March 16, 2011 Physics 122 Prof. E. F. Redish

- **Theme Music:** Gordon McRae
  The Surrey with the Fringe
- **Cartoon:** Brooke McEldowney
  9 Chickweed Lane

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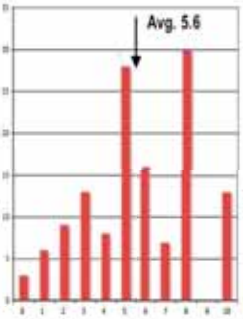
Quiz 5

	5.1	5.2	5.3	5.4
a	2%	16%	31%	43%
b	73%	11%	6%	8%
c	19%	66%	14%	4%
d	5%	2%	6%	17%
e	0%	6%	42%	29%



http://www.physics.uoguelph.ca/applets/Intro_physics/kisalev/java/clens/index.html

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Foothold wave ideas: Huygens' Principle

- The critical structure for waves are the lines or surfaces of equal amplitude: wavefronts.
- Each point on the surface of a wavefront acts as a point source for outgoing spherical waves (wavelets).
- The sum of the wavelets produces a new wavefront.
- The waves are slower in a denser medium.

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- Huygens' principle satisfactorily explains both the reflection and refraction principles (just as Newton's particle model does).
- But today we'll look at two situations a Particle Model cannot explain.

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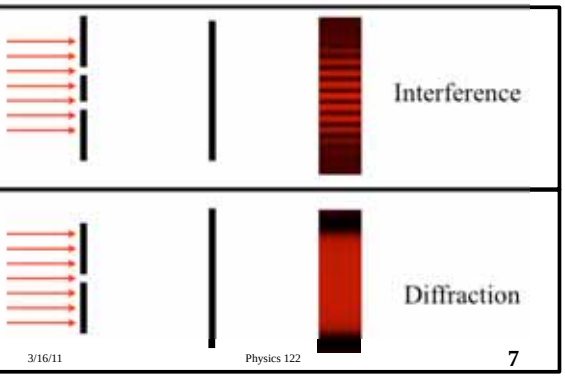
Two Non-Particle Situations



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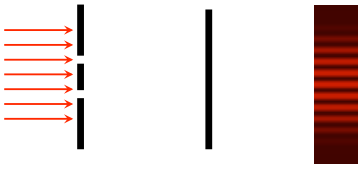
Very Roughly, Why Does the Light Spread Out?



Use Huygens' Model

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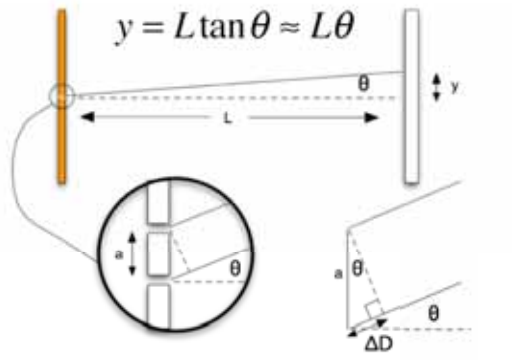
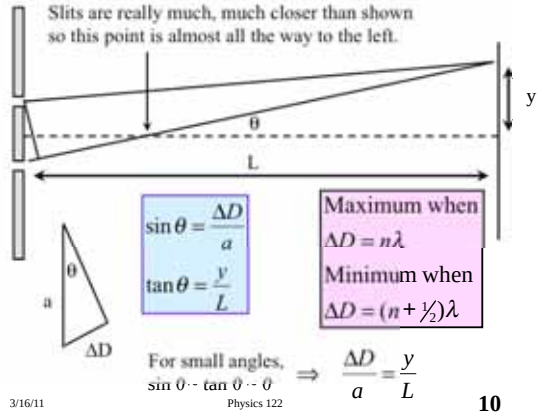
$$y = L\tan\theta \approx L\theta$$



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

Slits are really much, much closer than shown so this point is almost all the way to the left.



$$\sin\theta = \frac{\Delta D}{a}$$

$$\tan\theta = \frac{y}{L}$$

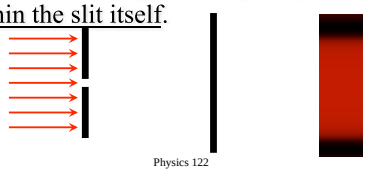
Maximum when $\Delta D = n\lambda$

Minimum when $\Delta D = (n + \tfrac{1}{2})\lambda$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ $\Rightarrow$ $\frac{\Delta D}{a} = \frac{y}{L}$

Diffraction

- What about from a single slit? We can see that the light spreads out, but not uniformly.
- To understand what happens from a single slit, we need to apply Huygens' principle within the slit itself.



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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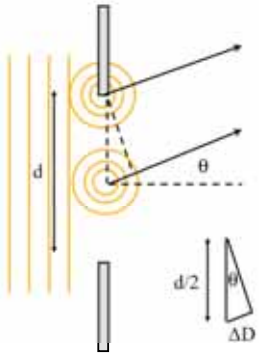

When the distance traveled by the wavelet from the middle of the slit is half a wavelength greater than the distance traveled by the wavelet from the top of the slit every wavelet from the top half of the slit has a canceling wavelet from the bottom half of the slit.

The result is no intensity at that angle.

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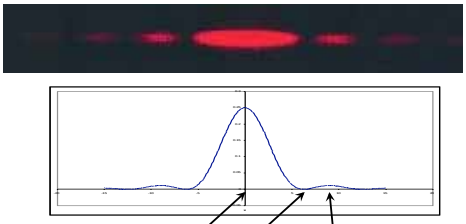

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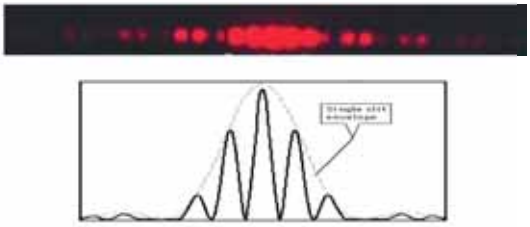
Combining interference and diffraction: 2 slits

- Even when we have two slits we have to consider both kinds of interference
  - from one slit to the other
  - within each slit.
- Both patterns are present.
- Since the width of the slit must be less than the separation between them (d < a or else the two slits would overlap) the diffraction pattern is wider than the interference pattern.



$$\frac{d}{2}\sin\theta_1^{DMin} = \frac{\lambda}{2} \qquad a\sin\theta_1^{DMin} = \frac{\lambda}{2}$$

$$\theta_1^{DMin} = \frac{\lambda}{d} \qquad \theta_1^{DMin} = \frac{\lambda}{2a}$$

Implications for sound

- Sound is a wave phenomenon like light. As a result, it can show interference effects.
- All the math is the same – only the speed is different – by a factor of one million!
  $c \sim 3.0 \times 10^8$ m/s
  $v_S \sim 3.4 \times 10^2$ m/s