Session-1 - wave optics

→ Recap

→ characteristics of a wave.

→ Huygen's wave theory

→ Interference

→ Coherent sources

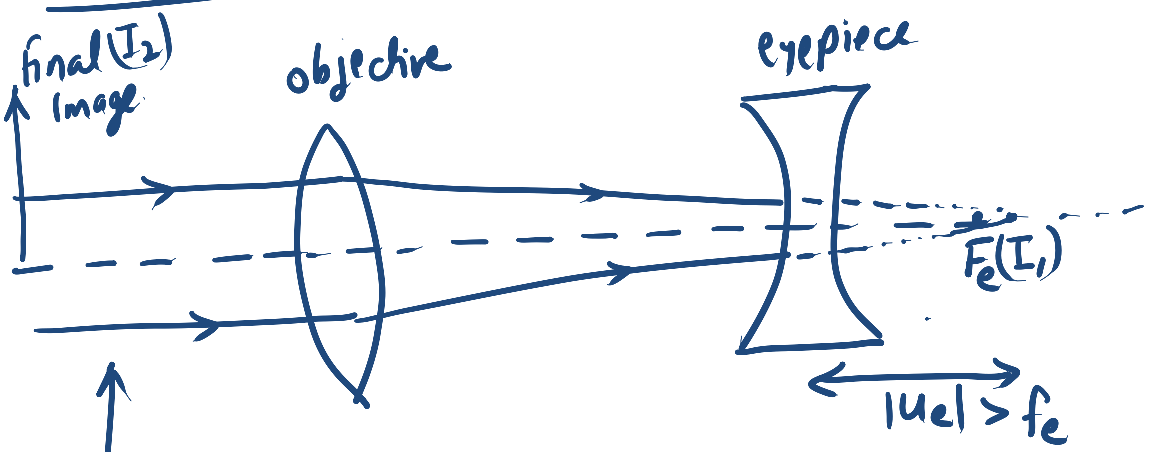
Recap

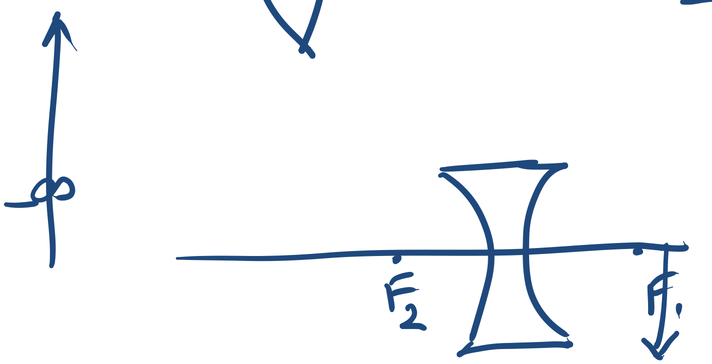
1). Astronomical telescope → M.P → -ve

2). Terrestrial — " — → M.P → +ve

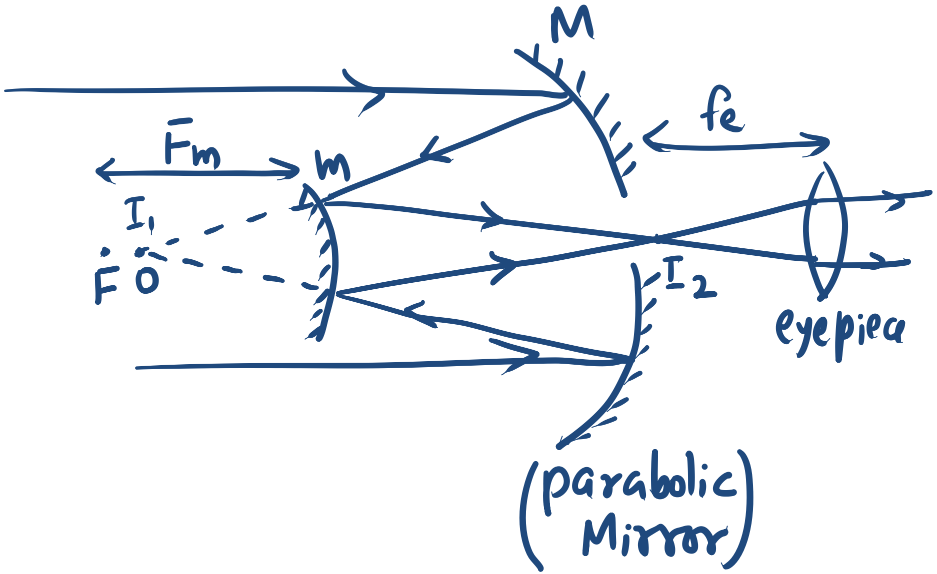
- → three convex lenses.
- → Galilean's → 1 convex 1 concave
- → Cassegrain's → Mirrors.

Galilean's Telescope





Cassegrain's Telescope

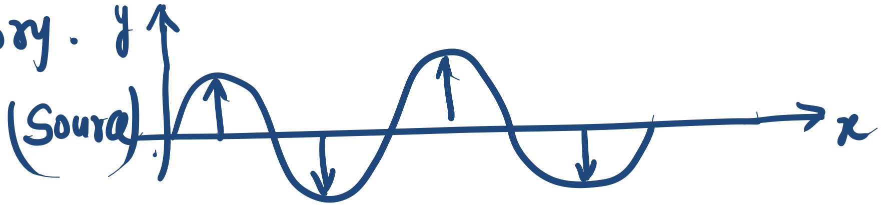


Wave Optics :-

↳ To deal with the objects of the size of the wavelength(λ) of light.

↳ Interference, diffraction, Scattering, polarization.

Theory – Huygen's wave theory.



Characteristics of wave :-

wave v/s particle

→ existential reality

→ The way they travel

→ How they combine.

wave → disturbance propagating in space & time

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

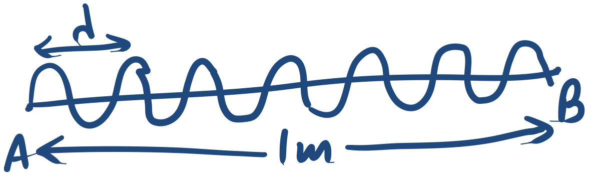
$$= A\sin\omega\left(t - x/v\right)$$

$\omega \rightarrow$ Angular frequency $= 2\pi f \longrightarrow$ No. of oscillations per sec.

No. of angular oscillations per unit time.

$k \rightarrow$ wave number $(m^{-1}) = 2\pi/\lambda$

No of waves per unit meter.



$k = ?$

$$\boxed{k = 6.5}$$

$$\rightarrow \frac{\omega}{v} = \frac{2\pi f}{f\lambda} = \frac{2\pi}{\lambda}$$

$$f = \frac{1}{T}$$

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

phase

↓

(Argument of Trig. term)

S_1 ·))) $A_1\sin(\omega t)$

S_2 ·)))) $A_2\sin(\omega t + \phi)$

phase diff $= (\omega t + \phi) - (\omega t)$

$= \phi$.

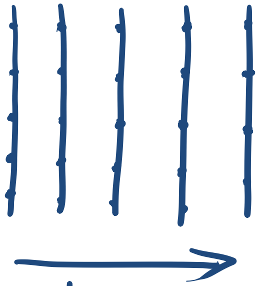
phase of $S_2 = (\omega t + \phi)$.

Huygen's Wave Theory :-

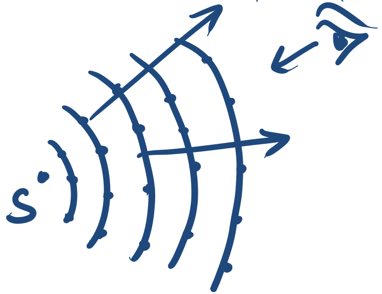
- proposed a hypothetical medium → luminiferous ether (अभिकल्पित).
  - made up of elastic & massless particles isotropic medium.
- explains → reflection, refraction, interference, diffraction
- doesn't explain → Polarization, Photoelectric Effect, emission & absorption spectrum, scattering of light.
- vel. of light decreases in a denser medium

Postulates of Huygen's Theory:-

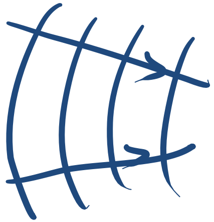
1). Light travels in a medium in the form of wavefronts.



Plane wavefront
(beam of light)



Spherical wavefront
(Convex wavefront)



Spherical wavefront
(Concave wavefront).

Cylindrical wavefront

2). Every point on the wavefront becomes the source of secondary wavefronts (wavelets)

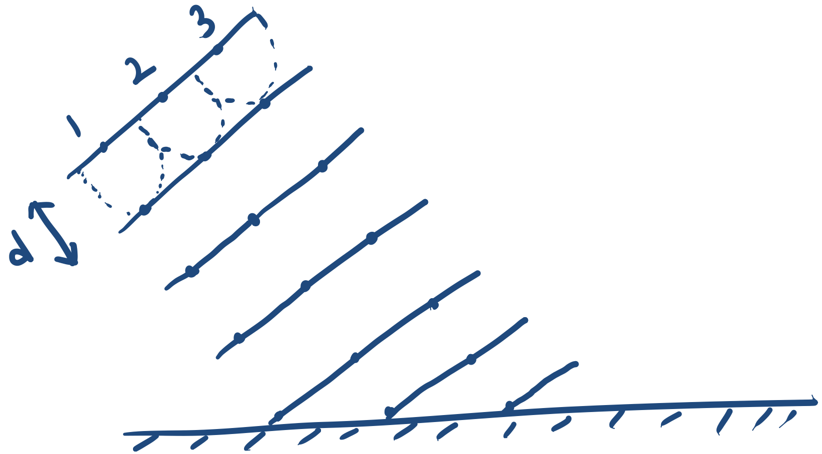
3). All the points on a wavefront lie in the same phase.

Secondary wavelets

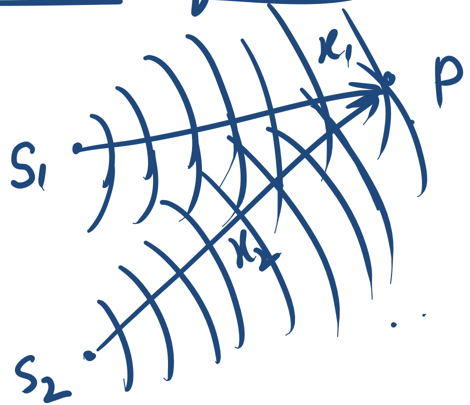
(Spherical) wavelets.	(cylindrical)	(plane)
$I \propto A^2$	$I \propto 1/r$	$I = const.$
$I \propto 1/r^2$	$A \propto 1/\sqrt{r}$.	$A = const.$
$A \propto 1/r$		

$I \rightarrow$ Intensity $A \rightarrow$ Amplitude, $r \rightarrow$ radial dist.

Reflection through Huygen's Theory



Interference of light :-



$S_1 = A_1 \sin(\omega t)$ @ source S_1

$S_2 = A_2 \sin(\omega t + \phi_i)$ @ source S_2

$(S_1)_{@p} = A_{1p} \sin(\omega t)$

$(S_2)_{@p} = A_{2p} \sin(\omega t + \phi_p)$

$$\Delta\phi_T = \Delta\phi_{\Delta x} + \Delta\phi_i$$

$\Delta\phi_{\Delta x}$ → due to path difference

$\Delta\phi_i$ → due to initial phase. → when the interfering wavefronts emitted from their sources.

Let $\Delta\phi_T = $ const.

$S_T = (S_1)_{@p} + (S_2)_{@p}$

$= A_{1p} \sin \omega t + A_{2p} \sin(\omega t + \phi_p)$.

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$$S_T = A_{1p}\sin\omega t + A_{2p}\sin\omega t\cos\phi + A_{2p}\cos\omega t\sin\phi$$

$$= \underbrace{(A_{1p} + A_{2p}\cos\phi)}_{R\cos\theta}\sin\omega t + \underbrace{A_{2p}\sin\phi}_{R\sin\theta}\cos\omega t.$$

$$R = \sqrt{(A_{1p} + A_{2p}\cos\phi)^2 + (A_{2p}\sin\phi)^2}$$

$$= R[\cos\theta\sin\omega t + \sin\theta\cos\omega t]$$

$$R = \sqrt{A_{1p}^2 + A_{2p}^2 + 2A_{1p}A_{2p}\cos\phi}$$

$$= R\sin(\omega t + \theta)$$

R → Resultant amplitude.

Intensity $\propto (\text{Amp})^2$

$$I = I_{1p} + I_{2p} + 2\sqrt{I_{1p}}\sqrt{I_{2p}}\cos\phi.$$

$$\tan\theta = \frac{A_{2p}\sin\phi}{A_{1p} + A_{2p}\cos\phi}$$