JEE MAIN

WAVE OPTICS – PART 1

FORMULAE

INTERFERENCE | YDSE

Now that's how you REVISE

-Mohit Goenka, IIT Kharagpur

EDUNITI YouTube Channel
Learn Like Never Before

List of Content on Eduniti YouTube Channel:

1. PYQs Video Solution Topic Wise:
   (a) JEE Main 2018/2020/2021 Feb & March
2. Rank Booster Problems for JEE Main
3. Part Test Series for JEE Main
4. JEE Advanced Problem Solving Series
5. Short Concept Videos
6. Tips and Tricks Videos
7. JEE Advanced PYQs
8. Formulae Revision Series

........and many more to come

EDUNITI

Eduniti for Physics

TOPICS COVERED

1. Wavefront
2. Net Amplitude and Intensity, Phase and Path difference relation
3. Constructive and Destructive Interference
4. YDSE
5. Position of Dark and Bright Fringes
6. Fringe Width and Angular Fringe Width
7. Effect on Fringe Width if YDSE Setup is in a Medium
8. Geometrical and Optical Path Length
9. Thin Film in YDSE
10. Shifting of Fringe in Oblique Incidence
11. White Light in YDSE
12. Slit Width effect in YDSE
13. Interference in Thin Films

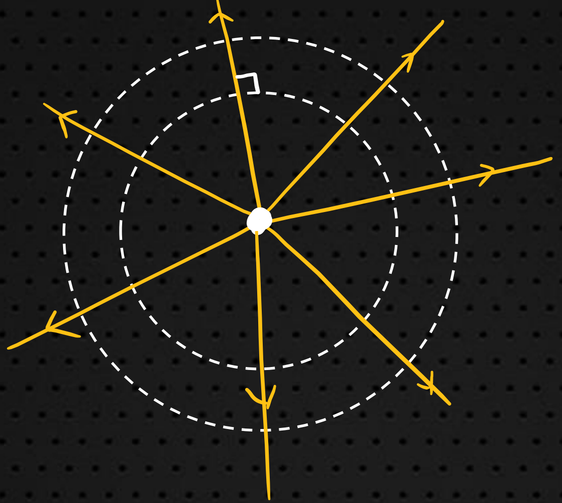
1. WAVEFRONT

\# When light propagates, the cross section where all particles oscillate in same phase is called Wavefront.

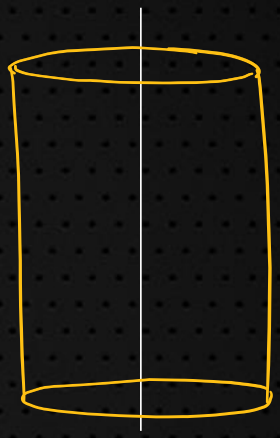
\# Wave front is Normal to Propagation direction

WAVEFRONT

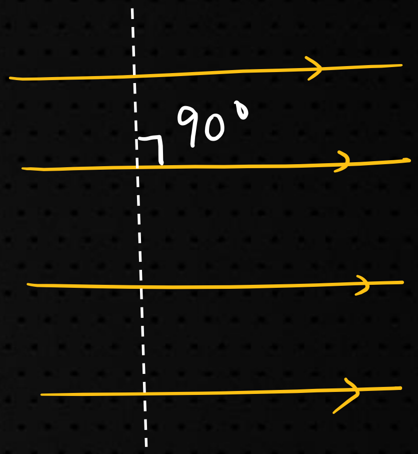
Spherical



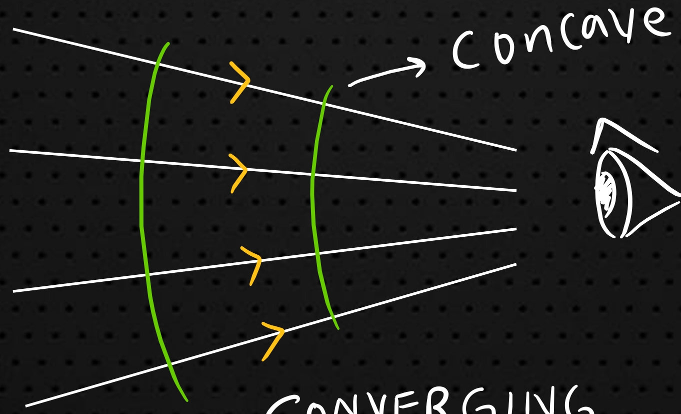
Cylindrical



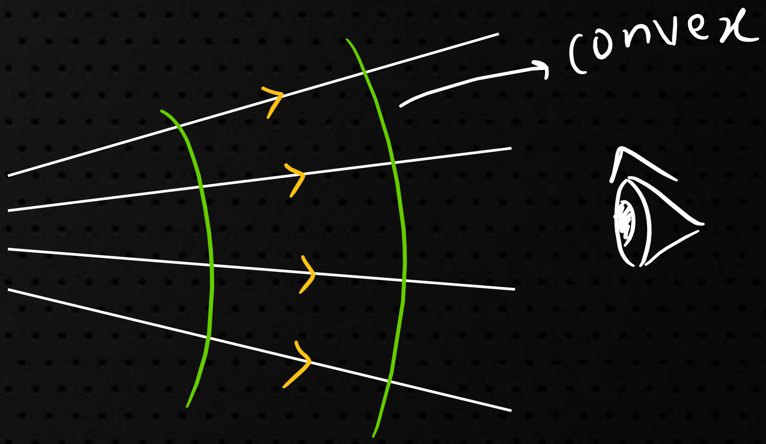
Planar



Ex:



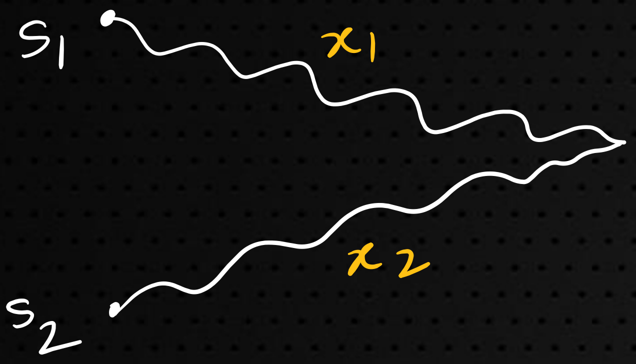
CONVERGING



DIVERGING

2. A_{net} and I_{net} IN INTERFERENCE (Coherent source, same ω)

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



$y_2 = A_2 \sin(\omega t - kx)$

$$y = y_1 + y_2 = A_1 \sin(\omega t - kx_1) + A_2 \sin(\omega t - kx_2)$$

phase difference, $\Delta\phi = k(x_2 - x_1) = k\Delta x$

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

$(I = kA^2)$

$$A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\Delta\phi}$$

If $A_1 = A_2 = A$

$$A_{net} = 2A\cos\frac{\Delta\phi}{2}$$

$$I_{net} = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\Delta\phi$$

If $I_1 = I_2 = I_0$

$$I_{net} = 4I_0\cos^2\frac{\Delta\phi}{2}$$

3. $\Delta\phi, \Delta x, A_{net}, I_{net}$

$$A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\Delta\phi}$$

$$I_{net} = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\Delta\phi$$

INTERFERENCE

CONSTRUCTIVE

(i) $\Delta\phi = 2n\pi$

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

$\Delta x = n\lambda$

(iii) $A_{net} = A_1 + A_2$

If $A_1 = A_2 = A$

$A_{net} = 2A$

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

If $I_1 = I_2 = I_0$

$I_{net} = 4I_0$ (MAXIMA)

DESTRUCTIVE

(i) $\Delta\phi = (2n+1)\pi$

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

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

(iii) $A_{net} = A_1 - A_2$

If $A_1 = A_2 = A$

$A_{net} = 0$

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

If $I_1 = I_2 = I_0$

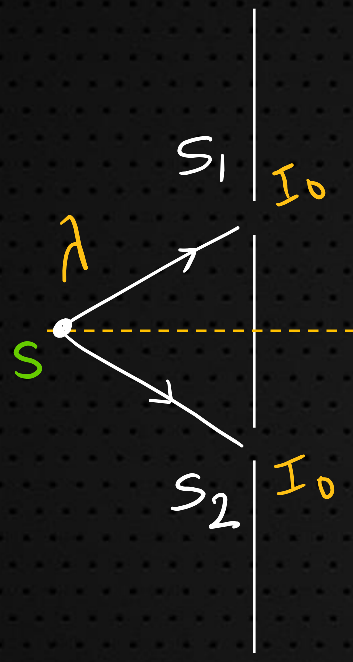
$I_{net} = 0$ (MINIMA)

4. YOUNG'S DOUBLE SLIT EXPERIMENT (YDSE)

C : Central Bright fringe

B : Bright fringe

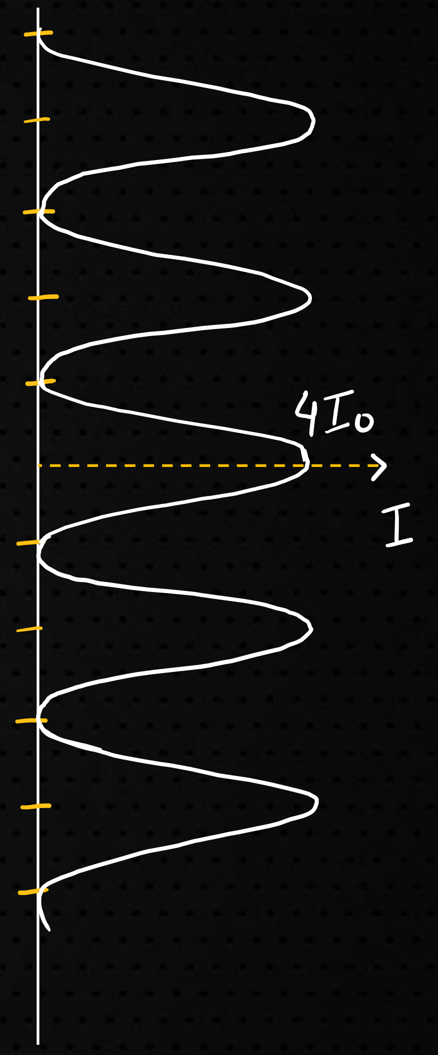
D : Dark fringe



S_1 and S_2 are slits.

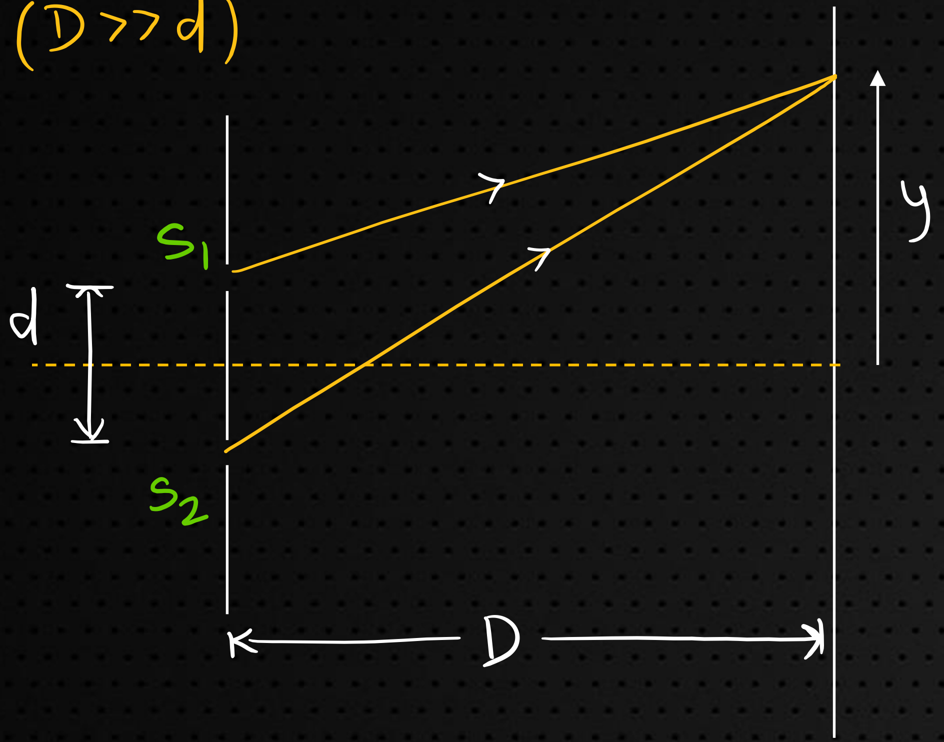
	Δx	I_{net}
D	$5\lambda/2$	0
B	2λ	$4I_0$
D	$3\lambda/2$	0
B	λ	$4I_0$
D	$\lambda/2$	0
C	0	$4I_0$
D		
B		
D		
B		
D		

SCREEN



5. DISTANCE OF BRIGHT AND DARK FRINGES

($D >> d$)



Path difference at y, $\Delta x = \frac{yd}{D}$

BRIGHT FRINGE

$\Delta x = n\lambda$

$\Rightarrow \frac{y_n d}{D} = n\lambda$

$\Rightarrow y_n = \frac{n\lambda D}{d}$

DARK FRINGE

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

$\Rightarrow \frac{y_n d}{D} = (2n-1)\frac{\lambda}{2}$

$\Rightarrow y_n = (2n-1)\frac{\lambda D}{2d}$

6. FRINGE WIDTH AND ANGULAR FRINGE WIDTH

↳ Distance between two successive Bright or dark fringe.

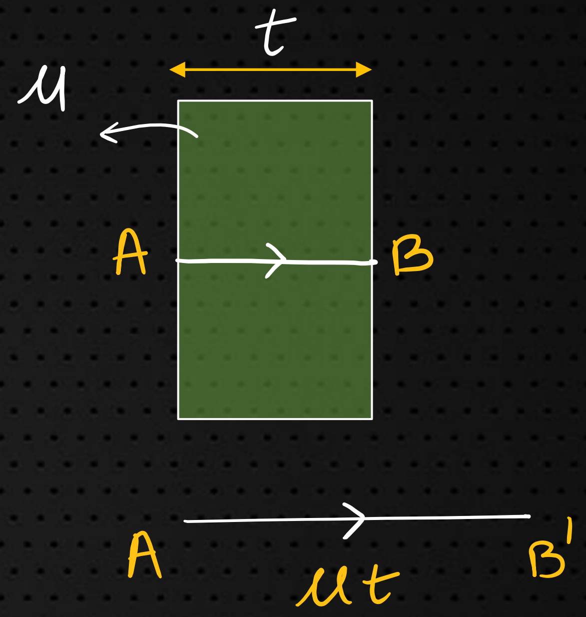
(a) $\beta = \frac{\lambda D}{d}$ (b) $\beta_\theta = \frac{\lambda}{d}$

7. β IF YDSE SETUP IS IN A MEDIUM OF RERACTIVE INDEX μ.

If in air, $\beta = \dfrac{\lambda D}{d}$

In medium, $\beta' = \dfrac{\lambda D}{\mu d} = \dfrac{\beta}{\mu}$

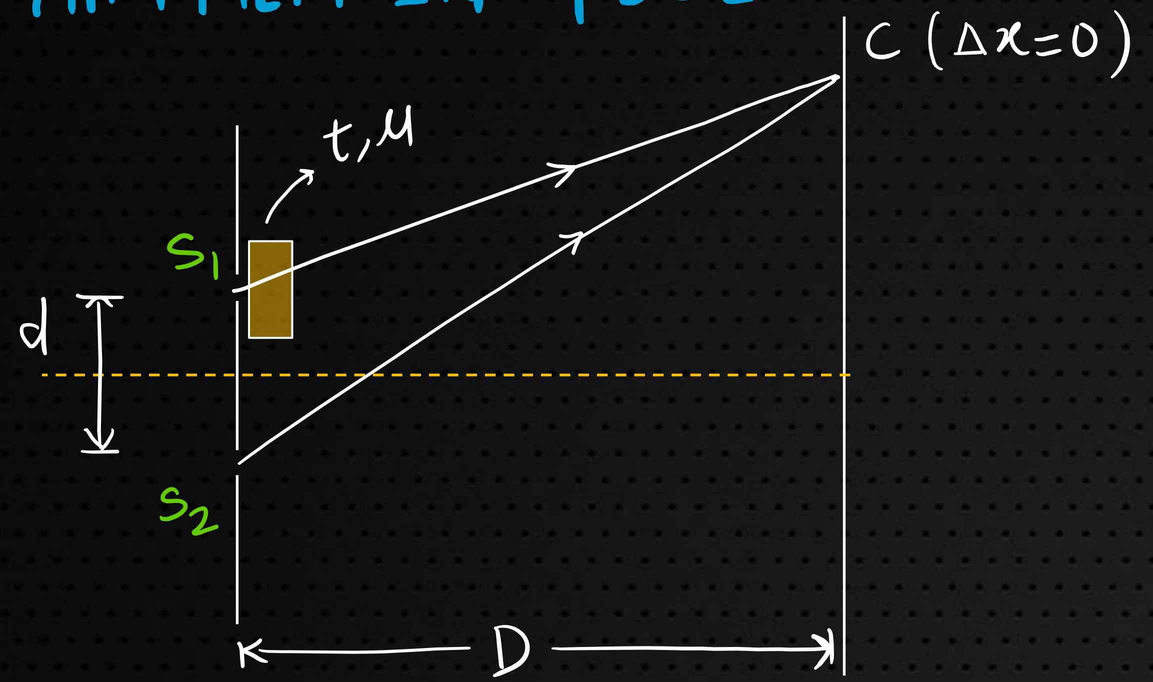
8. GEOMETRICAL AND OPTICAL PATH LENGTH



Geometrical path = AB = t

Optical path = AB' = μt

9. THIN FILM IN YDSE

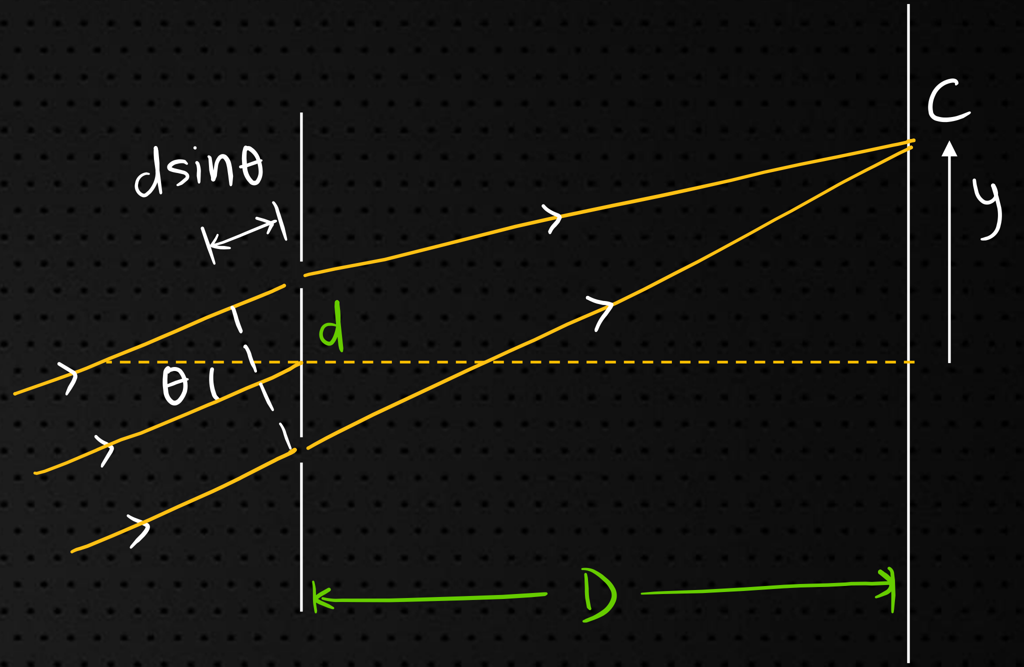


$$t(\mu-1) = \frac{yd}{D}$$

$$\Rightarrow y = \frac{tD(\mu-1)}{d}$$

↳ shift in fringe Pattern

10. SHIFTING OF FRINGE IN OBLIQUE INCIDENCE



FRINGE SHIFTS UP.

$$d\sin\theta = \frac{yd}{D}$$

$$\Rightarrow y = D\sin\theta$$

11. WHITE LIGHT IN YDSE

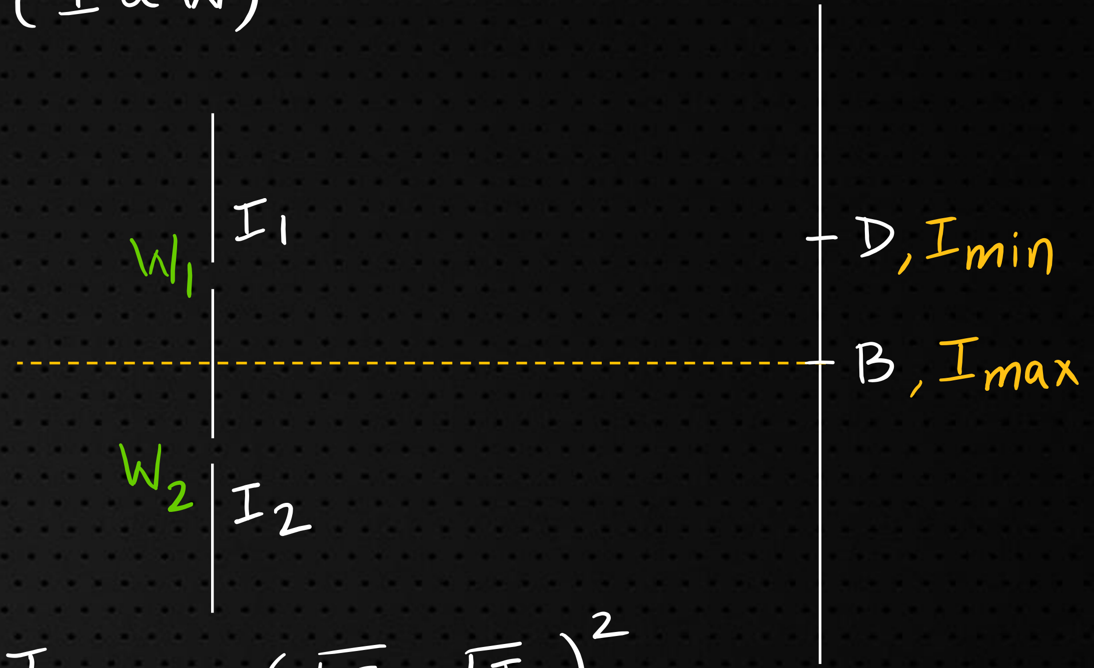
(1.) CENTRAL BRIGHT fringe is white colour

(2.) As you move a little away you see Reddish colour (violet destructive interference)

(3.) Move further away its bluish colour.

12. SLIT WIDTH EFFECT IN YDSE

$(I \propto W)$



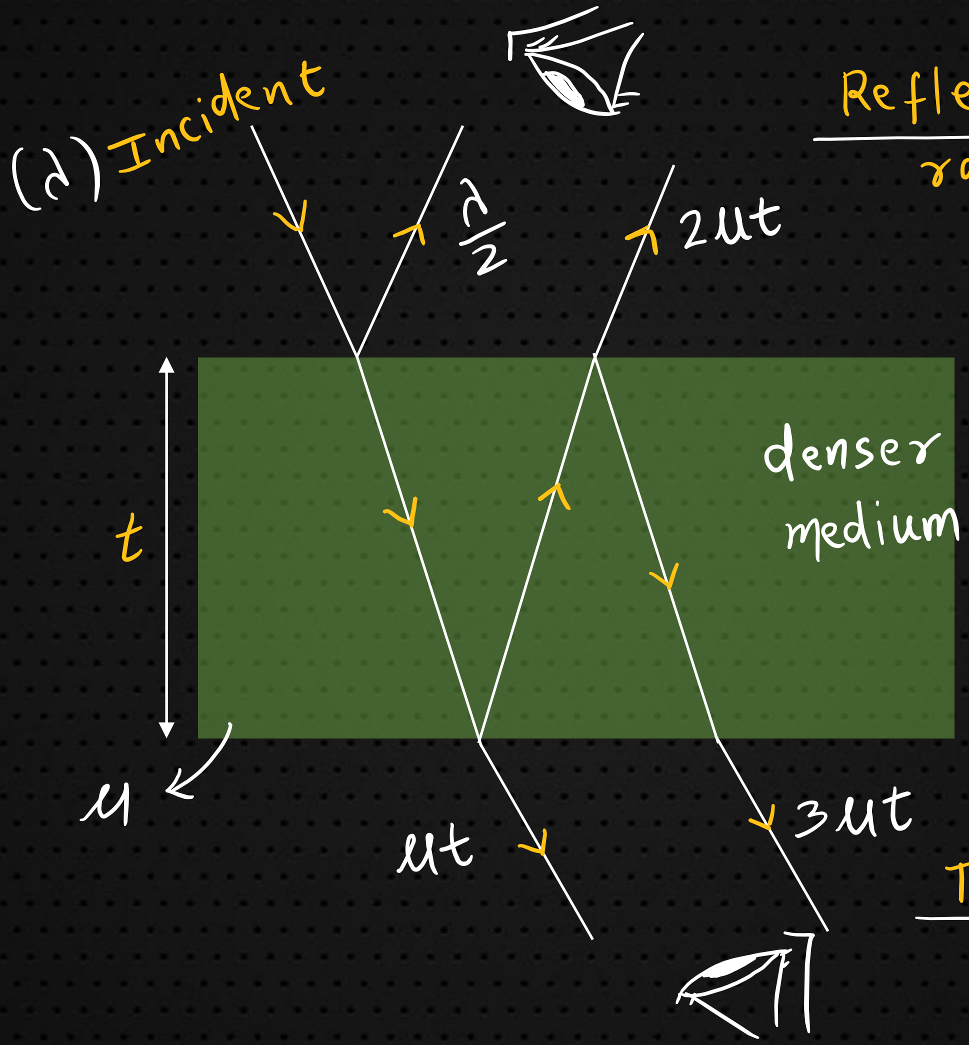
$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$$

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

Here we don't see contrasting fringe pattern

13. INTERFERENCE IN THIN FILMS (normal incidence)

NOTE:
When reflection is from denser medium $\frac{\lambda}{2}$ path difference is added



Reflected rays

- CONSTRUCTIVE: $2\mu t - \frac{\lambda}{2} = n\lambda$
- DESTRUCTIVE: $2\mu t - \frac{\lambda}{2} = (2n+1)\frac{\lambda}{2}$

Transmitted rays

- Constructive: $2\mu t = n\lambda$
- Destructive: $2\mu t = (2n+1)\frac{\lambda}{2}$