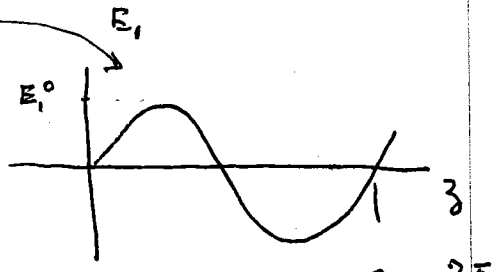
Physical Optics : Interference + Diffraction

Consider two waves (Travelling)

$$\vec{E}_1 = \vec{E}_1^{\,0} \sin(\omega t - kz)$$

$$\vec{E}_2 = \vec{E}_2^{\,0} \sin(\omega t - kz + \delta)$$



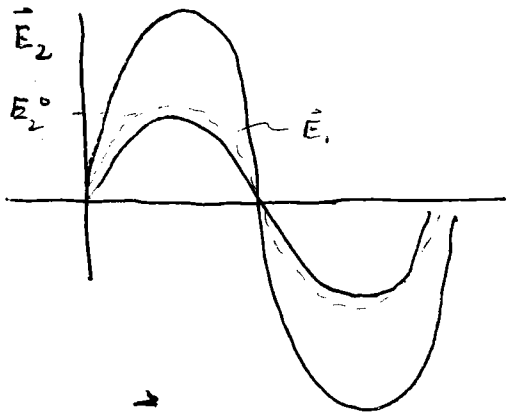
$\lambda = \frac{2\pi}{k}$

$k = 2\pi/\lambda$

at $t = 0$

argument is known as the phase

in phase let $\delta = 0$



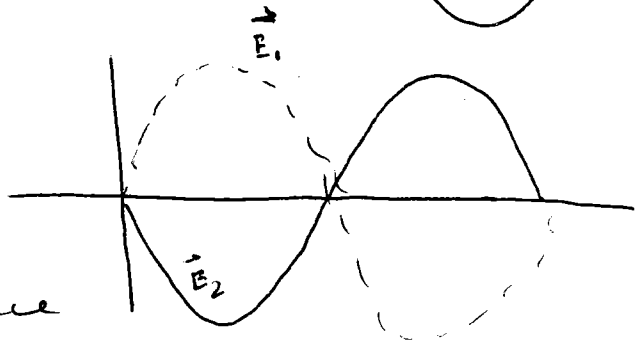
get Constructive Interference

wave superposition

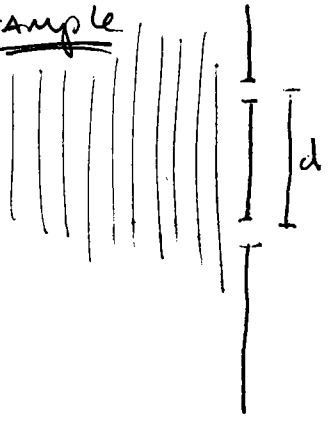
let $\delta = \pi$

cancel everywhere

destructive interference

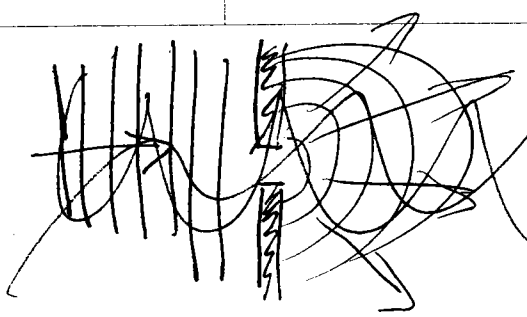


Example



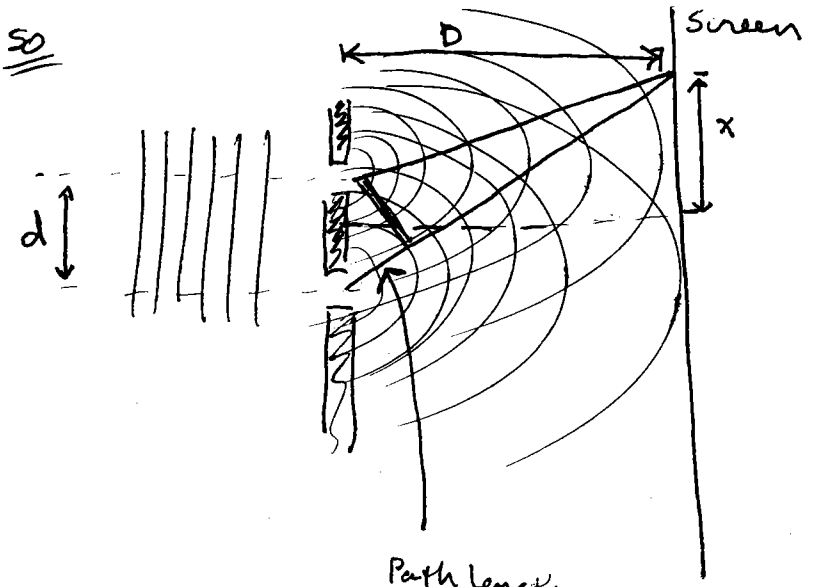
Suppose I have a plane wave incident on an opaque surface with 2 ~~slits~~ Thin slits a distance d apart.

What is the intensity pattern of the waves on a screen a distance D away



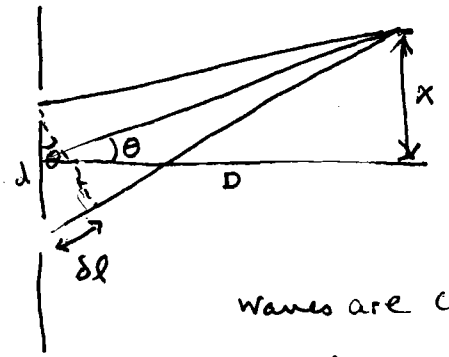
phenomenon is known as diffraction

So



Known as Young's Double Slit interference

Path length difference



$\frac{x}{D} = \sin\theta$

$\delta l = d \sin\theta$

waves are coherent ... have same phase at the start

δl = path length difference

A local intensity Maximum

Have Constructive interference (Bright fringe for light)

if $\delta l = m\lambda$ $m = 0, 1, 2 \ldots$

$d \sin\theta = m\lambda$

Destructive interference (No light intensity Dark fringe)

if

$$\delta l = \left(m + \tfrac{1}{2}\right)\lambda \quad m = 0, 1, 2 \ldots$$

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

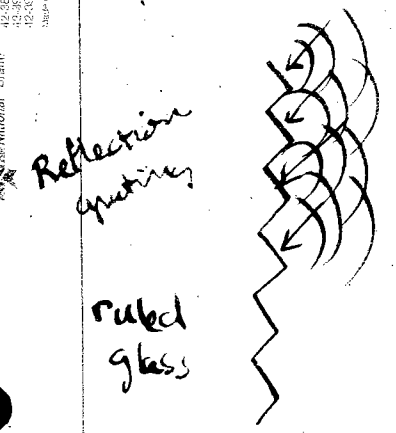
- Exams back Tuesday
- Solns posted on board
- I'll try to update library soon

April 1ST, 1999

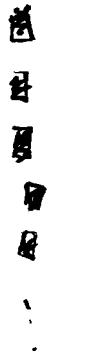
Finish Physical optics

Lens coating example

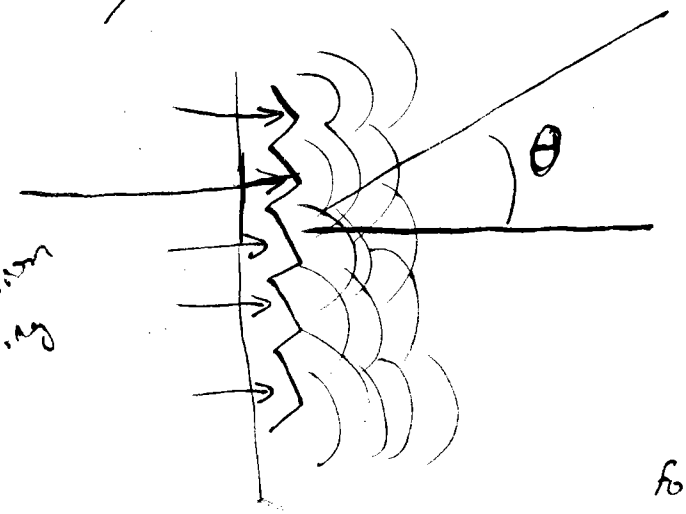
- Diffraction Grating



easier than



Making Many Slits



$d \sin\theta = m\lambda$

↑

order 0, 1, 2 ...

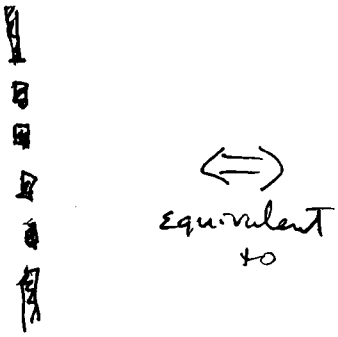
for fixed d, m

θ depends on λ

Allows one to do spectroscopy

get a different diffraction pattern w/ two "wide" slits
(sort of combines Youngs interference pattern w/ single slit diffraction pattern

can use many slits



$\Leftrightarrow$ equivalent to

Diffraction GRATING

easier to construct

(Surface of CD)

Id Intensity Maxima

$d \sin\theta = m\lambda$

usefulness: for fixed d, m θ depends on λ

$\Rightarrow$ Spectroscopy !!

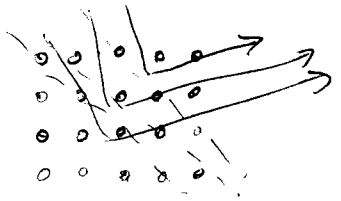
Better than a Prism !

X-ray diffraction

$\lambda \sim 10^{-10}$ m

Can't construct Mechanical grating

d, a etc must be $\sim O(\lambda)$



↑ crystal

X-ray crystallography use diffraction pattern to deduce structure of scattering crystal!