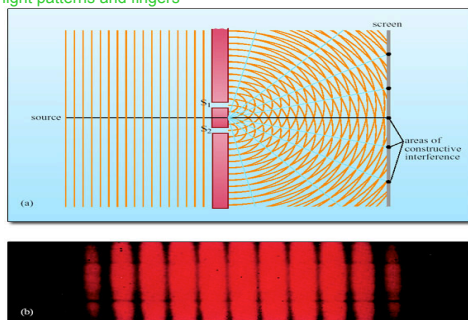


Chapter 27

Diffraction and Interference of light

demo - light patterns and fingers

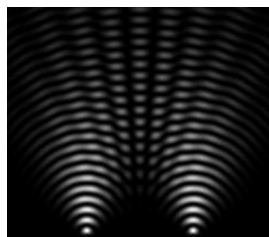


Wave Review

- **Superposition** = addition of multiple wave amplitudes
- **constructive interference** = two crests or two troughs combine = BRIGHT = MAX
- **destructive interference** = crest and trough combine = DARK = MIN

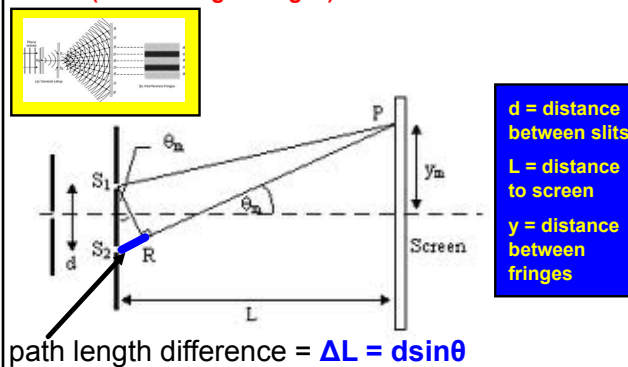
For COHERENT, IN PHASE light sources:

- Max
 - > antinode
 - > $\Delta L = m\lambda$
- Min
 - > node
 - > $\Delta L = (m+1/2)\lambda$

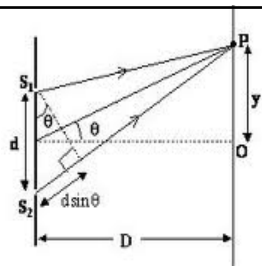


Young's Experiment - coherent, in phase light passed through two slits forming an interference pattern on a screen (dark and light fringes)

demo hair and laser



Young Experiment Equations



$d \sin \theta = m\lambda$ (max, bright)
 *** NOTE $m = 0$ = central bright ***
 $d \sin \theta = (m+1/2)\lambda$ (min, dark)
 $\tan \theta = y/L$

$\tan \theta = y/L = m\lambda/d = \sin \theta$ (for VERY small angles)

SO....

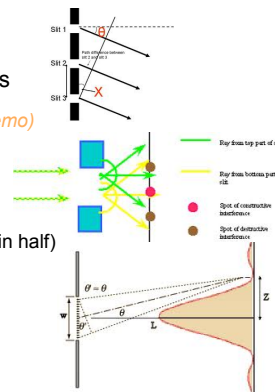
$y/L = m\lambda/d$ (max).....EQ sheet uses x for y

Multiple slits

- BRIGHTER..same equations
- Called Diffraction Grating (demo)

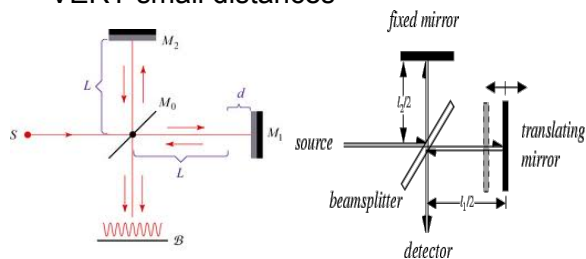
Single slit

- max/min reversed
- wave interferes with itself (splits in half)
- Use W instead of d
- $W \sin \theta = (m+1/2)\lambda = \text{max}$
- $W \sin \theta = m\lambda = \text{min}$



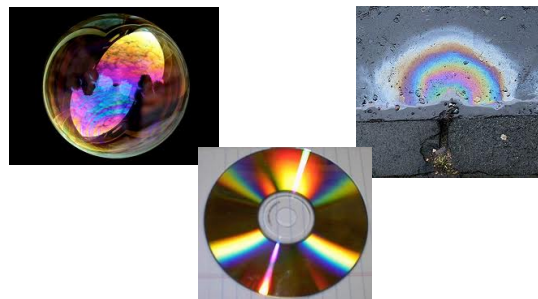
Interferometer

- Device using light interference to measure VERY small distances



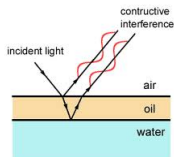
Thin Film Interference

demo karo syrup, sea shell, polarizer and cellophane

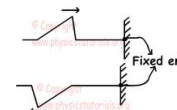


Thin Film Interference

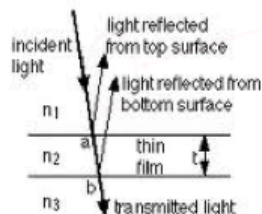
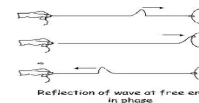
- Due to different n's in different media
- Dependent on
 - > n
 - > angle
 - > reflection from different surfaces



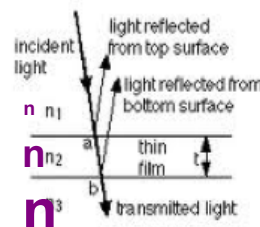
- If reflects off **BIGGER n** = fixed = **shifts** wave from crest to trough



- If reflects off **smaller n** = free = **no shift**



These waves make interference pattern
 If in phase = max for that color λ
 If out of phase = min for that color λ



if $n_2 > n_1$ = "fixed end" = shifts = out of phase with incident light

if $n_3 > n_2$ = "fixed end" = shifts = out of phase with incident light = in phase with other reflected wave

PLD = $\Delta L = 2tn$ (because it reflects AND slows down by factor of n)

$2tn = m\lambda$ (MAX...keeps IN PHASE)

$2tn = (m + 1/2)\lambda$ (MIN...shifts OUT OF PHASE)

color disappears = min when $t = \lambda/4n$

notice the quarter for a min

incident light
light reflected from top surface
light reflected from bottom surface
transmitted light

n_1
 n_2 thin film
 n_3

if $n_2 > n_1 =$ "fixed end" = shifts = out of phase with incident light
if $n_2 > n_3 =$ "fixed end" = shifts = out of phase with incident light = in phase with other reflected wave
PLD = $\Delta L = 2tn$ (because it reflects AND slows down by factor of n)

$2tn = (m+1/2)\lambda$ (MAX...puts it BACK in Phase)
 $2tn = m\lambda$ (MIN...keeps out of phase)

color disappears = min when $t = \lambda/2n$

notice "no order, no quarter" for a min

$\lambda_{\text{film}} = \lambda/n$so can also write equations as

$t = \lambda_{\text{film}}/2$ (no order min)
 $t = \lambda_{\text{film}}/4$ (order min)

the incident light is white light
Light reflected from both the top and bottom surfaces of the coating undergoes a 180° phase change. This is equivalent to shifting both waves by half a wavelength.
thickness of the coating is $1/4$ of the wavelength of green light in the coating material.

air $n = 1.00$
coating $n = 1.38$
glass lens $n = 1.52$

Figure A shows the situation two periods after Figure A. Note that both reflected waves have been moved to the right for clarity.

In this situation, the thickness of the thin film is exactly half the wavelength of the wave when it is in the film. This will result in completely destructive interference, as the two reflected waves cancel each other out.

Bragg Equation

- Used to determine thickness between atoms in layered crystal lattice
- Like thin film, light reflects off atoms

$m\lambda = 2d\sin\theta$

$n\lambda = 2d\sin\theta$

Bragg's Law Diagram (as applied to X-ray Diffraction techniques)

X-rays

Ten layers of Crystal Lattice

$n\lambda = 2d\sin\theta$
as the angle of incidence = the angle of reflection