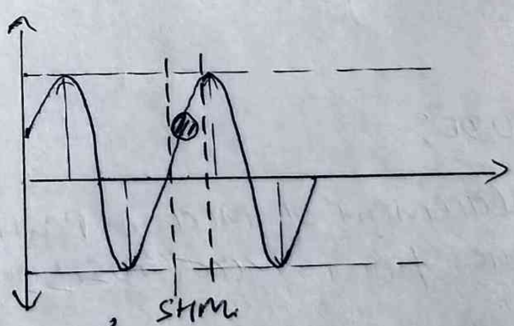


It is not Necessary that every Particle in PPW executes SHM!

However;

If the medium Particles executes SHM, then PPW is called SHW (Simple Harmonic waves)

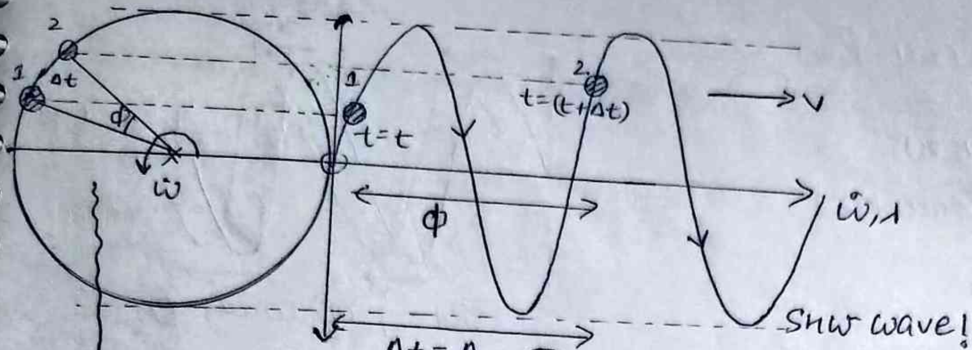




every Particle is doing SHM. ☺

> PHASE DIFFERENCE & PATH DIFFERCE IN SHW :-

(ϕ) (Δ)



$\Delta t = \frac{\Delta}{v}$ — (1)

$\omega = \frac{\phi}{\Delta t}$

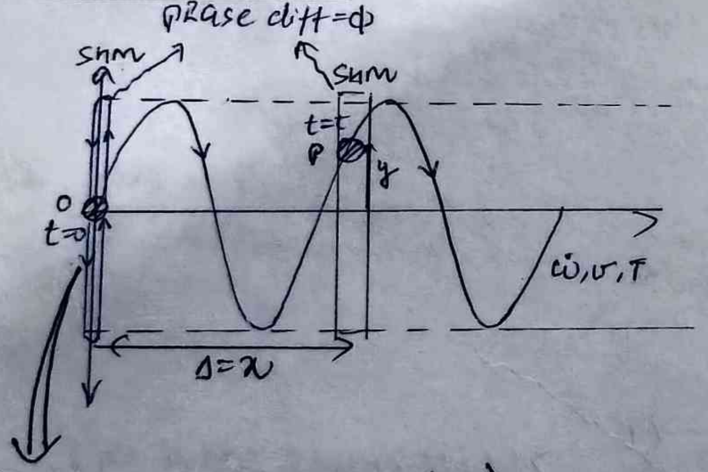
$\phi = \omega(\Delta t)$ — (2)

from eq 1 and 2

$\phi = \omega\left(\frac{\Delta}{v}\right) = \left(\frac{\omega}{v}\right)\Delta = \left(\frac{2\pi \cancel{\nu}}{\cancel{\nu}\lambda}\right)\Delta = \frac{2\pi}{\lambda}$

$\boxed{\phi = \left(\frac{2\pi}{\lambda}\right)\Delta}$; $\left(\frac{2\pi}{\lambda}\right)$ is Angular wave number (K)

> EQUATION OF SHW :-



and we know that

$\phi = K\Delta$

$\phi = Kx$; $x = \Delta$ — (2)

> equation of SHM = $y = A\sin(\omega t)$

SHM of Point P at $x = x$ / eq of SHW :-

$\boxed{y = A\sin(\omega t - \phi)}$ — (1)

∵ From eq 1 and 2

$\boxed{y = A\sin(\omega t - Kx)}$

Since Particle at Point O start SHM first than particle at Point P. So; phase of Point O is ahead than Point P. So, phase of Particle P is less than Point O

> VELOCITY OF PARTICLE IN SHW :-

$y = A\sin(\omega t - Kx)$

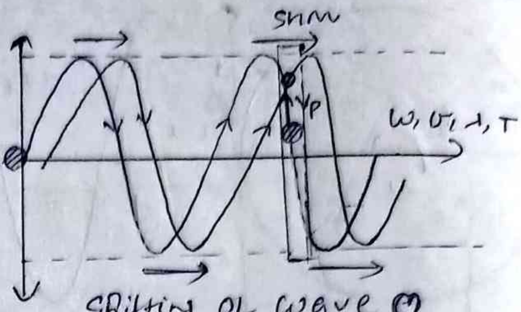
$V_P = \frac{dy}{dt} = A\omega\cos(\omega t - Kx)$

$V_P = A\omega\cos(\omega t - Kx)$

$V_P = A\omega = \sqrt{1 - \sin^2(\omega t - Kx)}$

$V_P = A\omega\sqrt{1 - y^2/A^2}$

$$\boxed{V_P = \omega\sqrt{A^2 - y^2}}$$



> VELOCITY OF PARTICLE - SLOPE - WAVE VELOCITY :-

$y = A\sin(\omega t - Kx)$

$V_P = \frac{dy}{dt} = A\omega\cos(\omega t - Kx)$ — ①

slope $= \frac{dy}{dx} = -AK\cos(\omega t - Kx)$ — ②

from eq 1 and 2

$\frac{V_P}{\text{slope}} = \frac{-\omega}{K}$

$V_P = -\left(\frac{\omega}{K}\right)$ slope

$\boxed{V_P = -(\text{slope})\,v}$; $v = \frac{\omega}{K}$

> ACCELERATION OF PARTICLE IN SHW :-

$V_P = A\omega\cos(\omega t - Kx)$

$a_P = \frac{dV_P}{dt} = -A\omega^2\sin(\omega t - Kx)$ — ①

slope of slope $= \frac{d^2y}{dx^2} = -AK^2\sin(\omega t - Kx)$ — ②

diving eq 1 and 2

$a_P = \left(\frac{\omega}{K}\right)^2$ slope of slope

$a_P = v^2$ slope of slope

> differential wave eq :-

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

KILLER VISUALIZATION

+ve

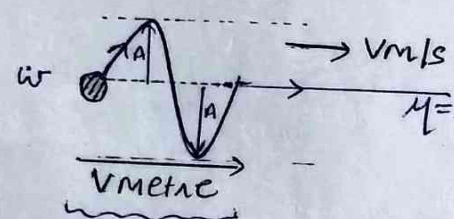
$y = A\sin(\underbrace{\omega t - kx}_{0})$ $\quad \omega t - kx = 0 \Rightarrow \frac{\omega}{k} = \frac{x}{t} \Rightarrow v = \frac{x}{t} \Rightarrow \boxed{v > 0}$ ♡

$y = A\sin(\underbrace{\omega t + kx}_{0})$ $\quad \omega t + kx = 0 \quad \frac{\omega}{k} = -\frac{x}{t} \Rightarrow v = -\frac{x}{t} \Rightarrow \boxed{v < 0}$

-ve

> POWER & INTENSITY OF A WAVE :-

Power = (Energy) out in 1sec



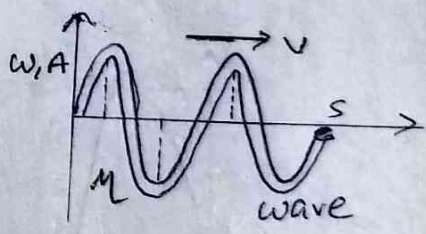
μ = linear mass density of wire

1 sec Analysis!

> Power = $(E_{out})_{1sec} = \frac{1}{2}(\text{mass}_{1sec})(A\omega)^2$

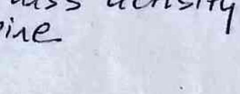
POWER = $\boxed{\frac{1}{2}(\mu v)(\omega A)^2}$

Intensity = Power / cross-sectional area.



$I = \frac{P}{S} = \frac{\frac{1}{2}(\mu v)(\omega A)^2}{S}$

and $\mu = \rho S$ ☺



$\mu = \frac{m}{l} \Rightarrow \mu = \frac{m}{1} \Rightarrow \boxed{\mu = m}$

and

$\rho = \frac{m}{A(1)} = \rho = \frac{m}{S}$ ♡

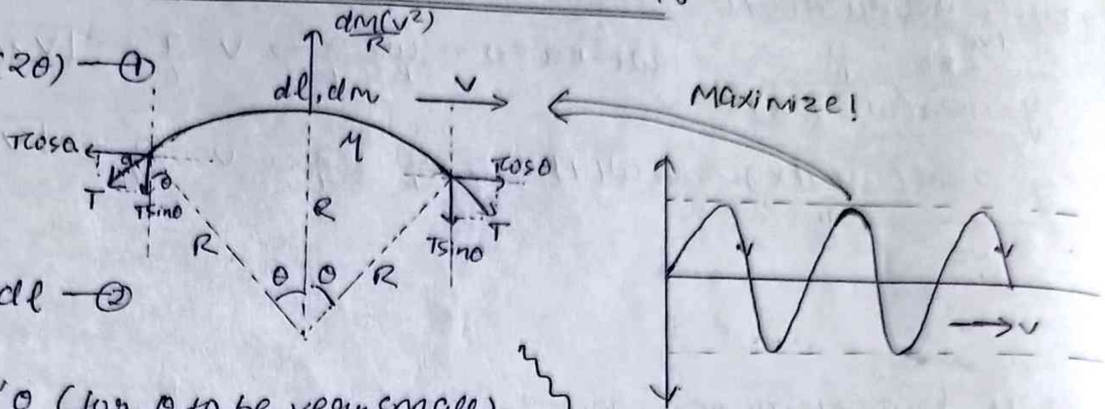
$\Rightarrow \rho = \frac{\mu}{S} \Rightarrow \boxed{\mu = \rho S}$

so;

$I = \frac{1}{2}\left(\frac{\rho \cancel{S} v}{\cancel{S}}\right)(\omega A)^2 \Rightarrow \boxed{I = \frac{1}{2}(\rho v)(\omega A)^2}$

> WAVE SPEED OF TRANSVERSE WAVE ON STRING :-

$dl = R(2\theta)$ —— ①



$dm = \mu dl$ —— ②

also;

$\sin\theta \simeq \theta$ (for θ to be very small)

Consider elemental wave doing UCM

$2(T\sin\theta) = \frac{dm(v^2)}{R}$

(Net upward force = Net downward force)

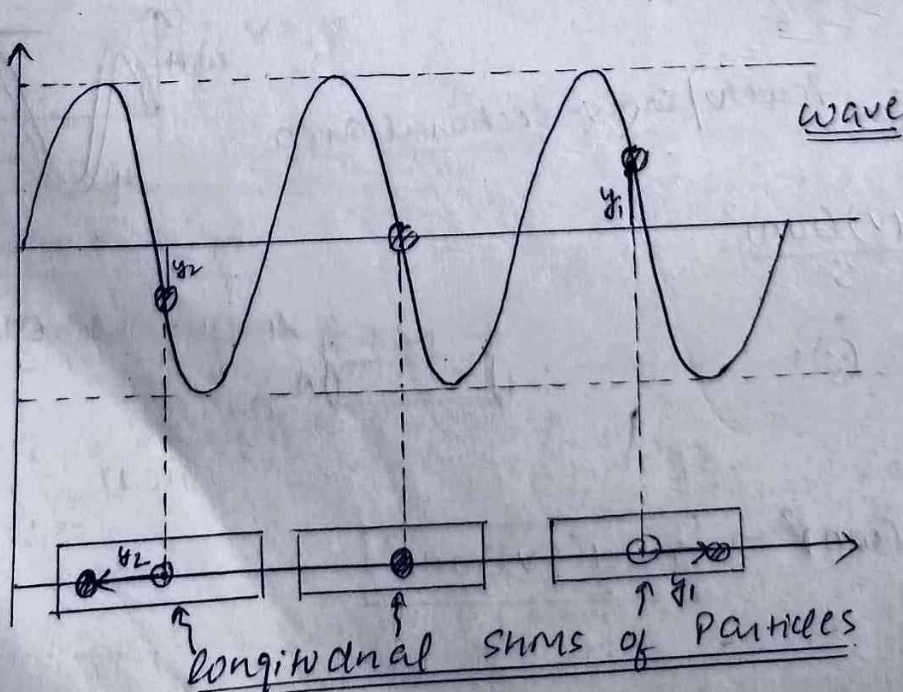
$2T\theta = \frac{\mu dl}{R} \cdot v^2$

from eq 1; $2\theta = dl/R$

$\left(\frac{\cancel{dl}}{R}\right) \times T = \mu\left(\frac{\cancel{dl}}{R}\right) v^2$

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

> SOUND WAVES :- (longitudnal wave)



>VELOCITY OF SOUND WAVES :-

In a medium, Sound speed = $\sqrt{\frac{E}{\rho}}$ E; Modulus of elasticity of med. ρ; density of Medium

(i) $E = Y$ (for solid) $\boxed{V_s = \sqrt{\frac{Y}{\rho}}}$

(ii) $E = B$ (for liquids) $\boxed{V_l = \sqrt{\frac{B}{\rho}}}$

>NEWTON's FORMULA FOR SOUND IN AIR :-

Newton assumed that,

Sound propagation is an isothermal phenomenon.

$PV = \text{Constant}$

$Pdv + vdP = 0$

$dP = \frac{-P}{V} dv \Rightarrow P = \frac{-dP}{dv/V} = B$

and $V = \sqrt{\frac{B}{\rho}}$

and since; $P = B$

★ $\boxed{V = \sqrt{\frac{P}{\rho}}}$

>LAPLACE CORRECTION IN NEWTON'S FORMULA :-

Laplace Analysis;

∵ Air molecules are cooled and heated in process of continuous compression and rarefaction at fast rates however overall heat of system remains constant!

Sound propagation is Adiabatic phenomenon. ∴

$PV^{\gamma} = \text{Constant}$

$V^{\gamma} dp + p\gamma V^{\gamma-1} dv = 0$

$\gamma P = \frac{-dP}{(dv/V)} = B$

$V = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{\gamma P}{\rho}} \Rightarrow$ ★ $\boxed{V = \sqrt{\frac{\gamma P}{\rho}}}$

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

so,

as the Temp. (↑) V_{sound} (↑)

> EFFECT OF PRESSURE & HUMIDITY

Since

$M_{dry} > M_{moist}$ $\left.\begin{array}{l} M_{dry\ air} = 29 \\ M_{H_2O} = 18 \end{array}\right\}$ ∵

and

$V = \sqrt{\frac{\gamma RT}{M}} \Rightarrow V \propto \frac{1}{\sqrt{M}}$

hence;

$$\boxed{V_{dry\ air} < V_{moist\ air}}$$

> EFFECT OF WIND ON VELOCITY OF SOUND :-

⟶ Sound (V_S) ⟶ Wind (V_W)

↓

$$\boxed{V_{S/ground} = V_S + V_W}$$

> V_{sound} Increases

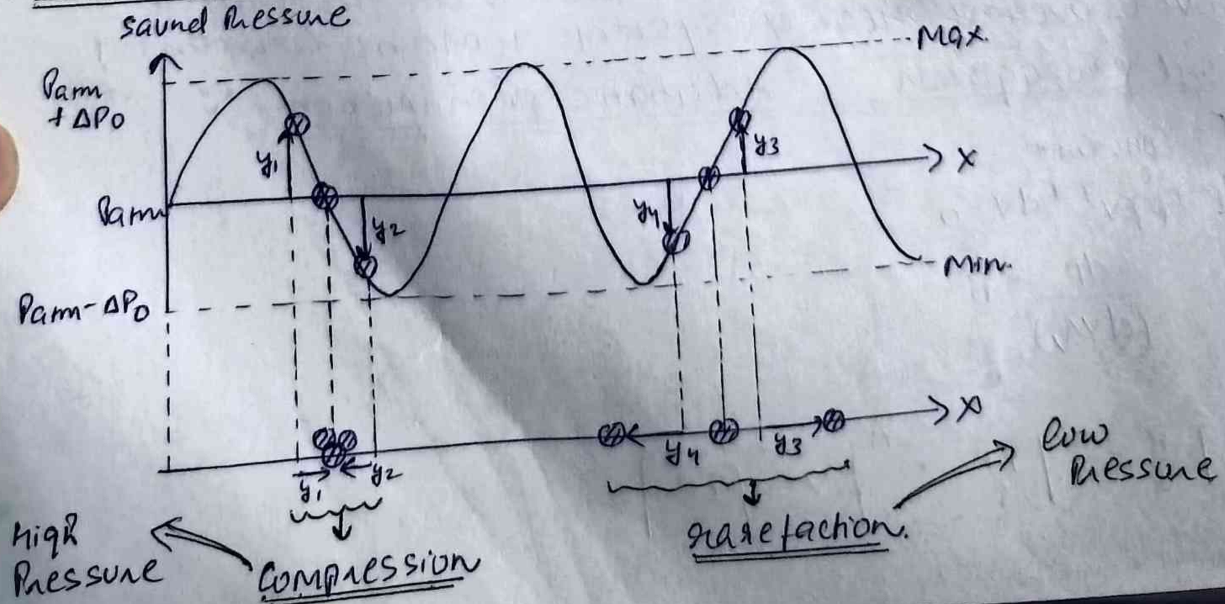
⟶ Sound (V_S) (V_W) Wind ⟵

↓

$$\boxed{V_{S/ground} = V_S - V_W}$$

> V_{sound} decrease

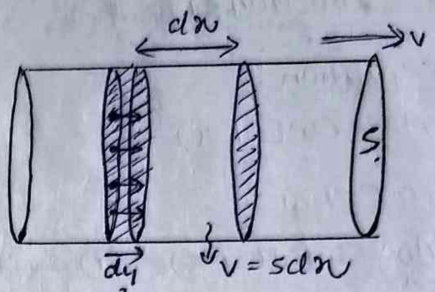
> SOUND WAVE AS PRESSURE WAVES :-



> PRESSURE VARIATION IN SOUND WAVE :-

$y = A\sin(\omega t - kx)$

$B = \frac{-\Delta P}{dV/V}$ — (5)



$dV = s\,dy$ — (1)

$V = s\,dx$ — (2)

$\frac{dV}{V} = \frac{dy}{dx}$ ∴ — (3)

$y = A\sin(\omega t - kx)$

$\frac{dy}{dx} = -Ak\cos(\omega t - kx)$ — (4)

from eq 3, 4, 5

∴ $\boxed{\Delta P = \underbrace{BAk}_{(\Delta P_0)\text{ Pressure Amplitude!}}\cos(\omega t - kx)}$

and

$\Delta P = P - P_{atm}$

$P - P_{atm} = BAk\cos(\omega t - kx)$

$P = P_{atm} + \Delta P_0 \cos(\omega t - kx)$; $\Delta P_0 = BAK$

> Rltn b/w Intensity and Pressure Amplitude :-

$I = \frac{1}{2}\rho v(\omega A)^2$ and $\Delta P_0 = BAK$

$A = \frac{\Delta P_0}{BK}$

$I = \frac{1}{2}\rho v\left(\frac{2\pi \nu}{BK}\Delta P_0\right)^2$

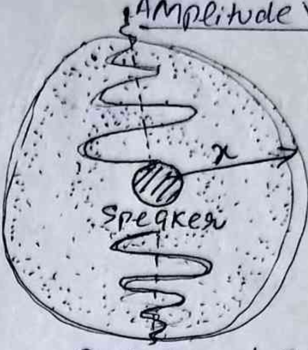
$I = \frac{1}{2}\rho v\left(\frac{2\pi \nu \Delta P_0 \lambda}{\rho v^2 \times 2\pi}\right)^2$; $B = \rho v^2$; $K = 2\pi/\lambda$

$$\boxed{I = \frac{\Delta P_0^{\,2}}{2\rho v}}$$

> SPHERICAL WAVES:-

Waves produced by a point istropic Source Uniformly in all directions!

Amplitude varies



SHW equation:-

$y = A\sin(\omega t - Kx)$

Spherical SHW:-

$\boxed{y = \left(\frac{A_0}{x}\right)\sin(\omega t - Kx)}$ — ①

$I = \frac{P}{4\pi x^2}$

$I \propto \frac{1}{x^2}$ — ②

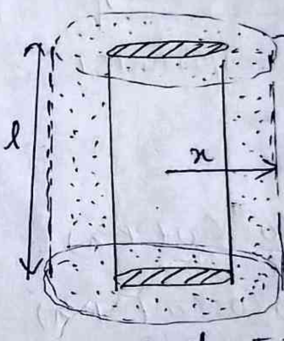
and $I = \frac{1}{2}\rho v(\omega A)^2$

$I \propto A^2$ — ③

from eq 2 and 3

$A^2 \propto \frac{1}{x^2} \Rightarrow A \propto \frac{1}{x} \Rightarrow \boxed{A = \frac{A_0}{x}}$

> CYLINDRICAL WAVES:-



$A = 2\pi x l$

SHW equation:-

$y = A\sin(\omega t - Kx)$

Cylindrical eq:-

$y = \left(\frac{A_0}{\sqrt{x}}\right)\sin(\omega t - Kx)$

$I = \frac{P}{2\pi x l}$

$I \propto \frac{1}{x}$ — ②

and $I = \frac{1}{2}\rho v(A\omega)^2$

$I \propto A^2$ — ③

from eq 2 and 3

$A^2 \propto \frac{1}{x} \Rightarrow \boxed{A = \frac{A_0}{\sqrt{x}}}$

> LOUDNESS:- (L)

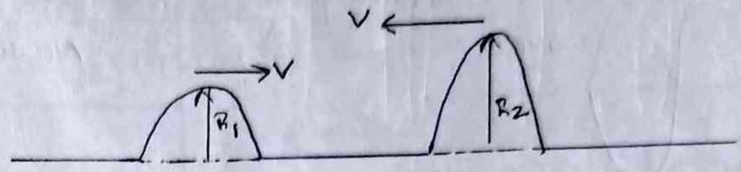
∴ Minimum sound Intensity detectable by Person:- $10^{-12}\, w/m^2$.

$\boxed{L(dB) = 10\log_{10}\left(\frac{I}{I_0}\right) ; \quad I_0 = 10^{-12}\, w/m^2}$

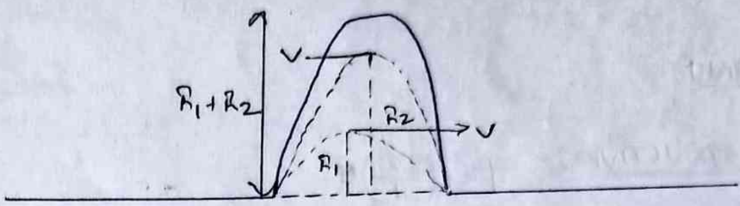
> SUPERPOSITION OF WAVES :-

When two or more waves superpose on a medium particle then this is called supersion Position at that Point!

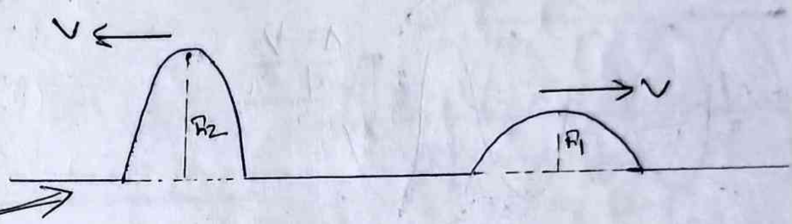
∵ **Before**



∵ Superposition



∵ After

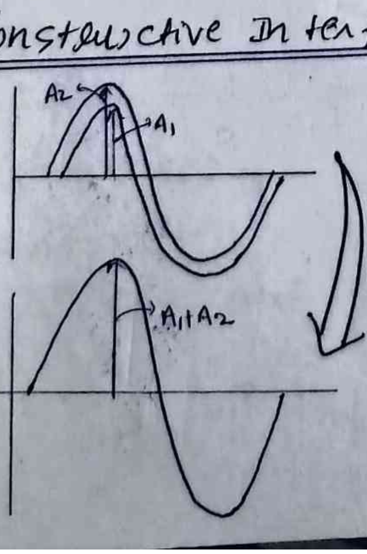


Superposition New affect further propagation of waves! ∵

> INTERFERENCE OF WAVE :-

When 2 or more waves of same v and Constent initial Phase diff superpose on a medium particle then superposition of such waves at point of superposition is called interference of wave

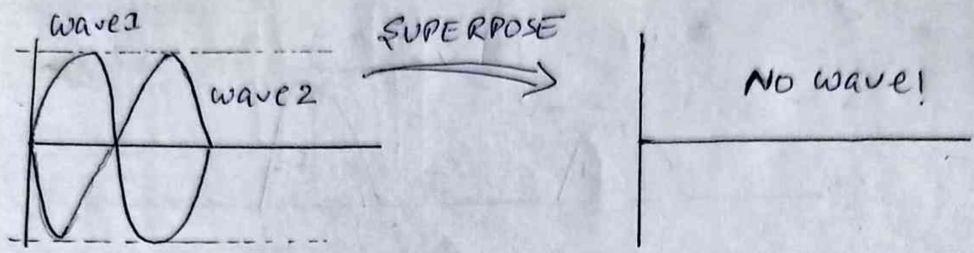
∵ Constructive Interference.



Constructive Interference!

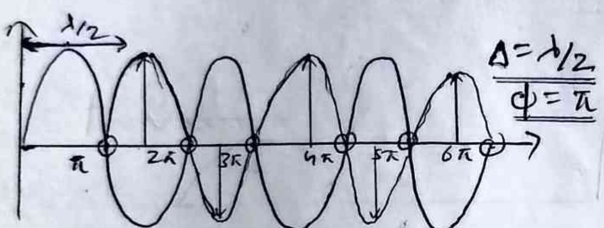
> DESTRUCTIVE INTERFERENCE:-

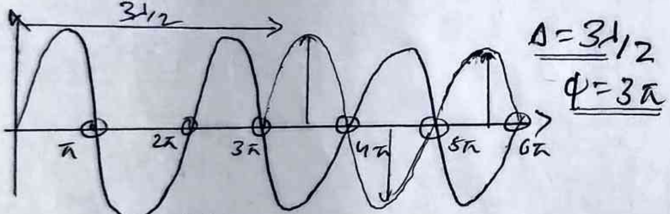
When two waves superpose on medium particle in opposite phase ($\phi = \pi, 3\pi, 5\pi \cdots$)

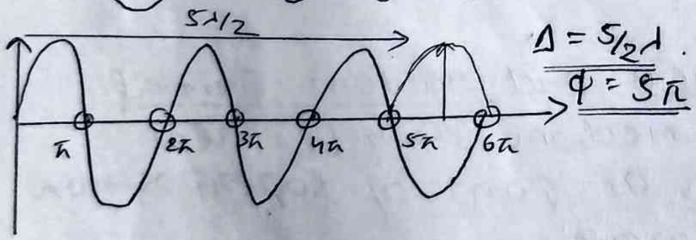


NAMO

DESTRUCTIVE :- $\phi = \left(\frac{2\pi}{\lambda}\right)\Delta$

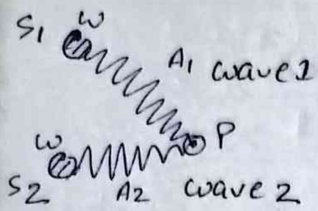






> CONSTRUCTIVE :-

> ANALYSIS OF WAVE INTERFERENCE :-



Particle SHM due to wave 1;

$y_1 = A_1 \sin(\omega t + 0)$ — ①

Particle SHM due to wave 2;

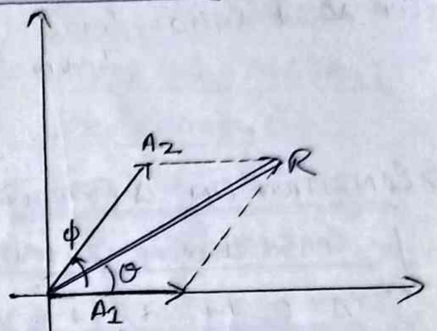
$y_2 = A_2 \sin(\omega t + \phi)$ — ②

∵ AT Point P;

$\boxed{y = (y_1 + y_2) = R\sin(\omega t + \theta)}$

resultant Amplitude! ♡ resultant initial phase!

PHASOR METHOD :-



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

∵ $\theta = \dfrac{A_2 \sin\phi}{A_1 + A_2\cos\phi}$

> Condition for Constructive Interference :-

Here; R is Max. and $\phi = 0, 2\pi, 4\pi$ ....

$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos 0} = \sqrt{(A_1 + A_2)^2} = (A_1 + A_2)$

$\boxed{R_{max} = (A_1 + A_2)}$

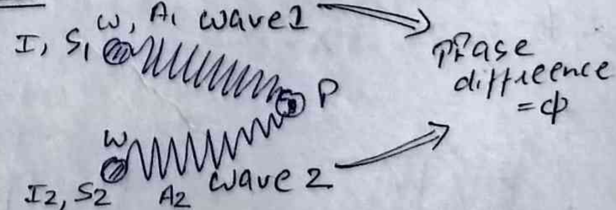
> Condition for destructive Interference :-

Here; R is Min. and $\phi = \pi, 3\pi, 5\pi$ ....

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

$R_{Min} = \sqrt{(A_1 + A_2 - 2A_1A_2)} \Rightarrow \boxed{R = (A_1 - A_2)}$

> INTENSITY AT POINT OF INTERFERENCE :-



$I \propto (\text{Amplitude})^2$

$I = KA^2$ — ①

$A^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$ — ②

$\dfrac{I}{K} = A^2$; $\dfrac{I_1}{K} = A_1^2$; $\dfrac{I_2}{K} = A_2^2$ — ③

From eq 2 and 3

$$\frac{I}{K} = \frac{I_1}{K} + \frac{I_2}{K} + 2\sqrt{\frac{I_1}{K}}\cdot\sqrt{\frac{I_2}{K}}\cdot\cos\phi$$

$$\therefore \boxed{I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cdot\cos\phi}$$

$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$$

$$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$$

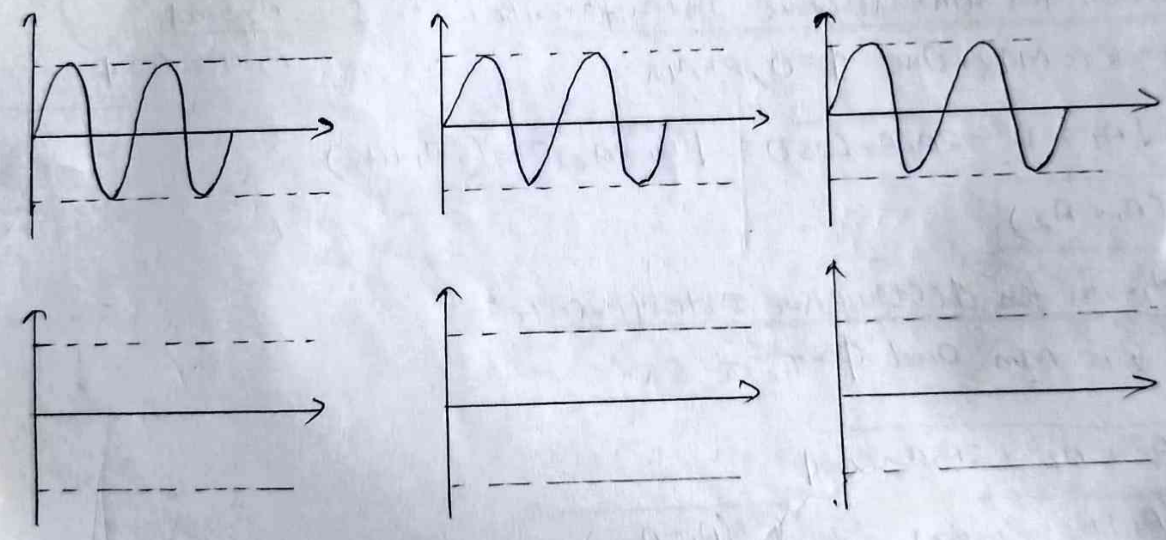
$\therefore$ Contrast ratio $= \frac{I_{max}}{I_{min}}$

> CONDITION ON Δ (PATH DIFF.) FOR CONSTRUCTIVE INT^n :-

for Constructive Interference;

$\because$ $\Delta = 0, 1\lambda, 2\lambda, 3\lambda \ldots\ldots$

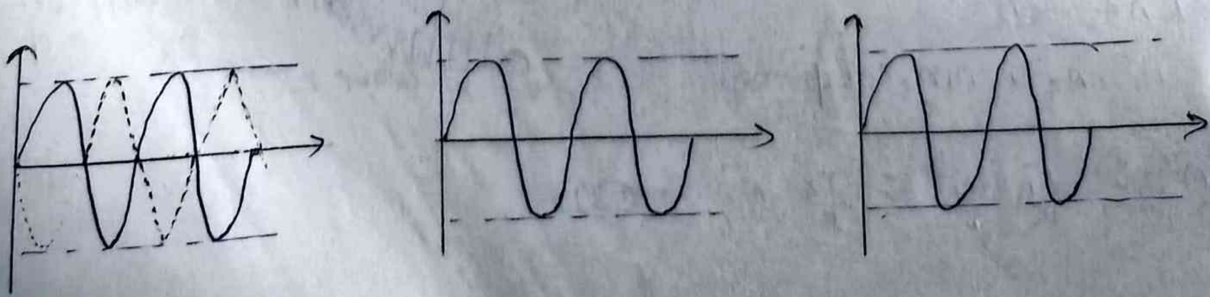
$\therefore$ $\phi = 0, 2\pi, 4\pi, 6\pi \ldots\ldots$



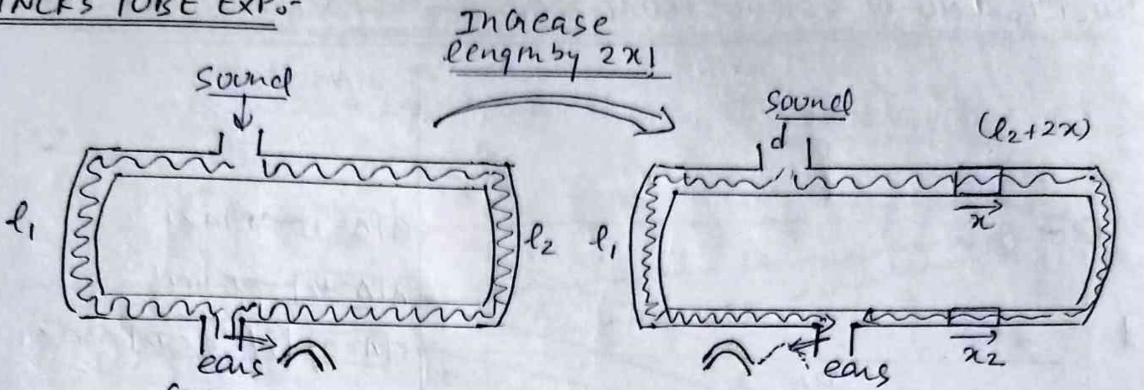
> CONDITION OF Path Diff FOR DESTRUCTIVE INT^n :-

$\because$ $\Delta = \lambda/2, \left(\frac{\lambda}{2}+\lambda\right), \left(\frac{\lambda}{2}+2\lambda\right) \ldots\ldots$

$\therefore$ $\phi = \pi, 3\pi, 5\pi \ldots\ldots$



>QUINCK's TUBE EXP:-



(Detect Maxima)

(Detect Next Maxima)

∵ for Maxima;

$\Delta = N\lambda$

and $\Delta = (l_2 - l_1)$

$(l_2 - l_1) = N\lambda$ —①

∵ for Next Maxima

$\Delta' = (N+1)\lambda$

and $\Delta' = (l_2 - l_1) + 2x$

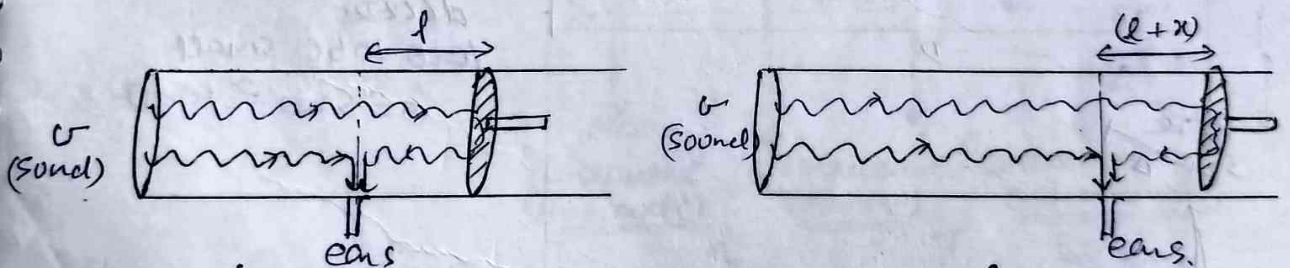
$(l_2 - l_1) + 2x = (N+1)\lambda$ —②

From eq 2 and 1

$\lambda = 2x$

$V = \upsilon\lambda = 2x\upsilon \Rightarrow \boxed{V = 2x\upsilon}$ ♡

>SEEBACK TUBE:-



(Detect Maxima)

(Detect Next Max.)

$\Delta = N\lambda$

$(2l) = N\lambda$ —①

$\Delta' = (2l + 2x)$

$\Delta' = (N+1)\lambda$

$(2l + 2x) = (N+1)\lambda$ —②

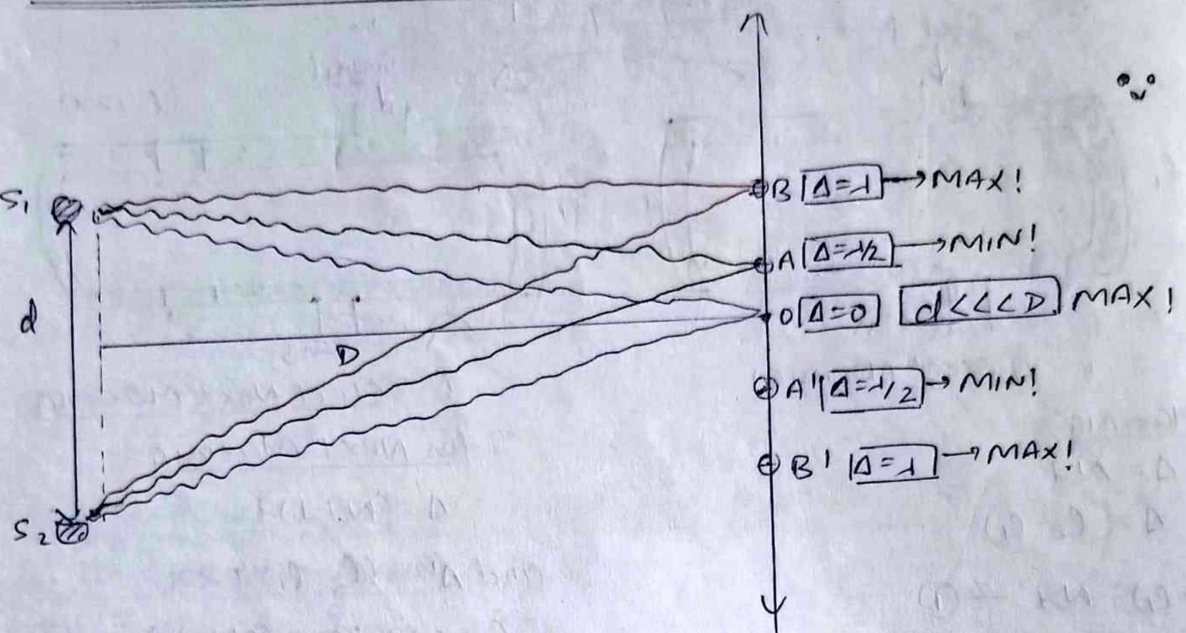
∵ From eq 1 and 2

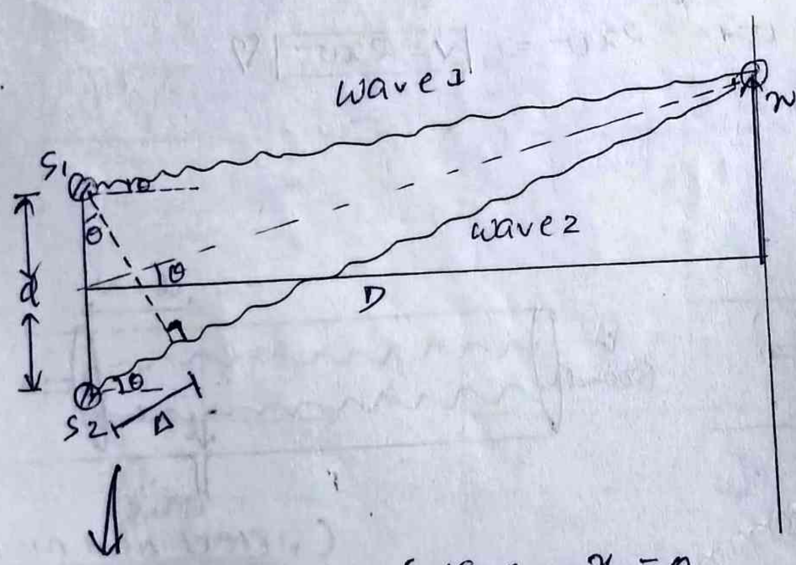
$\lambda = 2x$

$V = \upsilon\lambda$

$\boxed{V = (2x)\upsilon}$ ♡

> INTERFERENCE OF SOUND FROM 2 CLOSELY SPACED SOURCES :-





$d<<<D$
for θ to be small
$\theta \simeq \sin\theta \simeq \tan\theta$

$\Delta = d\sin\theta = d\theta$ — (1) ; $\tan\theta = \frac{x}{D} = \theta$ — (2)

from eq 1 and 2

$$\boxed{\Delta = d\left(\frac{x}{D}\right)}$$

for Max. ($\Delta = N\lambda$)

$d\left(\frac{x}{D}\right) = N\lambda$

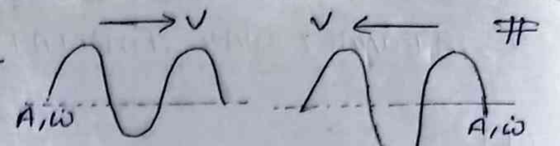
$$\boxed{x_N = \frac{DN\lambda}{d}}$$

for Min $[\Delta = (2N-1)\lambda/2]$

$d\left(\frac{x}{D}\right) = \frac{(2n-1)\lambda}{2}$

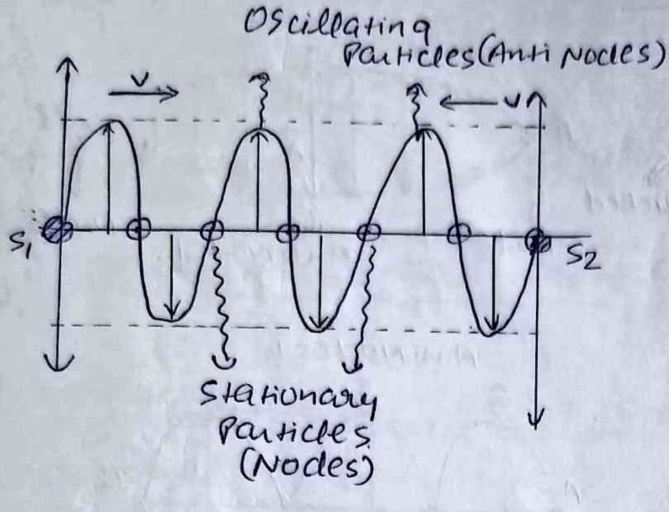
$$\boxed{x_N = \frac{(2n-1)\lambda D}{2D}}$$

> STATIONARY WAVE | STANDING WAVE :-

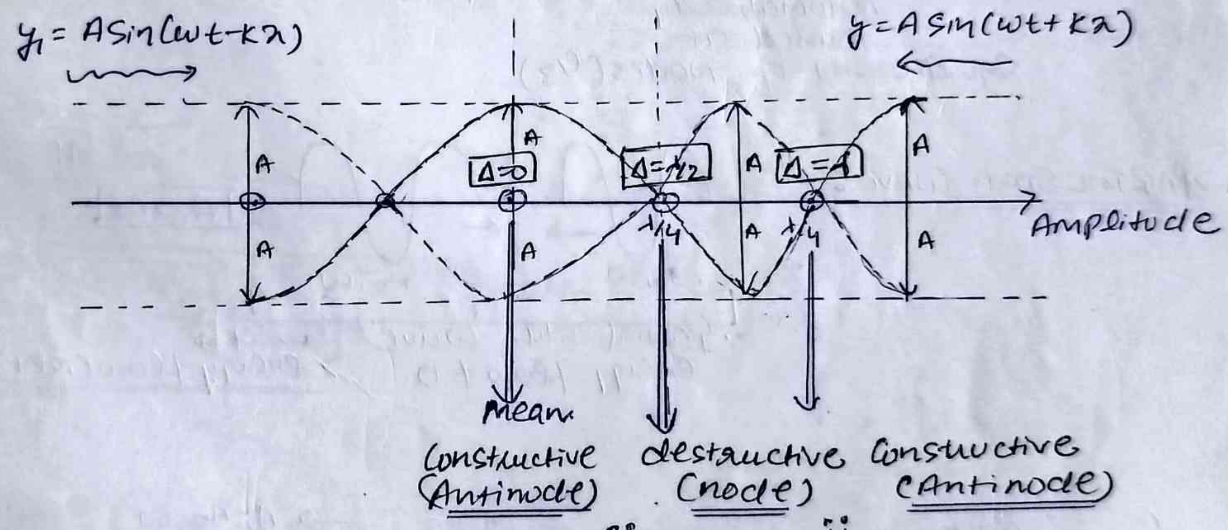


"No energy wave flow"

stationary wave!



Namo :-



> Analysis :-

$y_1 = A\sin(\omega t - kx)$ [+x direction]

$y_2 = A\sin(\omega t + kx)$ [−x direction]

After superposition ;

$y = y_1 + y_2$

$y = y_1 + y_2$

$\Rightarrow A[\sin(\omega t - kx) + \sin(\omega t + kx)]$

$\Rightarrow A[2\cos(kx)\sin(\omega t)]$

$\Rightarrow \underline{2A\cos(kx)} \cdot \sin(\omega t)$

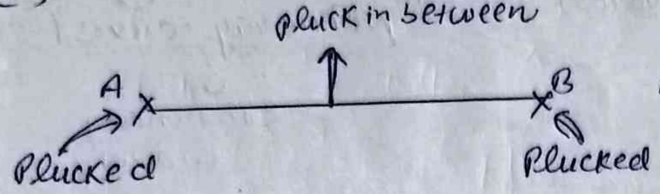
vary with x!

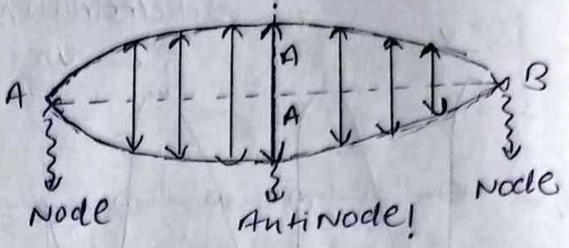
$\boxed{y = R\sin(\omega t)}$

; $R = 2A\cos(kx)$

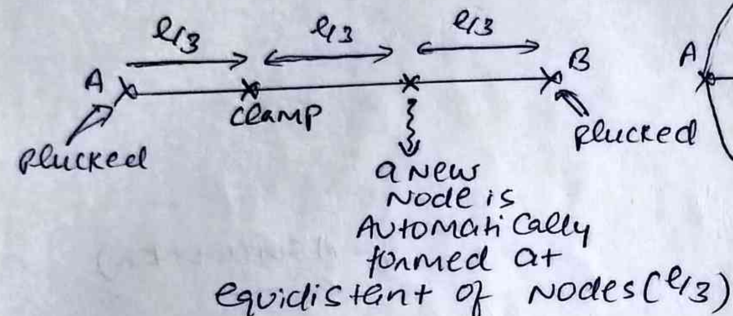
> STATIONARY WAVE FORMATION IN STRING :-

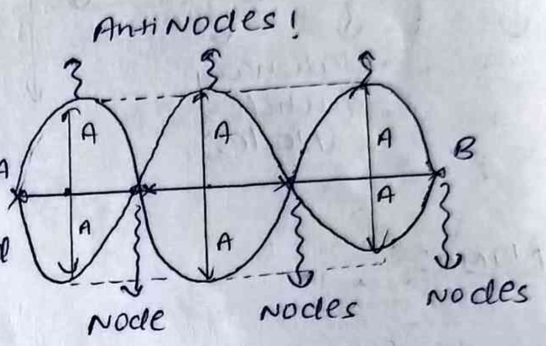
(I)



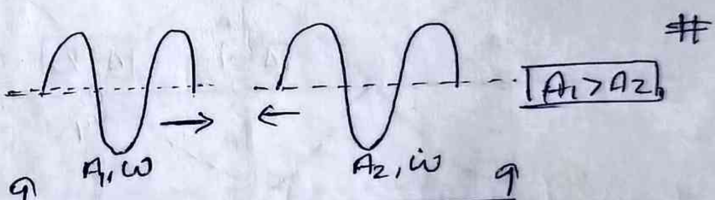


(II)

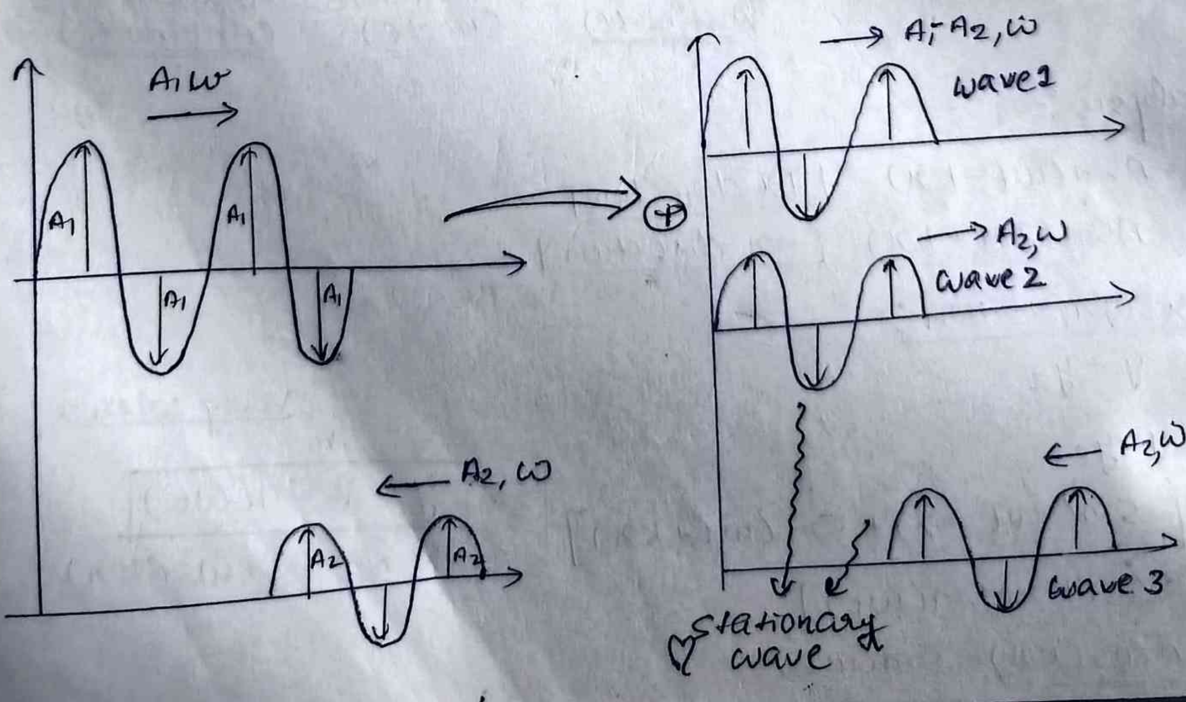




> PARTIAL STAT WAVE :-



∵ Partial stat wave energy flow ≠ 0 > energy flow (Net)



Clearly ♡:

∵ Partial stationary wave = Stationary wave + a simple harmonic (wave)

(wave 2, wave 3) (wave 1)

eq of stat wave Partial :- $\underline{2A_2\cos(kx)\sin(\omega t)} + \underline{(A_1-A_2)\sin(\omega t-kx)}$

∴ $\boxed{y = (A_1-A_2)\sin(\omega t-kx) + 2A_2\cos(kx)\sin(\omega t)}$!

> STATIONARY WAVE OF CLAMPED STRING :-

fundamental frequency = f_0 = ?

↳ (Minimum possible freq.)

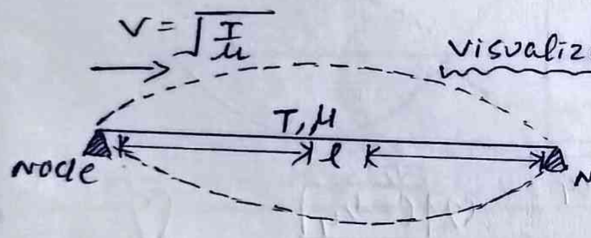
\#

$f_0 \rightarrow$ fundamental frequency

Next poss. $f_I \rightarrow$ I overtones

Next poss. $f_{II} \rightarrow$ II overtones

∵ I harmonic :-



visualize → $l = \lambda/2 \Rightarrow \boxed{\lambda = 2l}$ ∵

$V = \upsilon\lambda$

$\upsilon = \frac{V}{\lambda}$

$\upsilon_0 = \frac{V}{\lambda} \Rightarrow \frac{V}{2l} = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

$\boxed{\upsilon_0 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}}$ → also; $f_0 = 1f_0 = f_{1}$ → I harmonic!

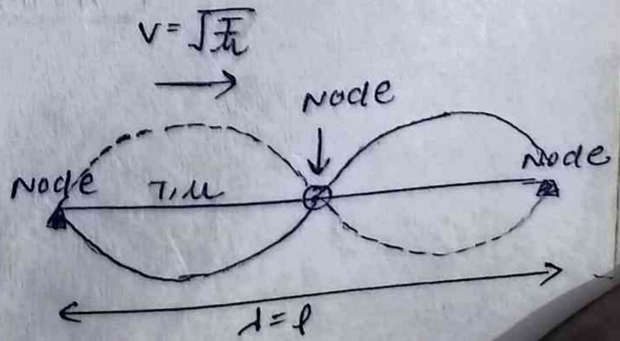
∵ I overtone :-

(Next possible frequency)

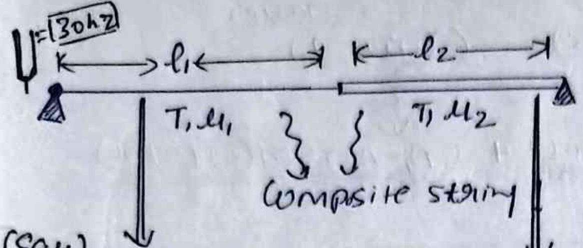
$f_I = \frac{V}{\lambda} = \frac{1}{\lambda}\cdot v$

$= \frac{1}{l}\sqrt{\frac{T}{\mu}}$ $\quad f_I = \frac{1}{l}\sqrt{\frac{T}{\mu}} = 2f_0$

∴ 2nd harmonic



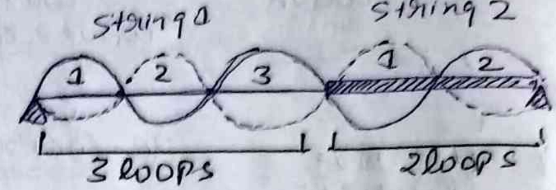
> STATIONARY WAVE IN COMPOSITE STRING :-



(Say)
10, 20 $\boxed{30}$ 40 ....
fundamental frequencies!

15 $\boxed{30}$ 45 ....
fundamental frequencies!

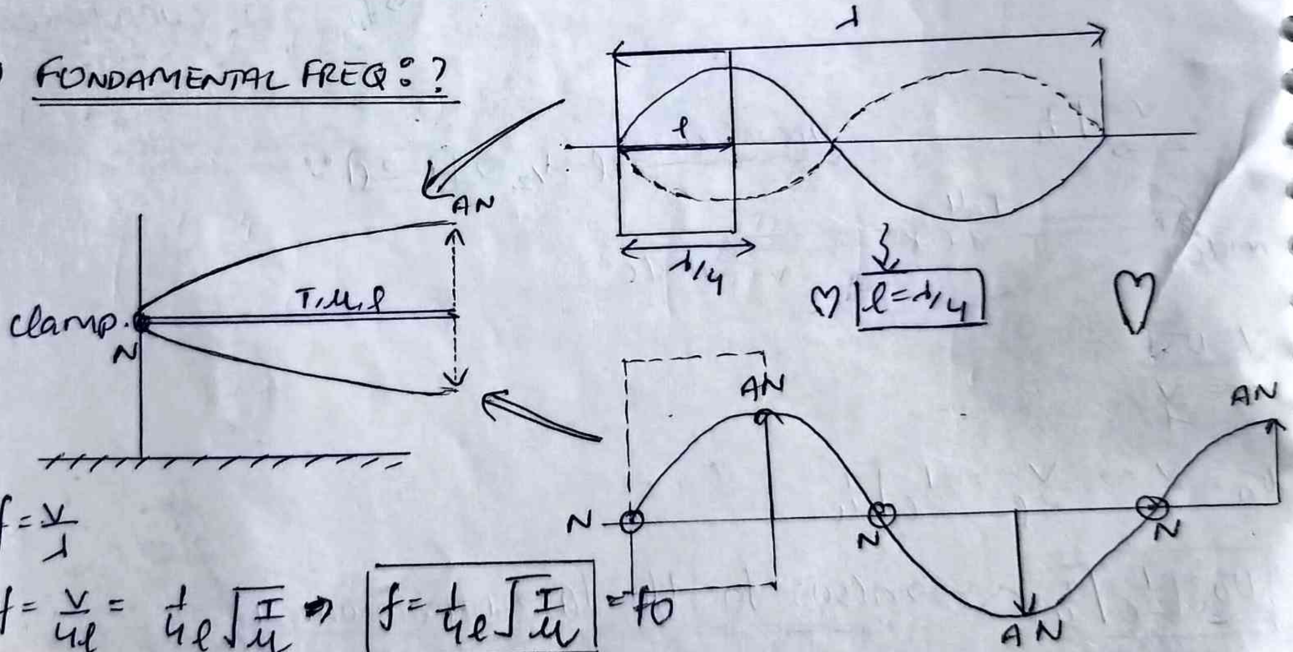
clearly; 30 Can be Resonance frequency :)



Concept :-
$f_T = f_1 = f_2$
Frequency never changes

> STATIONARY WAVE IN A STRING CLAMPED AT ONE END :-

(I) FUNDAMENTAL FREQ : ?



$\boxed{l = \lambda/4}$

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

$f = \frac{v}{4l} = \frac{1}{4l}\sqrt{\frac{T}{\mu}} \Rightarrow \boxed{f = \frac{1}{4l}\sqrt{\frac{T}{\mu}}} = f_0$

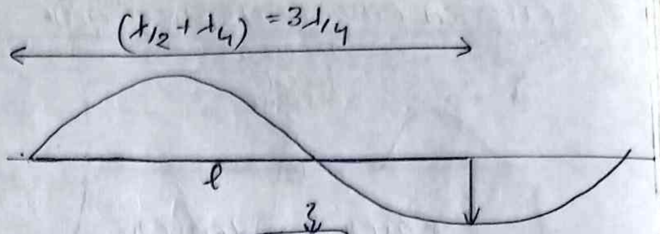
Ist harmonic, Ist overtone

(II) NEXT POSSIBLE FREQUENCY :-

$f_I = \frac{v}{\lambda}$
$= \frac{1}{(4l/3)} v$

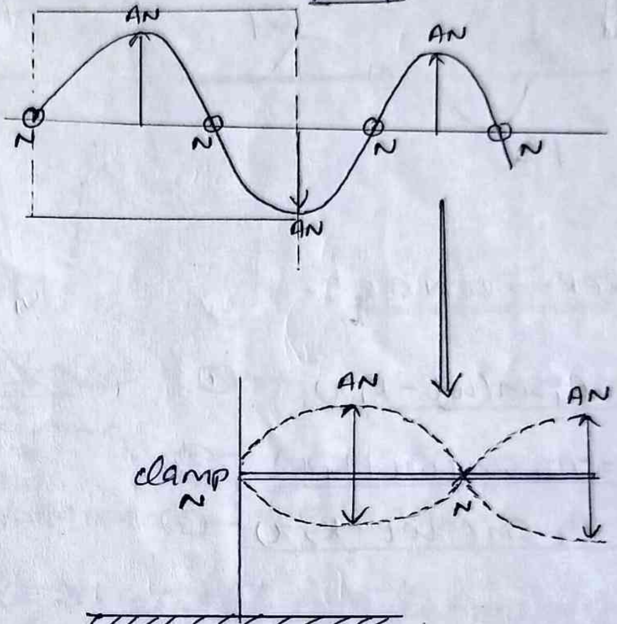
$$\boxed{f_I = \frac{3}{4l}\sqrt{\frac{T}{\mu}}}$$

$\Rightarrow \underbrace{\cancel{3l}\ \frac{3}{4l}\sqrt{\frac{T}{\mu}}}_{} = 3f_0$



♡ $\boxed{l = \frac{3\lambda}{4}}$

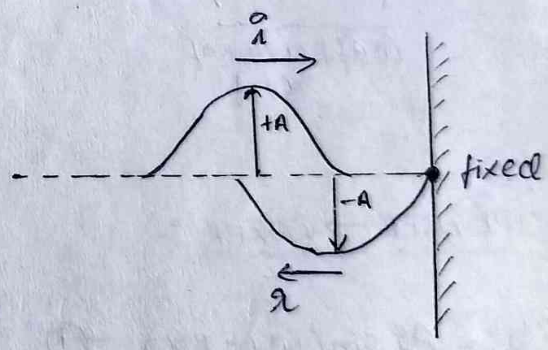
♡ IIIst Harmonic, 2nd Overtone



> REFLECTION FROM RIGID BODY :-

$y_i = A\sin(\omega t - kx)$ —— ①

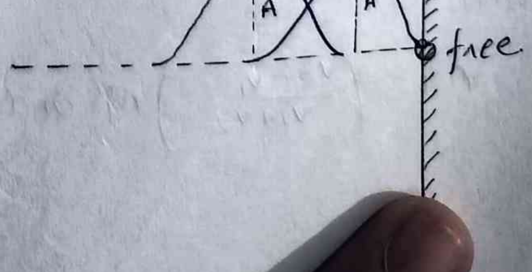
$y_r = -A\sin(\omega t + kx)$ or —— ② ☺
$A\sin(\omega t + kx + \pi)$



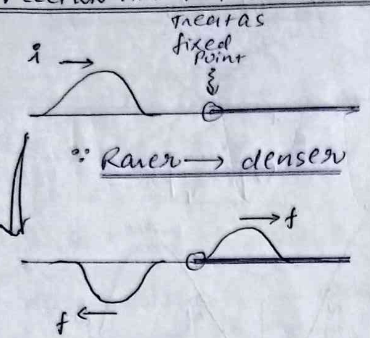
> REFLECTION FROM FREE END :-

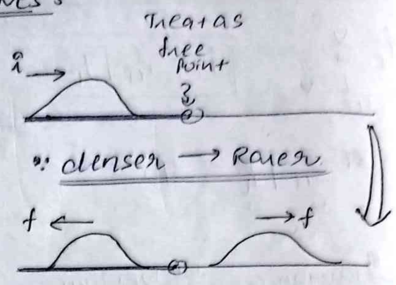
$y_i = A\sin(\omega t - kx)$ —— ①

$y_r = A\sin(\omega t + kx)$ —— ② ☺

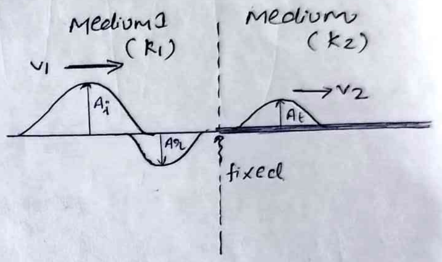


>REFLECTION AND TRANSMISSION OF WAVES :-





>RARER → DENSER :-



$\because$ $y_i = A_i \sin(\omega t - K_1 x)$ — (1)

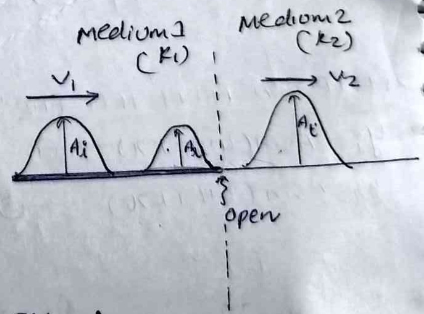
$\because$ $y_r = -A_r \sin(\omega t + K_1 x)$ — (2)

$\because$ $y_t = A_t \sin(\omega t - K_2 x)$ — (3)

and

$A_r = \underbrace{\left(\frac{v_2 - v_1}{v_1 + v_2}\right)}_{\text{Coefficient of ref!}} A_i$ and $A_t = \underbrace{\left(\frac{2v_2}{v_1 + v_2}\right)}_{\text{Coefficient of transmission!}} A_i$

>DENSER → RARER :-



$\because$ $y_i = A_i \sin(\omega t - K_1 x)$ — (1)

$\because$ $y_r = A_r \sin(\omega t + K_1 x)$ — (2)

$\because$ $y_t = A_t \sin(\omega t(-K_2 x)$ — (3)

and

$A_r = \left(\frac{v_2 - v_1}{v_1 + v_2}\right) A_i$ and $A_t = \left(\frac{2v_2}{v_1 + v_2}\right) A_i$

> BEATS :-

100Hz, 102Hz

∵ When 2 sound sources having almost same frequency are sound together phenomenon of Beat occur

∵ Sound of Avg. f is heard (101Hz) & Amplitude Periodically varies

∵ Beat frequency is equal to diff in frequency of two sources.

$y_1 = A\sin(2\pi f_1)t$

$y_2 = A\sin(2\pi f_2)t$

After superposition:

$y = y_1 + y_2$

$y = A[\sin(2\pi f_1 t) + \sin(2\pi f_2 t)]$

$$y = 2A\cos \underbrace{\frac{2\pi(f_1 - f_2)t}{2}}_{\text{very low frequency}} \cdot \sin \underbrace{\frac{2\pi(f_1+f_2)t}{2}}_{\text{avg frequency}}$$

Beat frequency → very low frequency   avg frequency ← wave frequency

$$\boxed{y = R\sin\frac{2\pi(f_1+f_2)t}{2}} \; ; \; R = 2A\cos\frac{2\pi(f_1-f_2)t}{2} \text{ (Amplitude)}$$

for R to be max;

$\cos\left(\frac{2\pi(f_1-f_2)t}{2}\right) = \pm 1$

$\frac{\cancel{2}\cancel{\pi}(f_1-f_2)}{\cancel{2}}t = n\cancel{\pi}$

$t = \frac{N}{(f_1-f_2)}$

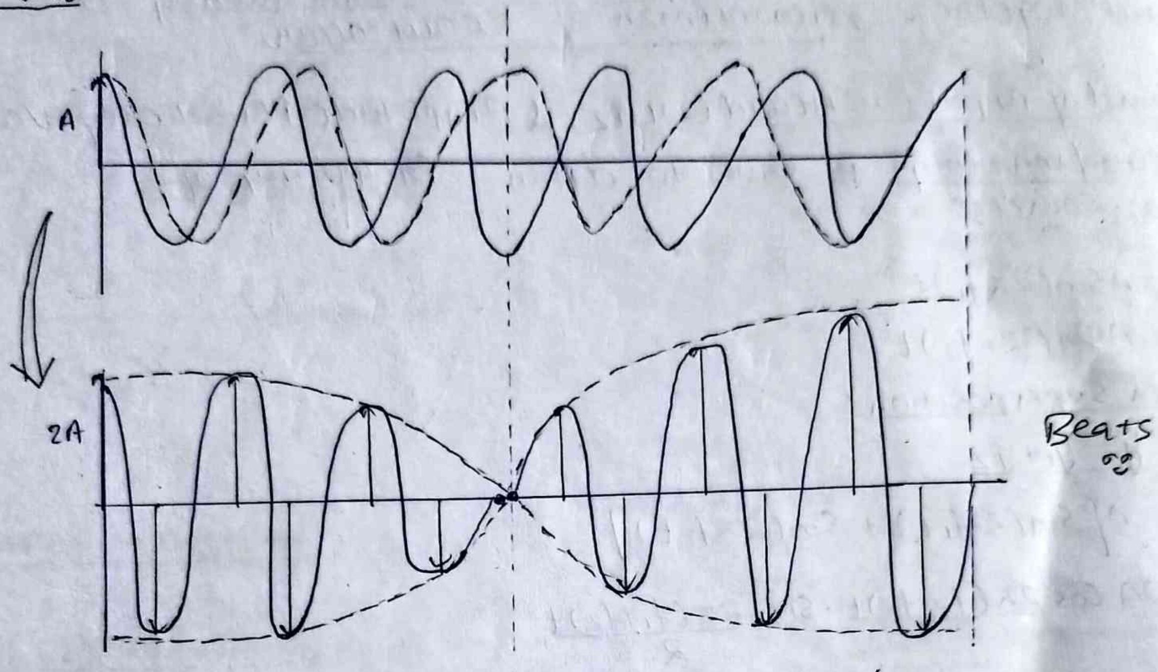
for $N = 1, 2, 3 \cdots$

$t = \frac{1}{(f_1-f_2)}, \frac{2}{(f_1-f_2)}, \frac{3}{(f_1-f_2)} \cdots\cdots$

∴ **Beat Period** :- $\frac{1}{(f_1-f_2)}$

∵ **Beat freq** :- (f_1-f_2)

※ NAMO



∵ Human ears can detect Beats upto 12-14z Hz !