

Waves that add: fringes and grating spectra

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

How can you measure the wavelength of light without a spectrometer? Use a diffraction grating of known spacing and a laser pointer, measure the positions of several orders on a wall and combine them to find λ .

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB C.3

Aim

To measure the wavelength of a laser pointer using a diffraction grating of known line spacing.

Equipment

- Low-power laser pointer (class 2 or lower)
- Diffraction grating, 300 lines per mm, in a holder
- Metre rule and a plain white wall or screen
- Clamp stand and a spirit level

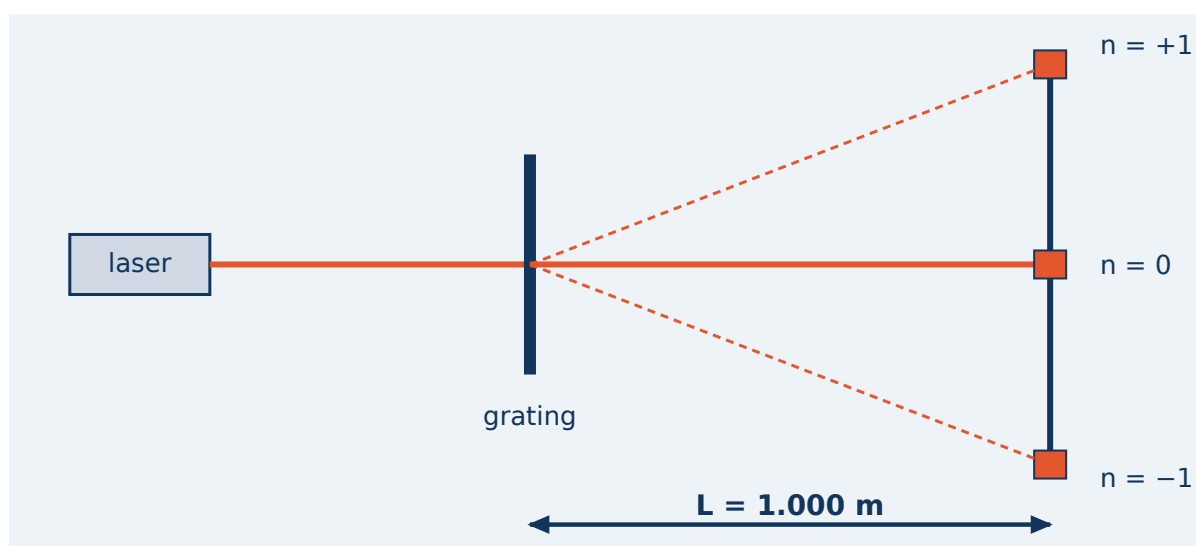
Safety

Safety

Never shine the laser at anyone's eyes or at shiny surfaces. Switch it off when not taking readings, remove jewellery from the beam path and keep other students out of the line of the beam.

Method

1. Clamp the grating at right angles to the beam, 1.000 m from the wall.
2. Switch on the laser and mark the central spot ($n = 0$).
3. Mark the first-, second- and third-order spots on each side of the centre.
4. Measure the distance x from the centre to each marked spot, and average the left and right values for each order.
5. Record the distance L from grating to wall.
6. Calculate $\theta = \tan^{-1}(x \div L)$ and $\lambda = d \sin \theta \div n$ for every order.



Set-up for measuring laser wavelength. L is the grating-to-wall distance.

Results

Sample measurements, averaged left and right, for $L = 1.000 \text{ m}$ and 300 lines per mm:

Order n	x / m	$\theta / ^\circ$	$\sin \theta$
1	0.200	11.31	0.1961
2	0.423	22.93	0.3896
3	0.723	35.87	0.5859

Analysis questions

Question 1 Slit spacing

Calculate d for a grating of 300 lines per mm in metres.

Question 2 Angle of the first order

Use the table to calculate θ for $n = 1$, and check the $\sin \theta$ column.

Question 3 Wavelength from each order

Calculate λ from each order and find the mean.

Question 4 Graph of $\sin \theta$ against n

Plot $\sin \theta$ against n and find the gradient. State how the gradient relates to λ .

Question 5 Uncertainty in x

The uncertainty in each distance x is $\pm 2 \text{ mm}$. Find the percentage uncertainty in x for $n = 1$

and say which order gives the best precision.

Question 6 Small-angle approximation

A student uses $\sin \theta \approx x/L$ for the third order. Calculate the error this causes in λ .

Question 7 Comparison

The laser label states 650 nm. Compare your mean with this value and suggest a reason for any difference.

Question 8 Improving the experiment

Suggest two improvements.