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WAVE OPTICS

OPTICS

Ray optics

- Based on rectilinar propagation of light
- Valid only if the Size of the obstacle is much larger than wavelength of light
- It only explains phenomena like reflections & refraction

Wave optics

- Size of obstacle is comparable to wavelength of light. rectilinear propagation of light is not possible in this case.
- Phenomena like reflection, refraction, interference, diffraction & Polarisation explained by wave optics.

Quantum optics

- Assumed that light is a stream of particle called photon.
- It explained phenomena related to emssion or absorption of light like 1) Photoelectric effect 2) Crompton effect.

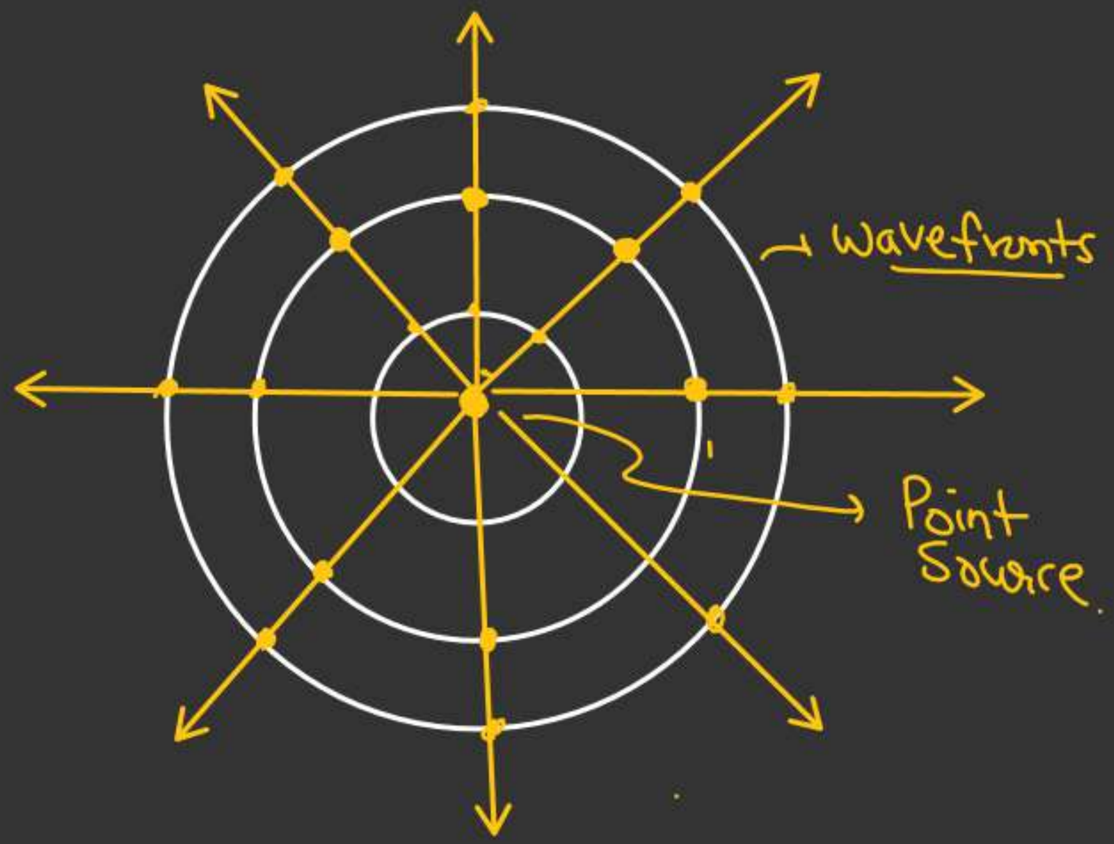
Wavefront :-

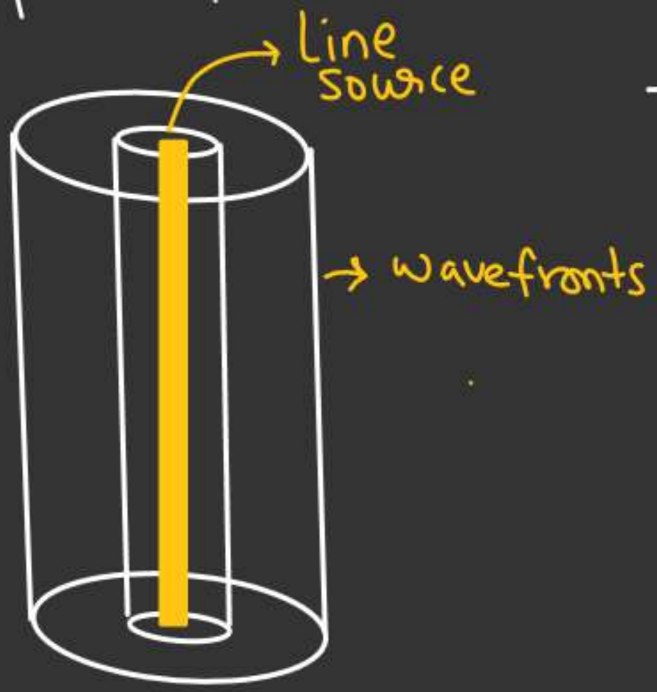
↳ locus of all the points which are vibrating in the same phase.

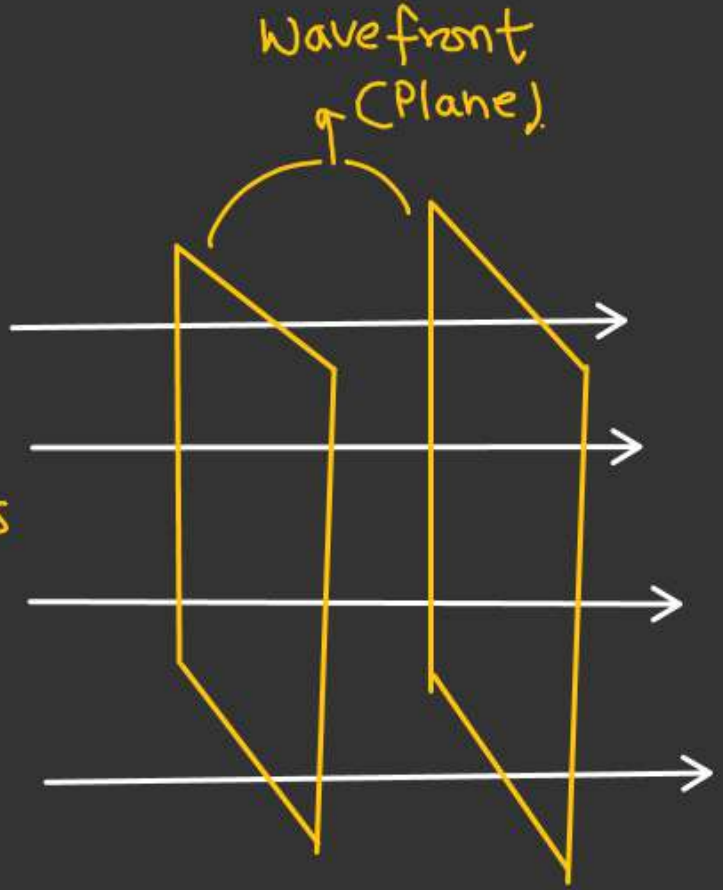
→ Point Source ⟶ Spherical wavefronts

→ Line Source ⟶ Cylindrical wave fronts

→ Source at infinite distance → Parallel planes.







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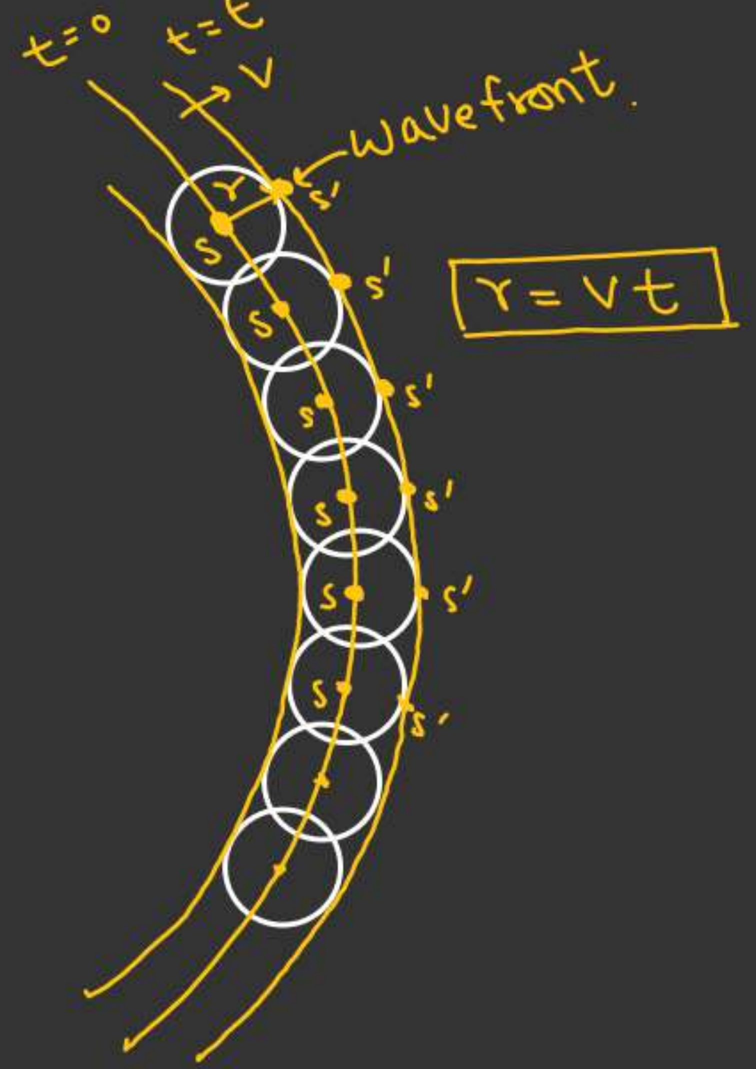
HUYGEN'S PRINCIPLE

- Every point on a wavefront acts as a source of new disturbance called. Secondary wavelets.

- The forward envelope of the secondary wavelets gives the new wavefront.



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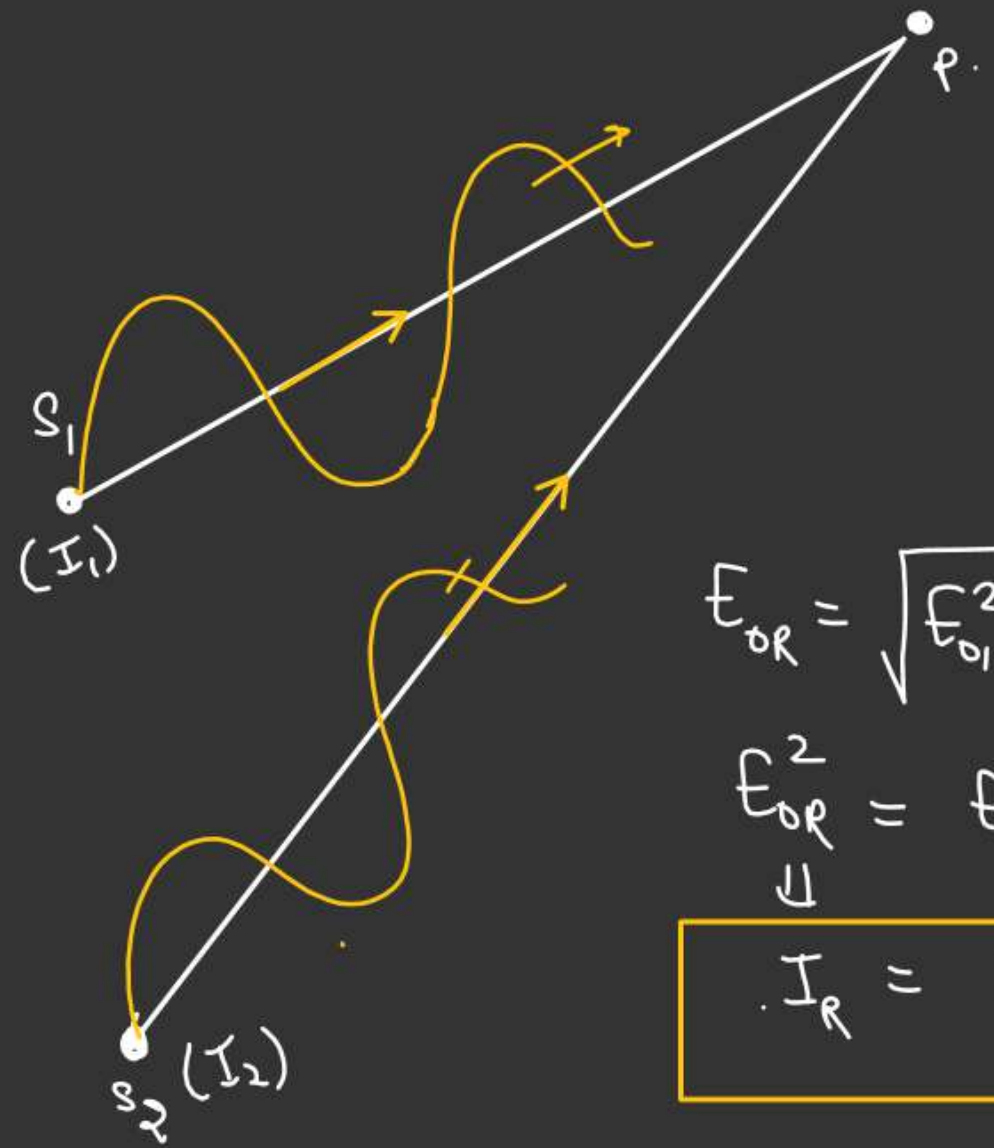
INTERFERENCE (Based on Superposition principle)

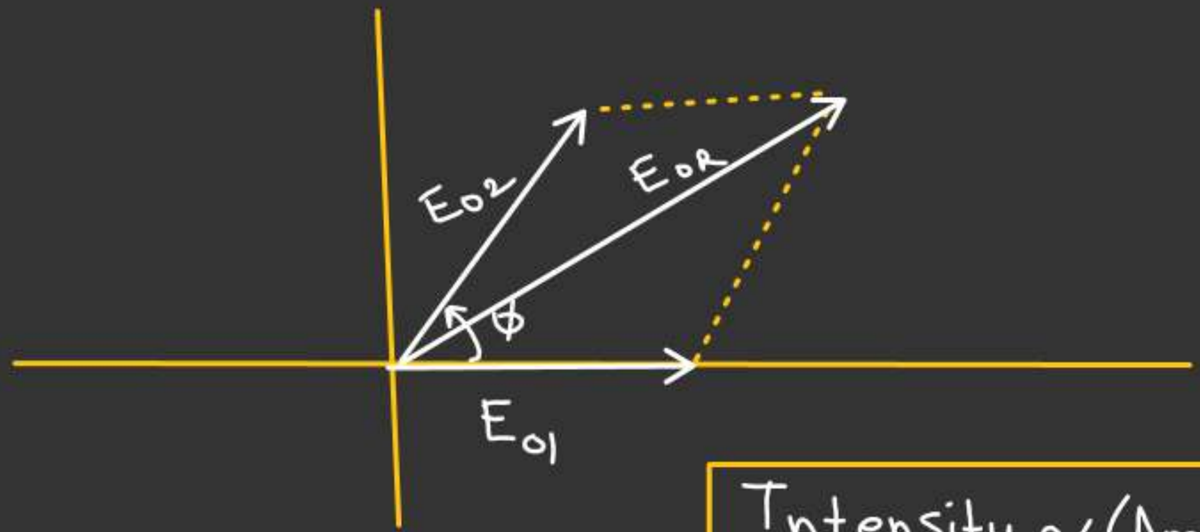
$E_1 = E_{01} \sin \omega t$

$E_2 = E_{02} \sin(\omega t + \phi)$

$E_R = E_1 + E_2$

$= E_{01} \sin \omega t + E_{02} \sin(\omega t + \phi)$





$$\boxed{\text{Intensity} \propto (\text{Amplitude})^2}$$

$$E_{0R} = \sqrt{E_{01}^2 + E_{02}^2 + 2E_{01} \cdot E_{02} \cos\phi}$$

$$E_{0R}^2 = E_{01}^2 + E_{02}^2 + 2E_{01}E_{02}\cos\phi$$

$\Downarrow$

$$\boxed{I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi}$$

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$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

$\Delta\phi = \phi =$ phase difference.

$$\begin{bmatrix} \phi_1 = 0 \\ \phi_2 = \phi \end{bmatrix}$$

Constructive Interference

(I_R) will be maximum.

i.e $\cos\phi = 1$

$$\boxed{\phi = (2n\pi) \quad n = 0, 1, 2, 3..}$$

$$\frac{2\pi}{\lambda}(\Delta x) = 2n\pi$$

$$\boxed{\Delta x = (n\lambda) \quad n = 0, 1, 2, 3..}$$

Path difference :- (Δx)

$E_1 = E_{01}\sin(\omega t + kx)$

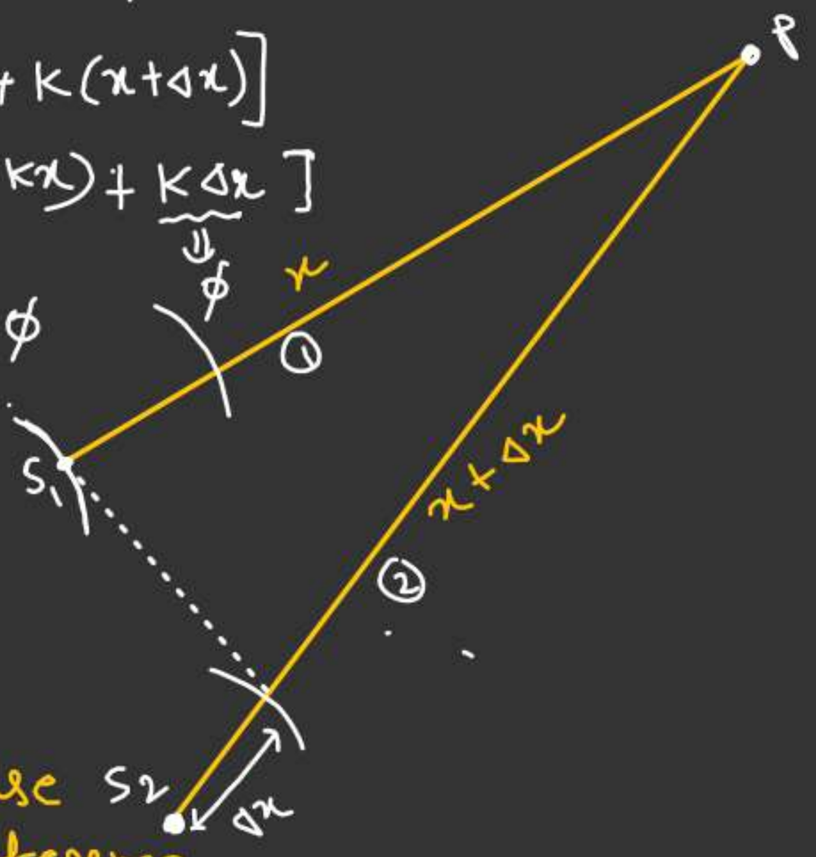
$E_2 = E_{02}\sin[\omega t + k(x + \Delta x)]$

$E_2 = E_{02}\sin[(\omega t + kx) + \underbrace{k\Delta x}_{\phi}]$

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

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

Path difference (Δx) — Phase difference ($\Delta\phi$)



$$(I_R)_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$$

$$\boxed{(I_R)_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2}$$

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Condition for destructive interference.

For destructive interference resultant intensity minimum.

For $(I_R)_{min}$, $\cos\phi = -1$.

$$\boxed{\phi = (2n+1)\pi}$$

$(n = 0, 1, 2, 3 \ldots)$

$$\boxed{\phi = (2n-1)\pi}$$

$(n = 1, 2, 3, 4 \ldots)$

In terms of path difference

$$\frac{2\pi}{\lambda}(\Delta x) = (2n+1)\pi$$

$$\boxed{\Delta x = (2n+1)\frac{\lambda}{2} \quad n = 0, 1, 2, 3, \ldots}$$

or

$$\boxed{\Delta x = (2n-1)\frac{\lambda}{2} \quad n = 1, 2, 3, 4 \ldots}$$

$$(I_R)_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2}$$
$$= \left(\sqrt{I_1} - \sqrt{I_2}\right)^2.$$

$$\frac{(I_R)_{max}}{(I_R)_{min}} = \left(\frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}}\right)^2$$

Find the ratio of $(I_R)_{max}$ to $(I_R)_{min}$ if ratio of their amplitude are in the ratio $2:1$.

Sol^n. $\frac{A_1}{A_2} = \frac{2}{1}$, $\frac{A_1^2}{A_2^2} = \frac{4}{1} \Rightarrow \left(\frac{I_1}{I_2} = \frac{4}{1}\right)$

$$\frac{(I_R)_{max}}{(I_R)_{min}} = \frac{(\sqrt{4}+1)^2}{(\sqrt{4}-1)^2} = \frac{9}{1} = 9:1.$$