Lecture 26

Thurs: Seminar

Fri: HW by 5pm

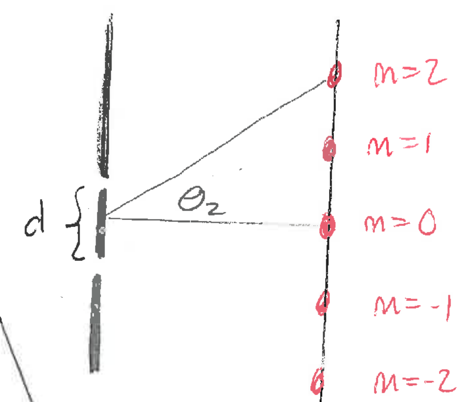
Supp Ex 89, 90, 91, 92, 93

Ch 17 Prob 8, 11, 19

Double slit interference.

We applied notions of waves to predict where the bright fringes in a double-slit interference pattern will be located.

We can label the bright fringes as illustrated.



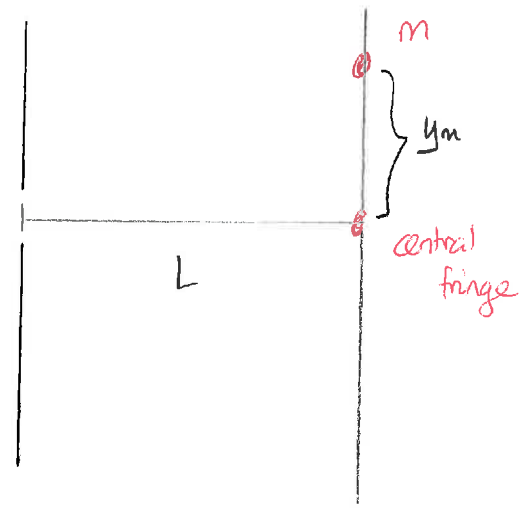
Then

> The angle θ_m at which the fringe labeled m appears satisfies
>
> $$d \sin\theta_m = m\lambda$$
>
> where d is the separation between the slits and λ is the wavelength of the light.

Quiz 1 60% → 70%

In some situations we want the location along the screen in terms of a position rather than angle measurement.

If the distance from the slits to the screen is L then the distance from the central fringe to the fringe labeled m is approximately



$$y_m = m\frac{\lambda L}{d}$$

This is true if $L \gg y_m$.

Example: Light from a HeNe laser has wavelength 632.8nm and is incident on a pair of slits with separation is 40μm. The pattern is produced on a screen 1.25m from the laser.

Determine:

a) location of m=1,2,3 fringes

b) separation between fringes

Answer: a) Use $y_m = m\frac{\lambda L}{d} = m\frac{632.8\times10^{-9}m \times 1.25m}{40\times10^{-6}m}$

$\Rightarrow y_m = m \times 0.0198m$

So $y_1 = 0.0198m$

$y_2 = 2\times0.0198m = 0.0396m$

$y_3 = 3\times0.0198m = 0.0593m$

b) $\Delta y = y_{m+1} - y_m = (m+1)\frac{\lambda L}{d} - m\frac{\lambda L}{d} = m\frac{\lambda L}{d} + \frac{\lambda L}{d} - m\frac{\lambda L}{d}$

$\Rightarrow \Delta y = \frac{\lambda L}{d} = 0.0198m$

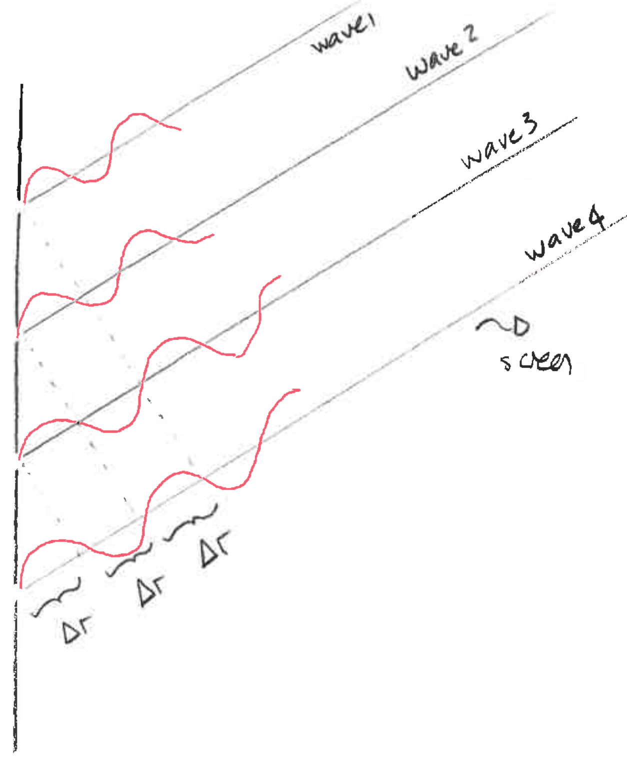
Quiz 2

Demo: U Hanover double slit images

Interference from multiple slits

We can allow light to pass through more than two slits. Consider light passing through four slits

There will now be four overlapping waves. Then



Δr = extra distance traveled by 4 vs 3

= " " " " 3 vs 2

= " " " " 2 vs 1

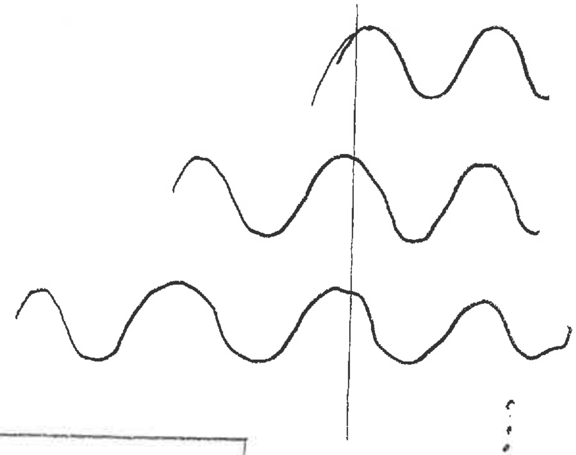
This will eventually determine when we get constructive or destructive interference.

Note:

	relative shift
Wave 1 vs 2	Δr
" 1 vs 3	$2\Delta r$
" 1 vs 4	$3\Delta r$
" 2 vs 3	Δr
" 2 vs 4	$2\Delta r$
" 3 vs 4	Δr

~~Quiz 2~~ Quiz 3

Then if $\Delta r = \lambda$ we will find that the crests of all waves line up. This will give constructive interference. So again when $\Delta r = m\lambda$ we get constructive interference. Thus



> For any number of slits there will be bright fringes when
>
> $$d \sin \theta_m = m\lambda$$
>
> where d is the spacing between adjacent slits.

Now consider other angles.

Quiz 4

We again get dark fringes when $\Delta r = \lambda/2, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \ldots$ These are the same locations as for the double slit. But there are more

Quiz 5

We now find dark fringes when $\Delta r = \lambda/4, \frac{3\lambda}{4}, \frac{5\lambda}{4}, \ldots$ as well. Dark fringes did not appear in such locations for a double slit.

So with more slits

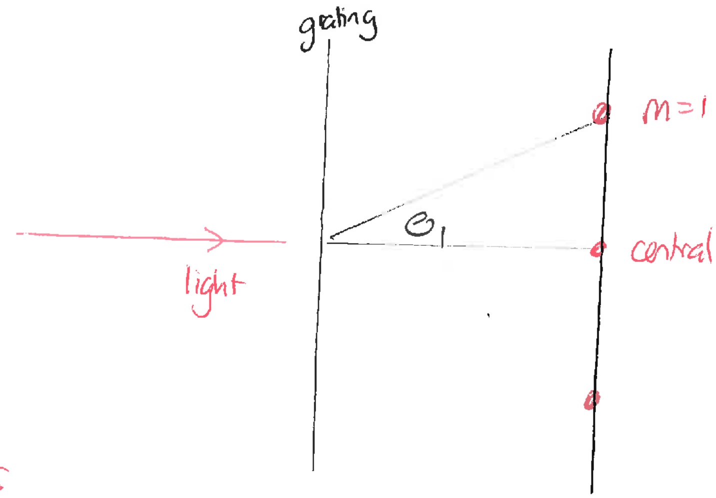
- bright fringe location is same
- there are more dark fringes.

Slide: multiple slit patterns

Demo: U Hanover pictures

A diffraction grating is a multiple slit arrangement with 100's or 1000's of evenly spaced slits. The resulting pattern is mostly dark except for a few precisely located bright fringes. Again one can locate these using waves. Bright fringes are located at angles θ_m such that

$$d \sin \theta_m = m\lambda$$



Demo Pass around diff gratings

Quiz 6