Physical Sciences 3

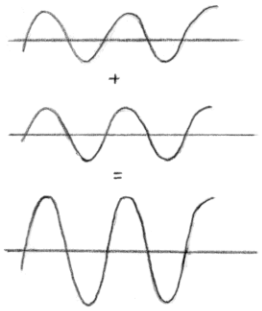
Lectures 18 and 19 – April 16, 2008 – Interference, Diffraction, and Resolution

Reading for Understanding: Chapter 16 s6, Chapter 34 s1,2, Chapter 35 s1

INTERFERENCE

When two waves simultaneously pass through the same region of space, they interfere with each other.

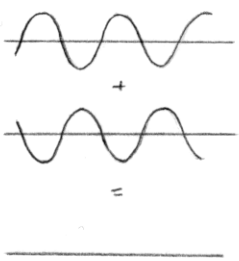
constructive interference



Overall amplitude increases; in phase waves; troughs interact with troughs. crests interact with crests.

(called antinodal lines)

destructive interference



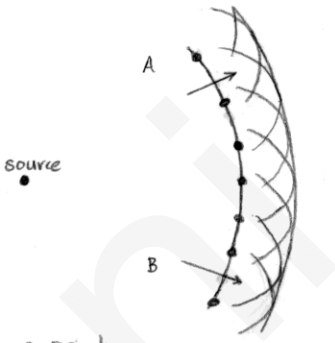
Overall amplitude decreases; out of phase waves (ϕ); crests interact with troughs.

(called nodal lines)

wave hits obstacle --->

HUYGEN'S PRINCIPLE

Every point on a wave front can be considered as a source of tiny wavelets that spread out in the forward direction at the speed of the wave itself.

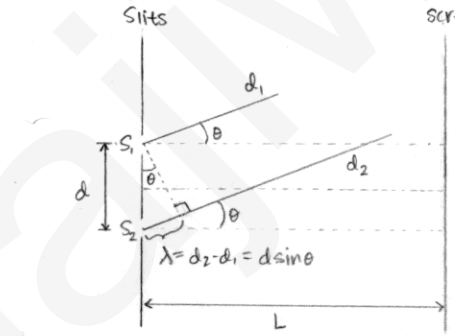


SO! a slit in a wall will act like a point source for new waves that move beyond the slit, driven by waves on the other side.

The bending of waves around obstacles = DIFFRACTION

(rings represent peaks, spaces represent troughs)

TWO-SLIT DIFFRACTION



- Constructive interference:

  $d\sin\theta = m\lambda \quad m = 0, 1, 2, 3 \ldots$

- destructive interference:

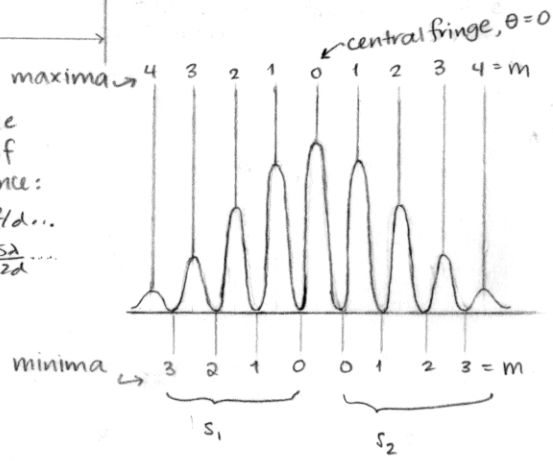
  $d\sin\theta = (m + \frac{1}{2})\lambda \quad m = 0, 1, 2, 3 \ldots$

$\sin\theta = \theta$

* using the small angle approximation, the θ of the lines of interference:

$\theta = \frac{m\lambda}{d}$ max: $0, \lambda/d, 2\lambda/d \ldots$ min: $\frac{\lambda}{2d}, \frac{3\lambda}{2d}, \frac{5\lambda}{2d} \ldots$

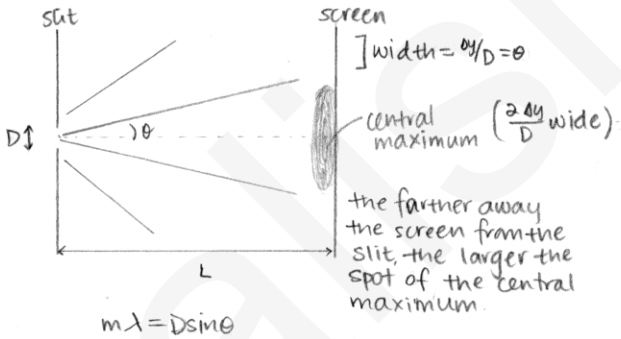
* maxima and minima are $(m)\frac{L\lambda}{d}$ apart $= \theta$



where "m" is the order of the interference fringe.

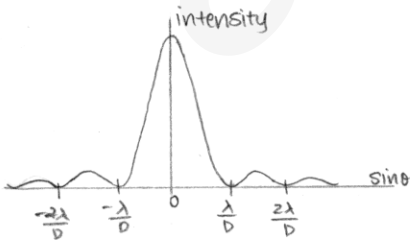
the first order is the first fringe on each side of the central fringe which is at $\theta = 0$, $m = 0$

SINGLE-SLIT DIFFRACTION



$m\lambda = D\sin\theta$ → for minima

$m = 1, 2, 3 \ldots$



- The smaller the λ, the smaller the diffraction spot
- The smaller D is, the bigger the diffraction spot
- Diffraction pattern will merge when $\theta_{object} < \lambda/D$
- Diffraction pattern will be distinct when $\theta_{object} > \lambda/D$

Rayleigh Criterion:

→ Objects have to be separated by distances greater than the radius of the central max in order to be resolved as 2 separate peaks