AS and A-level Physics Core Practical:

2.. Investigation of the interference effects by Young's slit and diffraction by a diffraction grating

Common Practical Assessment Criteria (CPAC) to be assessed: 1,2b, 3a, 4a, 4b

You will carry out 2 diffraction experiments using light from lasers. You will be provided with equipment but will need to make some decisions about which measurements to take. You will be guided in handling the uncertainties in measurements for each method

The first experiment A requires you to use your knowledge of how diffraction gratings work.

The second experiment B requires you to use your knowledge of Young's Double Slit experiment

Tables are provided for you, and space to answer questions. There is also space for you to write notes as you work through the sheets. You should write down your readings to the resolution of the apparatus, and state what that resolution is.

You are to work alone, or in groups of no more than two. You can collect data together, but must record it separately, and all analysis is to be done individually.

CPAC		met?
1		
2	**a**	
	b	
	c	
	d	
3	**a**	
	b	
	c	
4	**a**	
	b	
5	**a**	
	b	

You will be using low power lasers. Note here safety precautions you must take:

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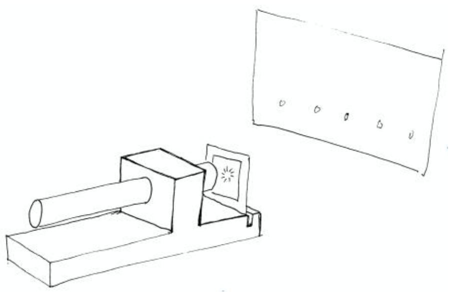
Turn the lasers on for a short time when you are taking measurements - keeping them on for long periods affects their performance.

<u>Experiment A – Determining the wavelength of light from a laser using a diffraction grating</u>



You are provided with a mounted laser, and three diffraction gratings with stated numbers of lines per mm.

In the space below, state the equation that relates the wavelength of the laser light (λ), the spacing of the lines on a diffraction grating (d), order of the maximum (n), and the angle of diffraction of the beam (θ)

nλ =

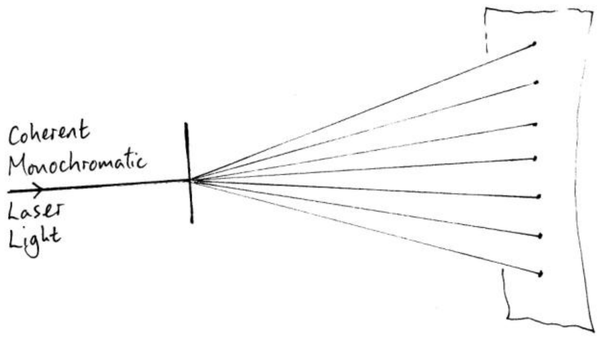
Your diffraction gratings will be marked in lines per millimetre. Convert this to lines per metre, then find the inverse to give the line spacing d in metres (show your working):

Line spacing for grating 1 = ………………………………………………………………………………………

Line spacing for grating 2 = ………………………………………………………………………………………

Line spacing for grating 3 = ……………………………………………………………………………………….

<u>Notes</u>

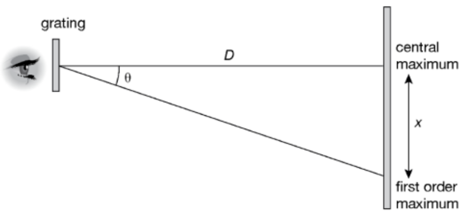


Set up the apparatus as shown in the diagram so that dots of light – maxima – are projected onto your screen. Move the laser mount away from the wall until the 3 maxima are spread by just under 300mm. Measure the distance the diffraction grating is away from the screen.

This is distance D for the calculations you will do later. (Do not confuse this with distance d, the slit spacing, which you will also use later.)

Shine the laser beam onto the diffraction grating - you should see an interference pattern.

Measure the distance between the first maxima on either side of the central maximum and divide this distance by 2 to calculate the distance between the central maximum and the first maximum. Record this measurement in the table provided (next page) as distance x.



Replace the diffraction grating with another with a different number of lines per millimetre, and repeat the above measurement. Record your results in the table provided and use your results to calculate θ for the first maximum.

Notes

Measurement of first maxima for diffraction gratings

No. of lines per mm of diffraction grating	d =Line spacing of diffraction grating / m	D = Distance of slide from screen /m uncertainty = ± m *calculate % uncertainty for each D*	x = distance between central maximum and 1st order maximum / m uncertainty = ± m *calculate % uncertainty for each x*	Angle θ for first maximum / degrees [calculate using $\theta = \tan^{-1}(x/D)$]	Wavelength of laser / m [use $\lambda = d\sin\vartheta$] *combine % uncertainties for each D and x to give % uncertainty for each λ*

Which of your measurements would you try to improve first if you wanted to reduce uncertainty?

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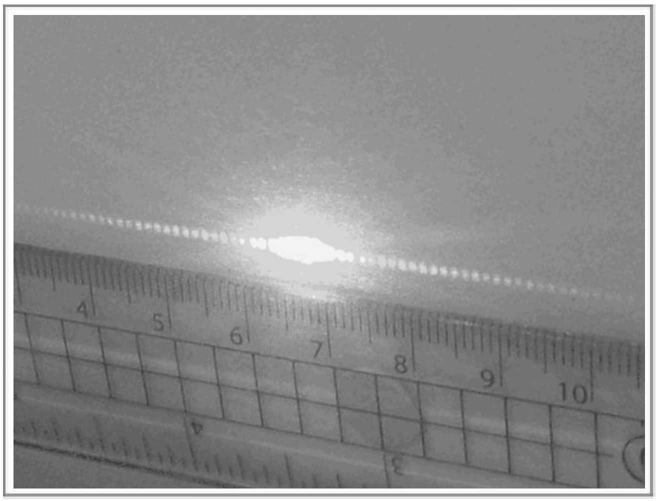
Experiment B – Determining the wavelength of laser light using a double slit

State the equation that relates the wavelength of the laser light (***λ***), the separation of the slits (***s***), the spacing of the bright fringes (***w***), and distance from the double slits to the screen (***D***):

$$\boldsymbol{\lambda} = \qquad .$$

Use the same apparatus set-up as in Experiment A, but replace the diffraction grating with a double slit which has a slit separation, ***s***, of 0.1 mm.

Move the laser and double slit closer to the screen until you can just make out the fringe pattern clearly. The screen-to-slit distance is ***D***.



Attach a 300mm ruler to the screen directly below where the fringe pattern is formed.

Shine the laser through the slits and take a photograph of the pattern against the ruler, as shown on the left

Use your photograph to measure the distance between ***n*** minima (at least 5, maybe a lot more) and divide by [***n***-1] to find the fringe separation, ***w***. Record your results in the table provided on the next page.

a. Why is it easier to measure between the minima than between the maxima?

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b. The fringe pattern is more difficult to measure than with a diffraction grating. Why is measuring the distance between lots of minima a good way of finding the fringe separation?

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Notes

- Increase the screen to slit distance.
- Measure ***D*** and ***w***
- Repeat until you have 6 sets of results over a range of distances.

A note on uncertainty of overall measurements of multiple repeats The uncertainty of the ruler (±1 mm) applies to the end points of the measurement – so if you measure 10 dot spacings as 120mm ±1mm, each one is 12 mm ± 0.1 mm. i.e. the same percentage uncertainty

Distance from double slits to screen ***D*** / m % uncertainty =	Fringe separation ***w*** /m *show your calculation for each value* % uncertainty =

c. Plot a graph of distance from wall (***D***) on the x-axis and fringe separation (***w***) on the y-axis

d. Show that the gradient of your graph is equal to ***λ/s***

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e. From the graph, what is the wavelength of the light from your laser?

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Notes

f. What is the uncertainty in the value of the wavelength you've calculated?

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g. What is the wavelength of your laser according to the manufacturer?

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h. Describe how your values for both methods A and B compare to each other and the actual value. Comment on your answer considering sources of uncertainty.

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