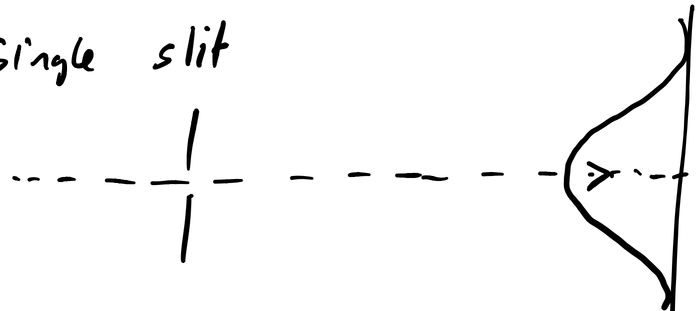
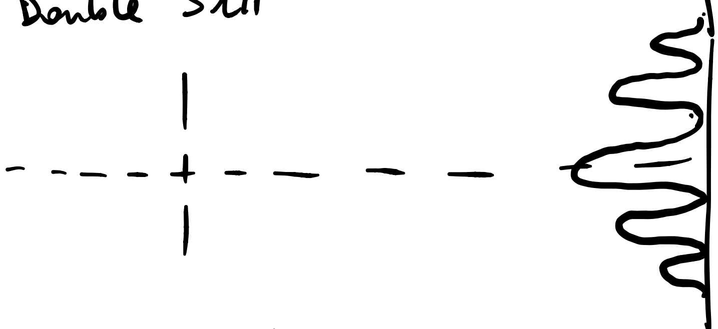
Multiple Slit Interference.

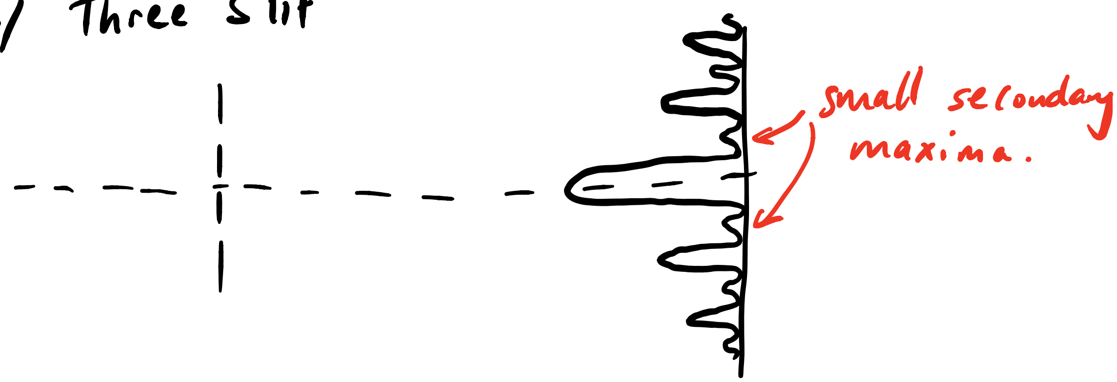
1/ Single slit



2/ Double Slit



3/ Three slit

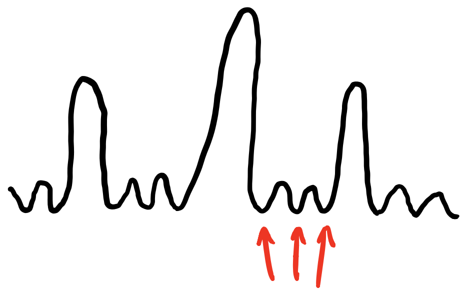


Trends

1/ All multiple slit inteference effects fall within the envelope of the single slit.

2/ Small secondary maxima begin to appear for slit number greater than 2.

3/ the number of minimas between primary maxima = (Number of slits − 1) eg: 4 slits would look like this.



3 minimas between 2 maximas

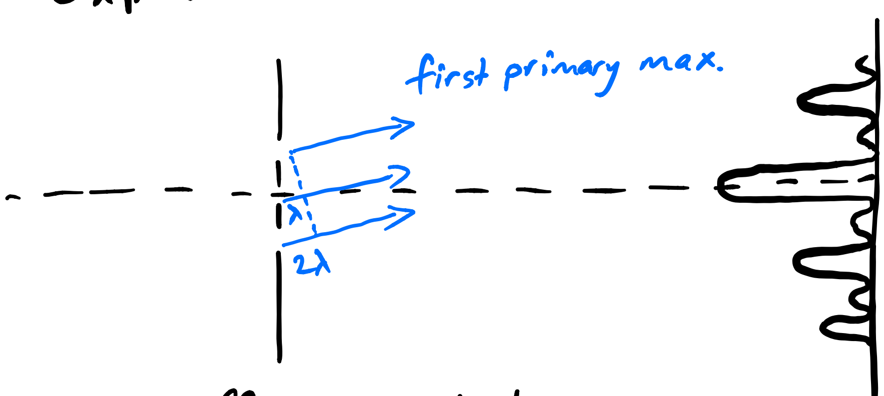
4/ the location of primary maxima is still dependant on $\sin\theta = \frac{m\lambda}{d}$

$m = 1, 2, 3 \ldots$

integer multiples of path difference λ

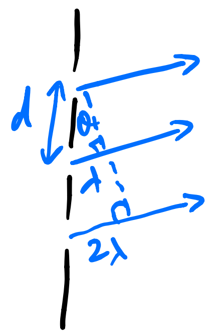
5/ the more slits the more intensity for primary maxima + the narrower are the primary maxima.

Explanation: Consider 3 slit.



Path difference between adjacent slits is λ

Therefore, just like the double slit.

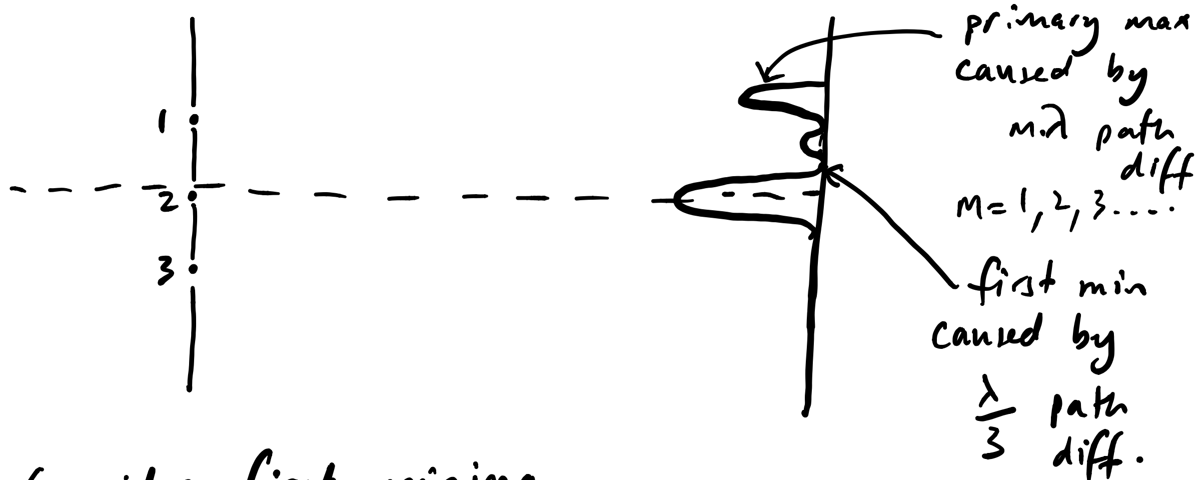


$$\sin\theta^{\circ} = \frac{\lambda}{d}$$

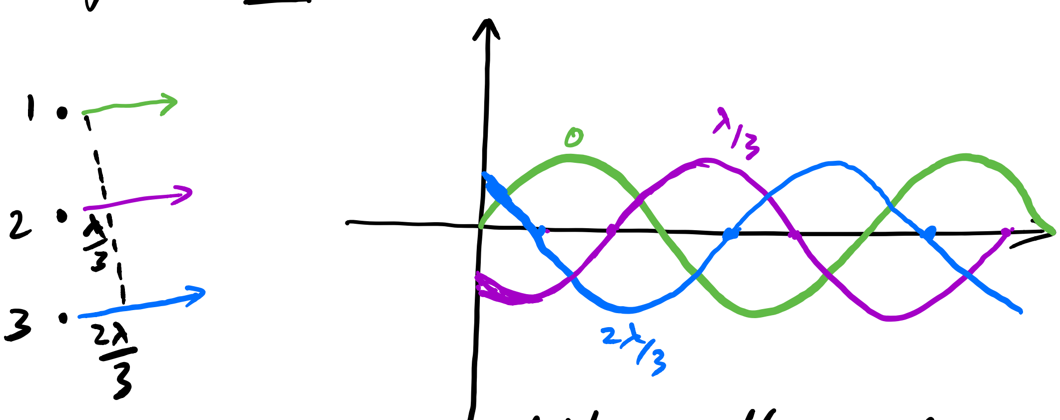
d = slit separation.

Note: every other slit has an integer multiple λ of path difference + therefore will constructively interfere.

Cause of minima and secondary maxima.



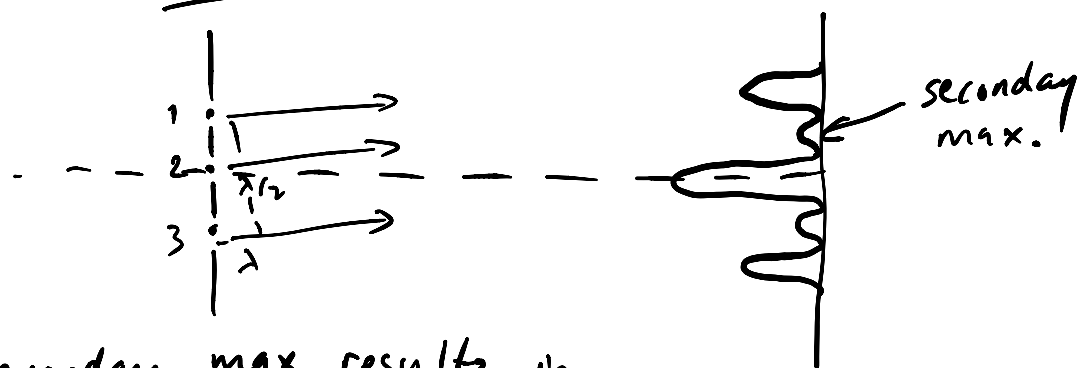
Consider first <u>min</u>ima



Adding all waves would cancel.

The same would occur if source 2 were shifted $2\lambda/3$ + source 3 shifted $4\lambda/3$

First secondary maximum.



secondary max results in a path difference between 1 and 2 $= \lambda/2$. Notice 1, 2 would cancel
2, 3 would cancel
1, 3 would add as path diff $= \lambda$.

Note: The width of the primary maximum depends on the position of the first minimum, which depends on the number of slits.

Try this problem.

1) light of wavelength 500nm is incident on a multiple slit. The width of the beam of light is 1mm and the slit density or line grating is 100 slits or lines / mm.

The observing screen is 2 metres away. What is the width of a primary maxima.

1) find the path difference to the first minimum. Number of slits

$= 1\cancel{mm} \times 100 \text{ slits}/\cancel{mm}$

$= 100$ slits

$\therefore$ path difference to first min $= \frac{1}{100}\lambda$

$$\sin\theta = \frac{\lambda/100}{d} = \tan\theta = y/x$$

d = spacing between slits = 100 slits /mm

= 100 000 slits /m

$\therefore$ m/slit $= \frac{1}{100\,000}$ m

$$\frac{5\cancel{00}\times10^{-9}/1\cancel{00}}{\frac{1}{100\,000}} = y/2$$

$y = 2 \times 5\times10^{-4}$

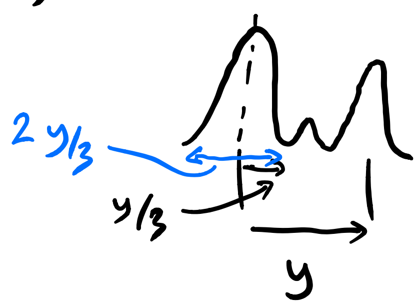
$y = 1\times10^{-3}$

$2y = \underline{\underline{2\text{ mm}}}$

OR

Find the distance separating primary maxima 'y'. Then divide this distance by the number of slits. Then multiply by 2.

eg: 3 Slit would be.



For the problem

$$y/x = \frac{\lambda}{d}$$

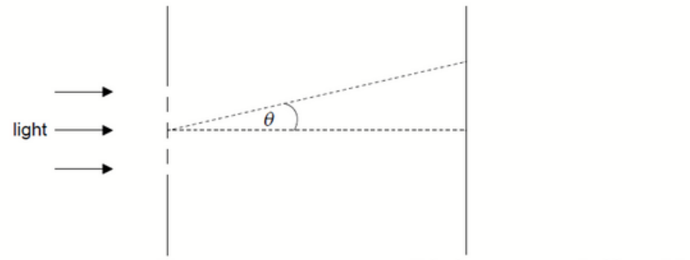
$$y = 2\left(\frac{500\times10^{-9}}{\frac{1}{100\,000}}\right)$$

$$= 1\times10^{-1}\,m$$

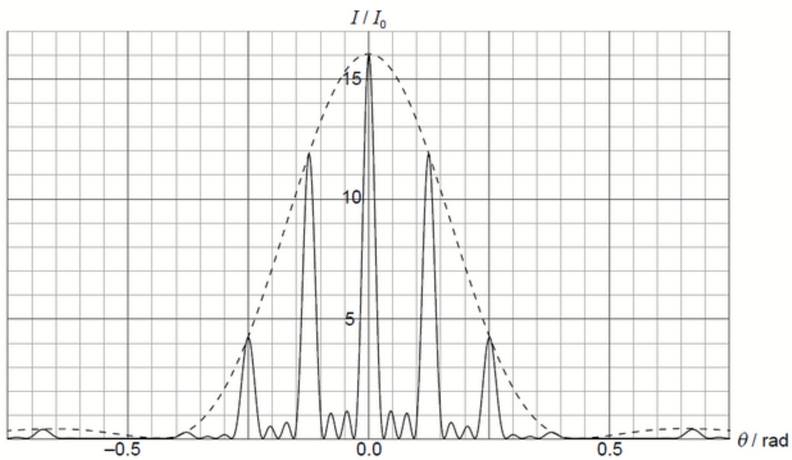
$$\therefore\ y/100 = 1\times10^{-3}\,m.$$

$$2(y/100) = \underline{\underline{2\,mm}}$$

Monochromatic light is incident normally on four thin, parallel, rectangular slits.



The graph shows the variation with diffraction angle θ of the intensity of light I at a distant screen.



I_0 is the intensity of the light at the middle of the screen from **one** slit.

(b) The width of each slit is 1.0 μm. Use the graph to

(i) estimate the wavelength of light. [2]

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(ii) determine the separation of **two** consecutive slits. [2]

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(c) The arrangement is modified so that the number of slits becomes very large. Their separation and width stay the same.

(i) State **two** changes to the graph on page 20 as a result of these modifications. [2]

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(ii) A diffraction grating is used to resolve two lines in the spectrum of sodium in the second order. The two lines have wavelengths 588.995 nm and 589.592 nm.

Determine the minimum number of slits in the grating that will enable the two lines to be resolved. [2]

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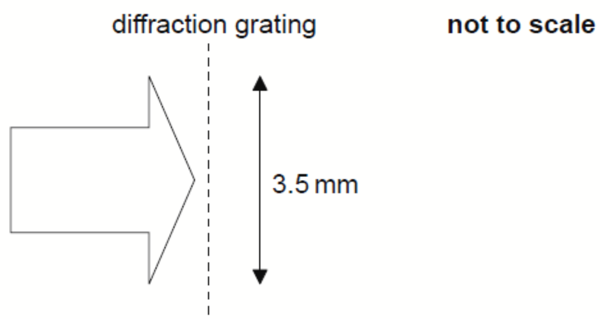
A low-pressure hydrogen discharge lamp contains a small amount of deuterium gas in addition to the hydrogen gas. The deuterium spectrum contains a red line with a wavelength very close to that of the hydrogen red line. The wavelengths for the principal lines in the visible spectra of deuterium and hydrogen are given in the table.

	Hydrogen wavelength / nm	**Deuterium wavelength / nm**
Red line	656.288	656.107
Violet line	410.180	410.048

Light from the discharge lamp is normally incident on a diffraction grating.



(i) The light illuminates a width of 3.5 mm of the grating. The deuterium and hydrogen red lines can just be resolved in the second-order spectrum of the diffraction grating. Show that the grating spacing of the diffraction grating is about 2×10^{-6} m. [2]

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(ii) Calculate the angle between the first-order line of the red light in the hydrogen spectrum and the second-order line of the violet light in the hydrogen spectrum. [3]

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(iii) The light source is changed so that white light is incident on the diffraction grating. Outline the appearance of the diffraction pattern formed with white light. [3]

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