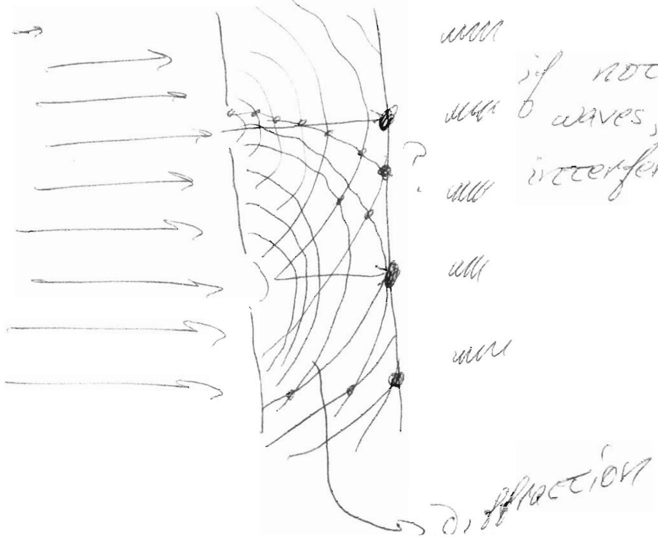
Interference

- coherence
  - → phase of EM waves is constant
  - → incoherence holds in light bulb
- to see interference
  - → want monochromatic light
    - ↦ single λ

Double Slit

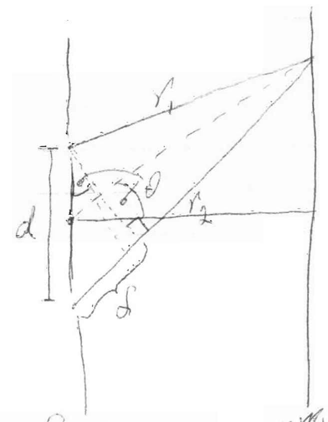
- → Consider Huygens assertion
  - → wavelike
  - → every pt on wave, a source of additional waves



if not waves, no interference

Interference

Imagine 2 slits

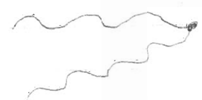


assume r_1 + r_2 //

What is δ? (path difference)

$\delta = r_1 - r_2 \approx d\sin\theta$

→ when δ is some # m of λ's
→ constructive interference



$\delta = d\sin\theta_{bright} = m\lambda$

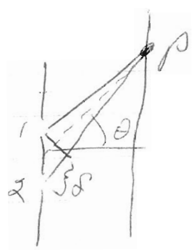
$\delta = d\sin\theta_{dark} = (m+\frac{1}{2})\lambda$

↳ dark fringes

37.3

Light Intensity of Double Slit

→ $\mathcal{E}$ field @ pt P



$\mathcal{E}_1 = \mathcal{E}_0 \sin\omega t$

$\mathcal{E}_2 = \mathcal{E}_0 \sin(\omega t + \phi)$

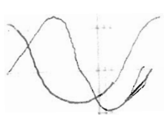
→ ϕ is result of $\delta \neq 0$

→ → $\phi = 2\pi \frac{\delta}{\lambda} = \frac{2\pi d}{\lambda} \sin\theta$

→ relationship of phase ϕ with angle θ

- magnitude of $\mathcal{E}$-field

$\mathcal{E}_P = \mathcal{E}_1 + \mathcal{E}_2 = \mathcal{E}_0 [\sin\omega t + \sin(\omega t + \phi)]$



$= 2\mathcal{E}_0 \cos\left(\frac{\phi}{2}\right) \sin\left(\omega t + \frac{\phi}{2}\right)$

bright $\phi = 0, 2\pi, 4\pi \ldots$
dark $\phi = \pi, 3\pi, 5\pi \ldots$

Intensity

$I \propto \mathcal{E}_P^2$
↳ intensity of a wave

$I \propto 4\mathcal{E}_0^2 \cos^2\left(\frac{\phi}{2}\right) \sin^2\left(\omega t + \frac{\phi}{2}\right)$ — time averaged → $\frac{1}{2}$ (time avg.)

$\propto 2\mathcal{E}_0^2 \cos^2(\phi/2)$

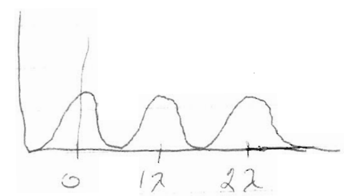
$\propto \cos^2(\phi/2)$

$= I_{max} \cos^2 \phi/2$

We know how ϕ with θ + distance between slits (i.e. exp. geom.)

$I = I_{max} \cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)$

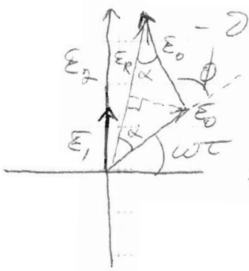
conditions
- $L \gg d$
- small θ



Phasors + Waves

→ Same initial example

$\varepsilon_1 = \varepsilon_0 \sin\omega t$; $\varepsilon_2 = \varepsilon_0 \sin(\omega t + \phi)$



– defined by two coords: ε_0 + ωt
[polar coords: (r, angle)]

$\alpha = \phi/2$

← $\cos\alpha = \dfrac{\varepsilon_R/2}{\varepsilon_0}$ by trigon.

$\varepsilon_R = 2\varepsilon_0 \cos\alpha = 2\varepsilon_0 \cos(\phi/2)$

→ phasor shows

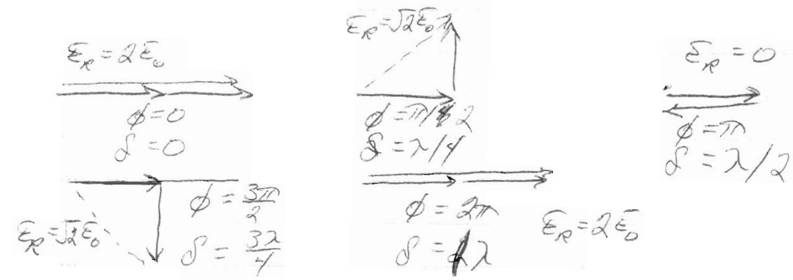
$\varepsilon_p = \varepsilon_R \sin(\omega t + \alpha) = \varepsilon_R \sin(\omega t + \phi/2)$

$= \boxed{2\varepsilon_0 \cos(\phi/2) \sin(\omega t + \phi/2)}$

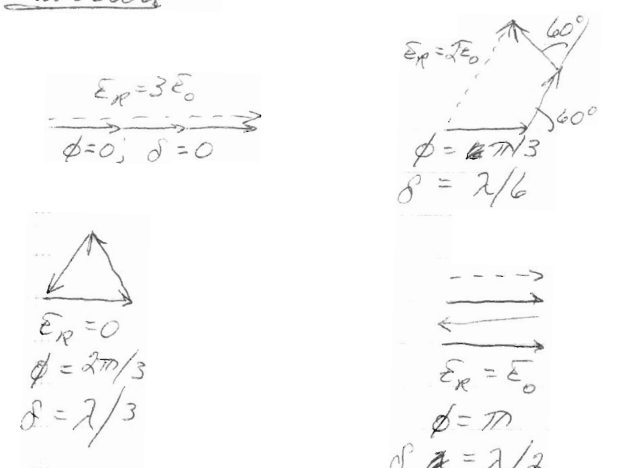
Phasors (cont.)

2 slits:

as move thru θ (as opposed to ωt)

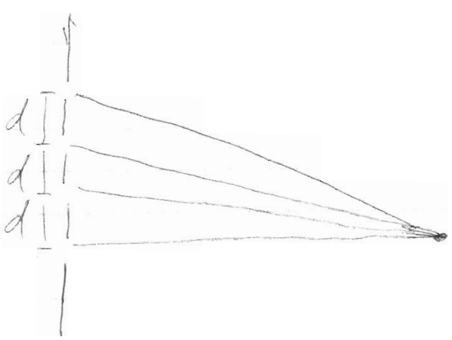


3 slits:



Prob. 27

4 slits



→ phasors to get minimum ϕ for which

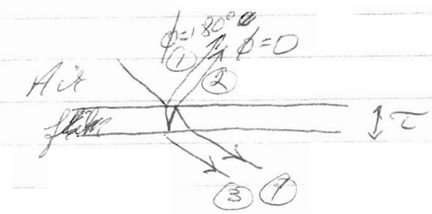
→ need $\wedge$ to point to first tail

∴ $N * \phi = 360$

↳ # phasors

$\phi = 360/N = \pi/2$

Thin Films



→ when go to higher n (index of refr.)

$\phi = 180$

→ wavelength changes when n changes

$\lambda_n = \lambda / n$

→ So ① + ② out of phase by π ($\lambda/2$) except

② also goes $2t$ further

→ constructive interference

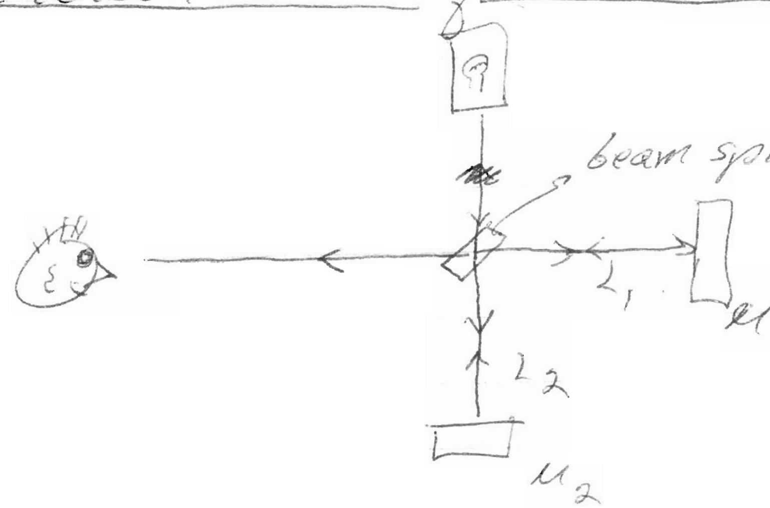
$2t = (m + \frac{1}{2})\lambda_n$

↳ due to ϕ change

$2nt = (m + \frac{1}{2})\lambda$

→ destructive → $2nt = m\lambda$

Michelson Interferometer



M_1 adjust to produce interference changes at observer

- if move M_1 by $\lambda/4$, path difference is $\lambda/2$ → change phase between L_1 + L_2
  - → see a dark center → bright, for instance
- if know d, get λ
  - λ, d
- use to measure speed of light