March 18, 2011   Physics 122

■ **Theme Music:**
  Kermit the Frog
    Rainbow Connection
■ **Cartoon:**
  Pat Brady
    Rose is Rose

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Outline

■ Interference and Diffraction
  – Recap
  – Limits of resolution
  – Play with simulations
  – Go over HW problems

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Superposition from two sources

■ If we are at a particular point in space and two traveling waves, $y = A\sin(kx - \omega t)$, reach us coming from different starting points, we are at different "x" values for the two waves.
■ The result looks like the sum of two waves with different phases:

$y = A\sin(kx_1 - \omega t) + A\sin(kx_2 - \omega t)$
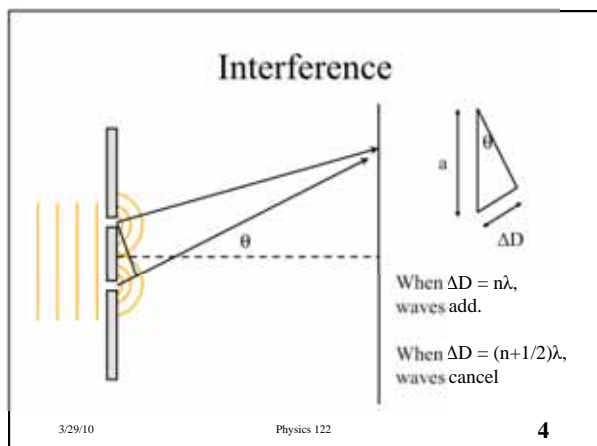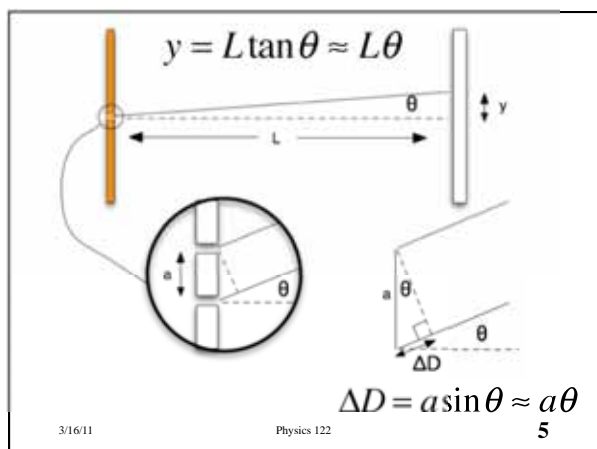$y = A\sin(\phi_1 - \omega t) + A\sin(\phi_2 - \omega t)$

x_1 x_2
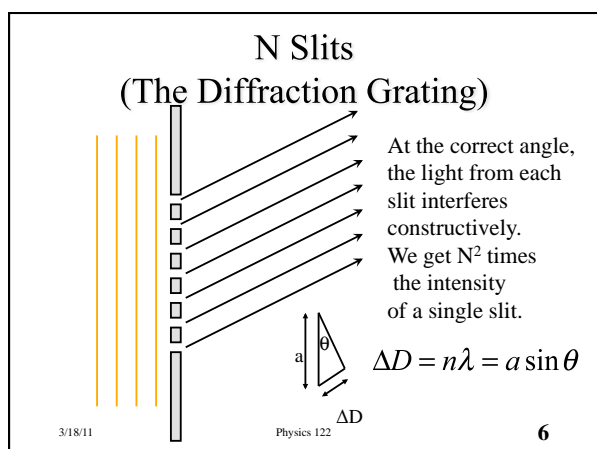
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Interference

When $\Delta D = n\lambda$, waves add.

When $\Delta D = (n+1/2)\lambda$, waves cancel

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$$y = L\tan\theta \approx L\theta$$

$$\Delta D = a\sin\theta \approx a\theta$$

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N Slits
(The Diffraction Grating)

At the correct angle, the light from each slit interferes constructively. We get N^2 times the intensity of a single slit.

$$\Delta D = n\lambda = a\sin\theta$$
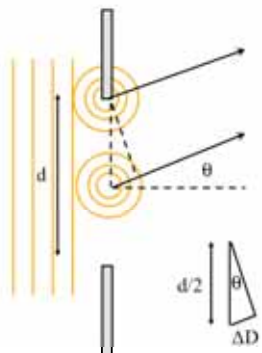
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Diffraction

- Every bit of the interior of the slit acts as a source of outgoing spherical Huygens' wavelets.
- The outgoing wavelets from one part of the slit can interferer with the wavelets from another part of the slit.

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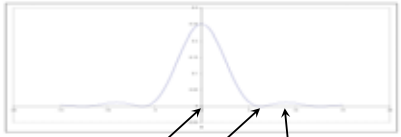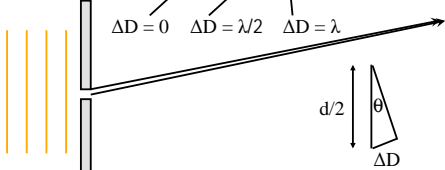
Slide 8

When the distance traveled by the wavelet from the middle of the slit is half a wavelength greater than the distance traveled by the wavelet from the top of the slit every wavelet from the top half of the slit has a canceling wavelet from the bottom half of the slit.

The result is no intensity at that angle.

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$\Delta D = 0$ $\Delta D = \lambda/2$ $\Delta D = \lambda$

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Diffraction Limitation of Resolving Power

■ Because diffraction "spreads out" he image of a point source created by any aperture, a magnifying lens is limited in its ability to magnify an object by the wavelength of light.

■ This restricts both how small an object we can see with our eyes and how small an object we can see with a microscope.
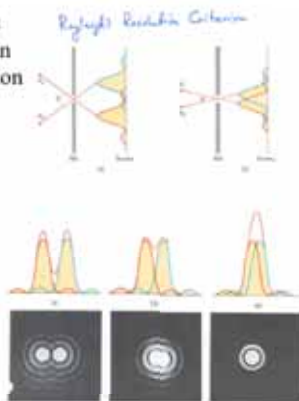
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When the angular separation between points is greater than the angle to the first diffraction minimum, the points can be separated.

This is called the Rayleigh resolution criterion.

The minimum of a diffraction pattern occurs at an angle

$$\sin\theta_R = 1.22\frac{\lambda}{d}$$

Rayleigh Resolution Criterion

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?

The separation of the dots is about 0.25 cm.
The diameter of the pupil of the eye is ~0.25 cm.
How far do you have to stand for the dots to blend?

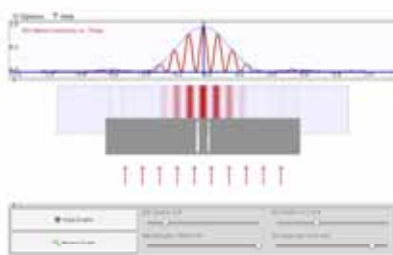3/18/11   Physics 122   **12**

Wavelength = 522.5 nm   Slit Width = 7364.1856 nm

Single Slit Diffraction

http://www.folksemantic.com/visits/71765

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■ http://projects.cbe.ab.ca/sss/science/physics/
map_north/applets/grating/grating.html

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