Wave Optics

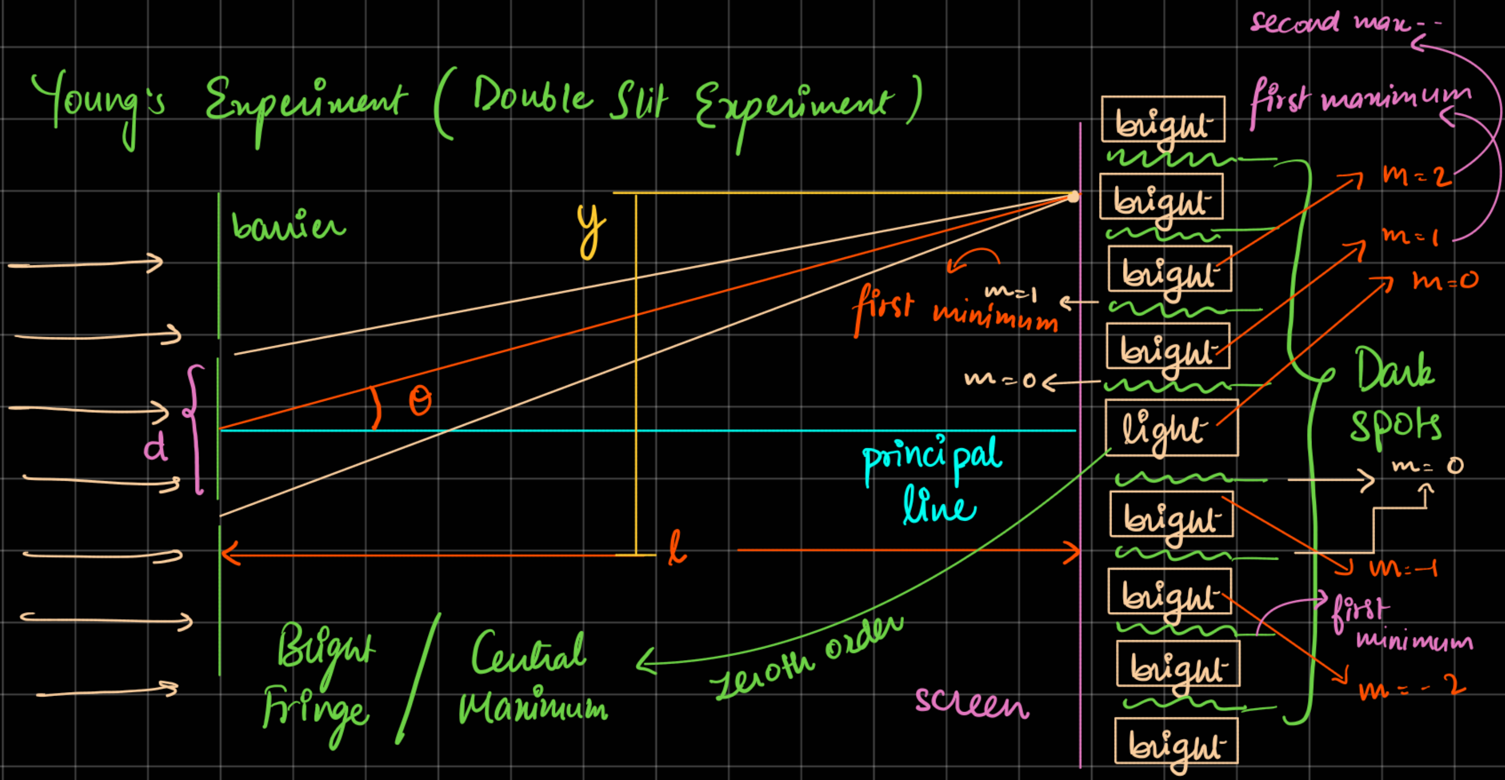
Diffraction

Spreading of light in all directions because λ > size of slit
$\lambda \downarrow$ wavelength

Interference

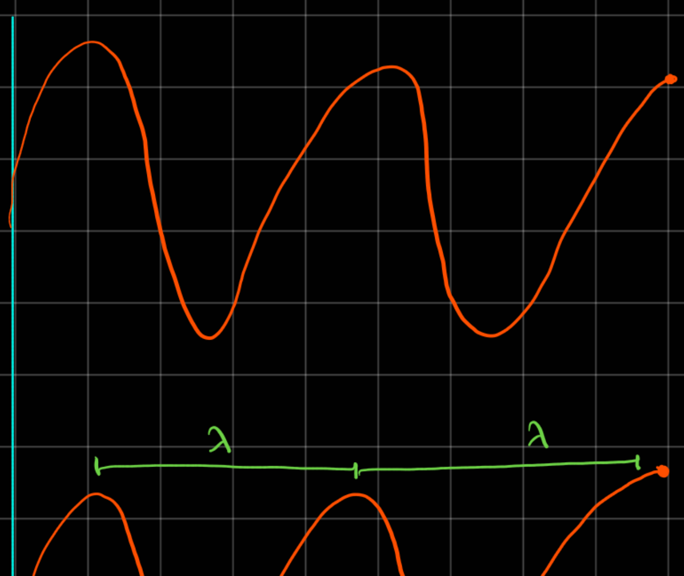
Two waves interfere with each other
They either combine and become stronger or destroy each other.

Young's Experiment (Double Slit Experiment)

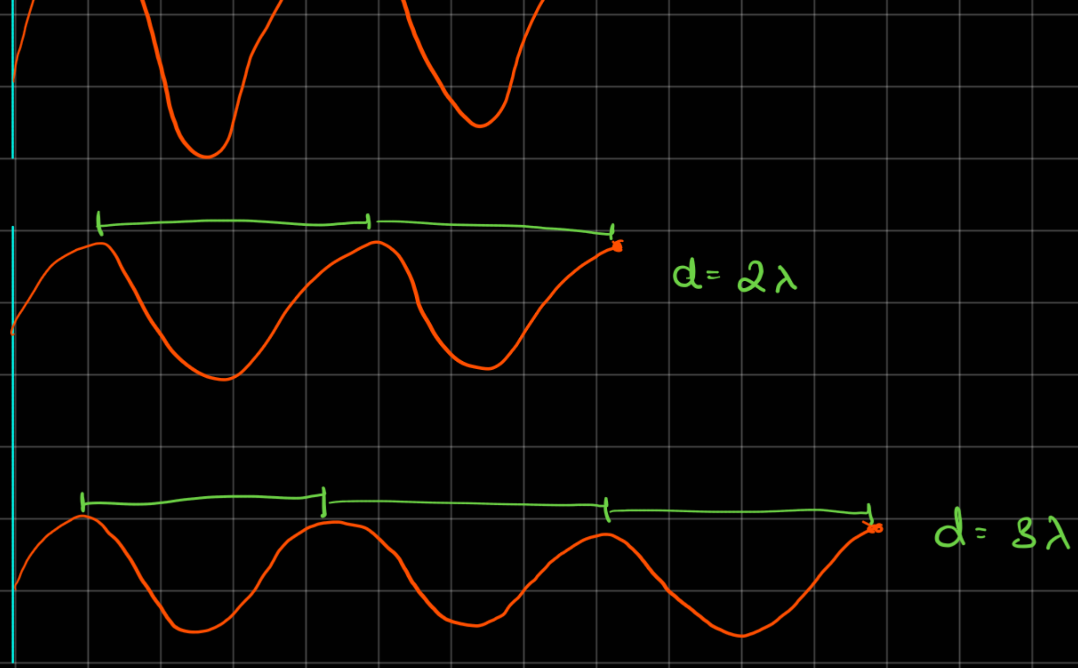


→ Waves add constructively at bright spots
→ Waves cancel each other out at dark spots

Alternating light and dark bands OR fringes

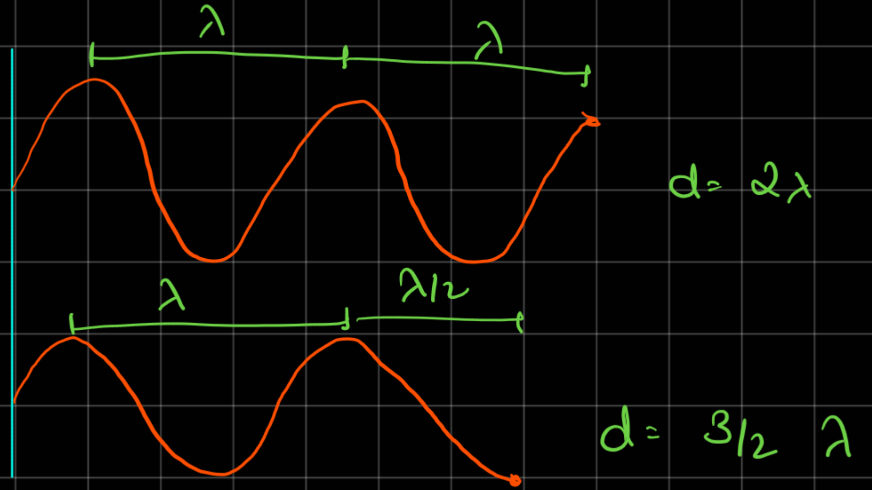


$d = 2\lambda$



For constructive interference

If the path difference = $m\lambda$, where m is a positive whole number, then the interference is constructive.



Destructive

For destructive interference

If the path difference = $(m + \frac{1}{2})\lambda$, where m is a positive whole number,

then the interference is destructive

Path difference = $\delta = d \sin\theta$ → angle between point & principal lines

↓

distance b/w slits

Constructive $m\lambda = d \sin\theta$

Destructive $(m + \frac{1}{2})\lambda = d \sin\theta$

$\tan\theta = \frac{y}{l}$

θ is small $\Rightarrow$ $\tan\theta \approx \sin\theta$

$\sin\theta = \frac{y}{l}$

Constructive $\frac{d\,y_{bright}}{l} = m\lambda$

Destructive $\frac{d\,y_{dark}}{l} = \left(m + \frac{1}{2}\right)\lambda$

Fifth max $m = 5, -5$

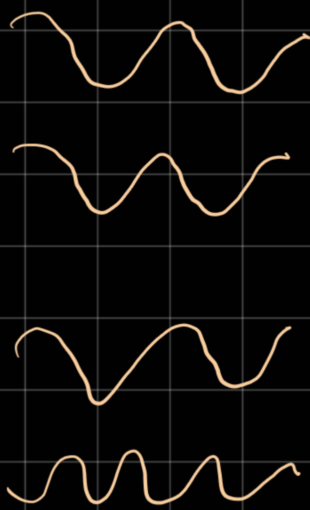
Fifth min $m = 4, -4$

Conditions for Interference

- Source light should be monochromatic
  single λ
- Source must be coherent
  constant phase

coherent

non coherent



Example

$l = 4.8\ m$

$d = 0.03 \times 10^{-3}\ m$

$m = 0$

$y_{dark} = 4.5 \times 10^{-3}\ m$

$\frac{d\,y}{l} = \left(m + \frac{1}{2}\right)\lambda$

$$\lambda = \frac{0.03\times10^{-3} \times 4.5\times10^{-3}}{4.8} \times \left(\frac{2}{2(0)+1}\right)$$

B) $y_2 - y_1 = y_3 - y_2 = y_4 - y_3$

take adjacent m, find y for both m, subtract

$$y_{bright} = \frac{l}{d} m\lambda$$

$$y_1 = \frac{l}{d}\lambda$$

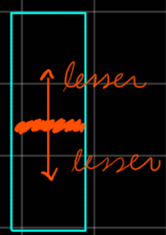
$$y_2 = \frac{2l}{d}\lambda$$

$$y_2 - y_1 = \frac{l}{d}\lambda$$

Light Intensity

Light is brightest at the middle of the bright fringe

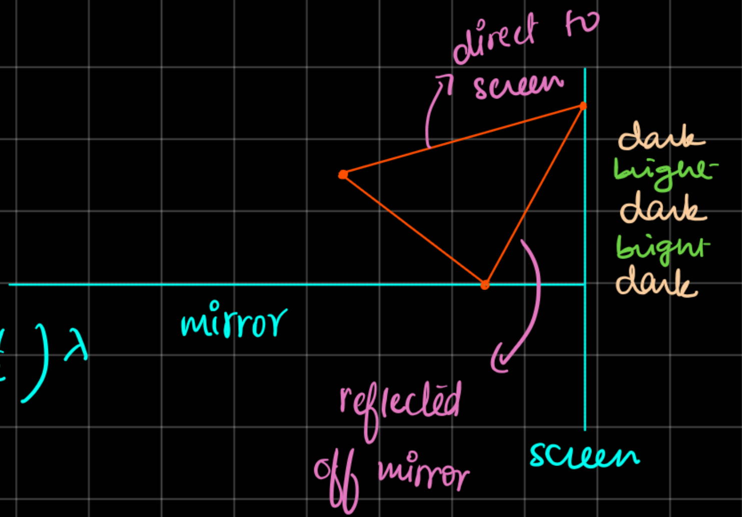
Darkness is darkest at the middle of the darkest fringe



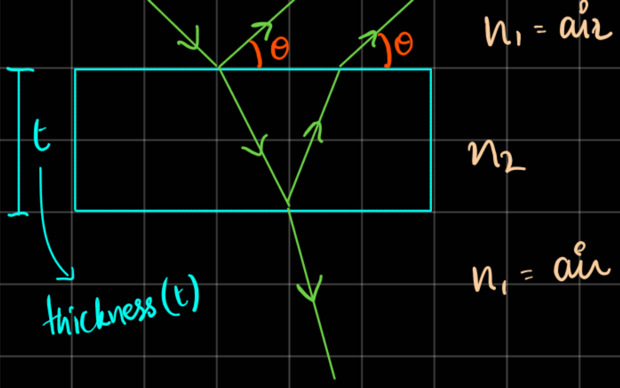
Lloyd's Mirror

Destructive $d\sin\theta = \frac{d y_{dark}}{l} = m\lambda$

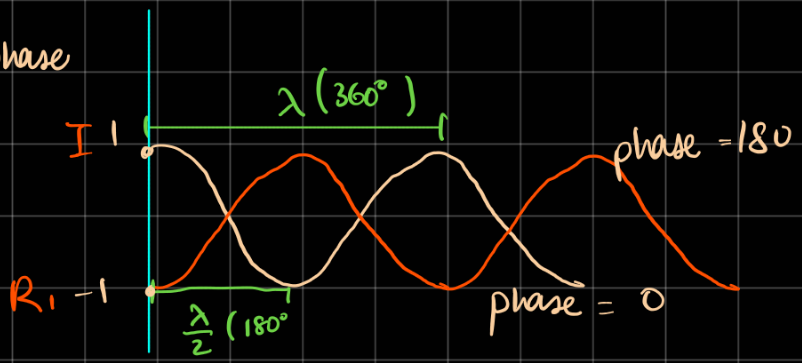
Constructive $d\sin\theta = \frac{d y_{bright}}{l} = \left(m+\frac{1}{2}\right)\lambda$

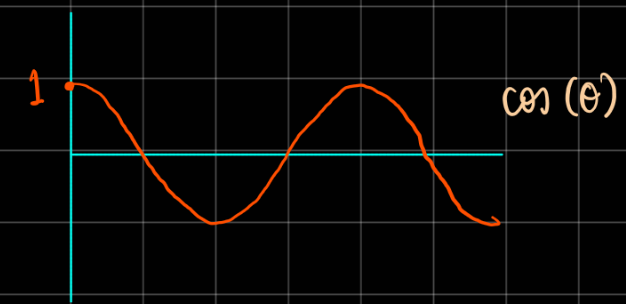


Thin Film



I & R_1 are 180° out of phase

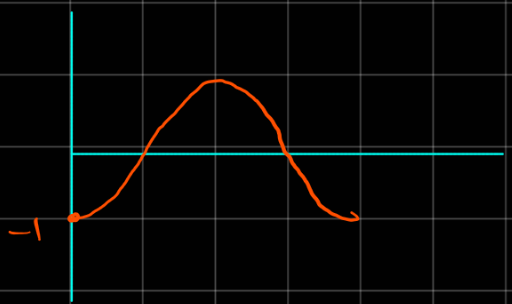




phase is calculated at t = 0

θ = 0

∴ phase = 0



θ = π   phase = π = 180°

I & R_2 are in phase

If reflection from higher n
Incident & reflected are out of phase by 180°

If reflection from lower n
Incident & reflected are in phase

Refraction does NOT change phase

R_1 & R_2 are $\underbrace{\text{out of phase by } 180°}_{\text{difference between distance } = \lambda/2}$

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

Total path distance $= 2t + \frac{\lambda}{2}$

$$= \lambda$$

$\downarrow$

constructive

$$\left.\begin{array}{ll} \text{Constructive} & 2t = \left(m + \frac{1}{2}\right)\frac{\lambda}{n} \\ \text{Destructive} & 2t = m\frac{\lambda}{n} \end{array}\right\} \quad m = 0, 1, 2 \ldots$$

These two equations are valid as long as $\boxed{\begin{array}{l} n > n_1 \\ n > n_2 \end{array}}$

If

$n > n_1$	OR	$n < n_1$
$n < n_2$		$n > n_2$

$\Downarrow$

SWAP

Constructive $\Longleftrightarrow$ Destructive

Constructive $\quad 2t = m\frac{\lambda}{n}$

Destructive $\quad 2t = \left(m + \frac{1}{2}\right)\lambda$

$\Big(\quad \frac{1}{2} \Big) \; \frac{}{n}$