Physical Optics: Interference + Diffraction

Consider two waves (traveling)

\[ E_1 = E_0 \sin (\omega t - k z) \]

\[ E_2 = E_0 \sin (\omega t - k z + \varphi) \]

at \( t = 0 \)

arg. is known as the phase

in phase \( \varphi = 0 \)

\[ \frac{\lambda}{k} \]

\[ \frac{\lambda}{2\pi/k} \]

get constructive interference

wave superposition

\( \varphi = \pi \)

cancel everywhere

destructive interference

Example

Suppose I have a plane wave incident on an opaque surface with 2 thin slits a distance \( d \) apart. What is the intensity pattern of the waves an distance \( D \) away?
The phenomenon is known as diffraction.

\[ \text{Path length difference} \]

\[ \frac{X}{D} = \sin \theta \]

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

If \( SL = \text{path length difference} \),

- **Constructive interference** (Bright fringe for light)
  \[ SL = m \lambda \quad m = 0, 1, 2, \ldots \]

- **Destructive interference** (No light intensity)
  \[ SL = (m + \frac{1}{2}) \lambda \quad m = 0, 1, 2, \ldots \]

A local intensity maximum.

Known as Young's Double Slit interference.
April 1st, 1999

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

Finish Physical Optics

Lens Coating Example

- Diffraction Grating

Surface of Cd

I d

Ruled Glass

Transmission Grating

d \sin \theta = m \lambda

\text{Order } 0, 1, 2 \ldots

For fixed \ d, m

\theta \text{ depends on } \lambda

Allows one to do spectroscopy
get a different diffraction pattern w/ two "wide" slits
(sort of combines Young's interference pattern w/ a single slit diffraction pattern)

\[ d \sin \theta = n \lambda \]

\[ \frac{\lambda}{d} \rightarrow \text{equivalent to} \]

**Diffraction Grating**

easier to construct

(Surface of CD)

usefulness:

for fixed \( d, m \) \( \theta \) depends on \( \lambda \)

\[ \Rightarrow \text{Spectroscopy} !!! \]

Better than a Prism /\

**X-ray diffraction**

\( \lambda \approx 10^{-10} \text{m} \)

Can't construct mechanical grating

\( d, a, \text{etc.} \text{ must be} \approx \lambda \)

\[ \text{X-ray crystallography} \]

use diffraction pattern to deduce structures of scattering crystal