

PHY152H1S – Practical 10: Wavelength of Laser Light

Don't forget:

- List the NAMES of all participants on the first page of each day's write-up. Note if any participants arrived late or left early.
- Put the DATE (including year!) at the top of every page in your notebook.
- NUMBER the pages in your notebook, in case you need to refer back to previous work.

Today's Textbook Reference to review before lab:

"Principles & Practice of Physics" by Eric Mazur

Chapter 34 Wave and Particle Optics, Section 34.2 "Diffraction gratings" and Section 34.6 "Multiple-slit interference", in particular White-volume page 925, equation 34.16 on principal maxima.

Introduction

In 1801 Thomas Young was able to make a measurement of the wavelength of light using a two-slit experiment. Today you will try to reproduce this experiment using laser-light, which is monochromatic.

Theory

In two-slit interference, light falls on an opaque screen with two closely spaced, narrow slits. As Huygen's wavelet principle tells us, each slit acts as a new source of light. Since the slits are illuminated by the same wave front, these sources are in phase. Where the wave fronts from the two sources overlap, an interference pattern is formed. As shown in Figure 1, d is the centre-to-centre slit spacing, L is the distance between the slits and the viewing screen, and Δy is the distance between adjacent bright fringes seen on the viewing screen.

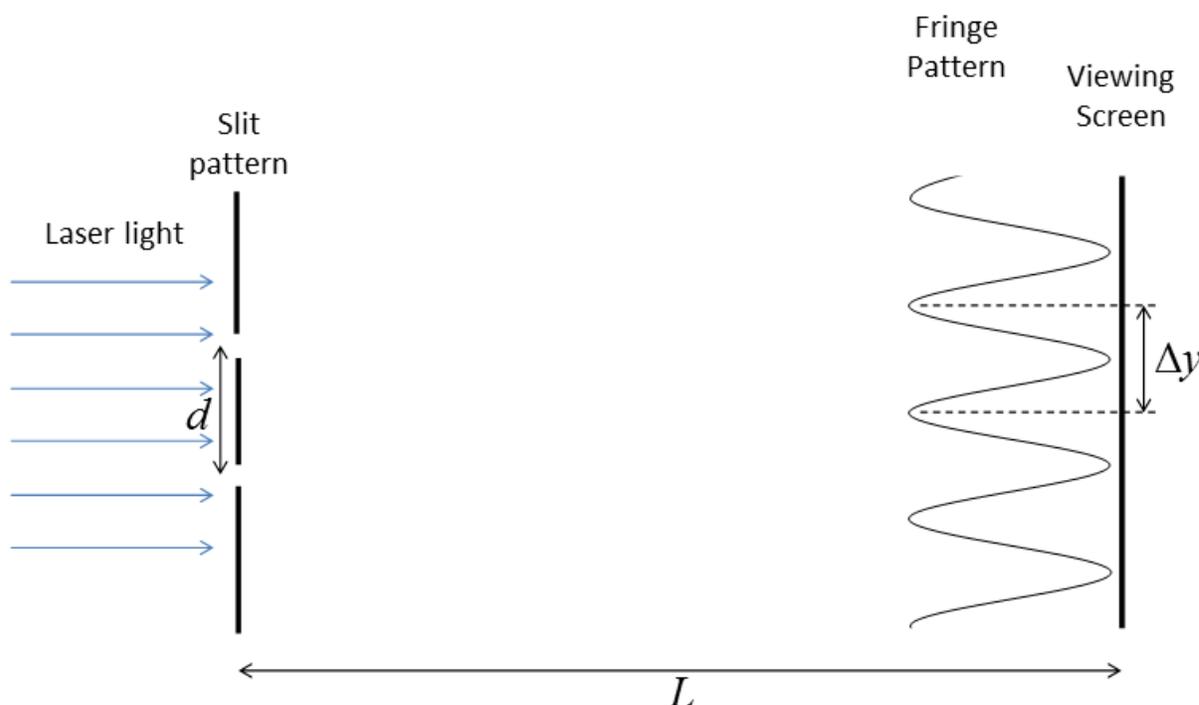


Figure 1. Schematic for a Young's double-slit experiment.

The angular positions θ_m of the bright fringes are given by Equation 34.16 in your text, where m is any integer. For this experiment you can use the small angle approximation:

$$\sin \theta_m \approx \theta_m \quad [1]$$

So, employing this approximation, $d \theta_m = m\lambda$. Also $\theta_{m+1} - \theta_m = \Delta y/L$, where Δy is the spacing between adjacent bright fringes on a screen a distance L away from the slits. Combining these equations and solving for λ we get:

$$\lambda = \frac{d}{L} \Delta y \quad [2]$$

Please show the derivation of eq.2 in your notebook to check it.

Equipment

You have a 2.2 m aluminium track to be used as an optical bench, a viewing screen mounted vertically, and a PASCO Basic Optics OS-8453 “Multiple Slits” set of diffraction slits. This is a wheel with a reflective, opaque sheet of aluminium with transparent holes scratched in it of well-known width and spacing. In addition, you have a red and blue laser, which can be mounted so they can shine parallel to the track, through the slits, eventually illuminating the viewing screen.

Experiment

Use the red laser and one of the double-slit patterns to form fringe patterns on the viewing screen. Count the number of fringes in some measured distance to obtain a measurement of Δy and its uncertainty. Measure L and its uncertainty, and use d in mm as printed on the PASCO slit-wheel. You may assume the uncertainty in d is very small. Compute the wavelength of laser-light and its uncertainty. (Don't forget to propagate your uncertainties!) Repeat for at least one other double-slit pattern, and repeat both patterns with the blue laser.

For each measurement, comment on the result and the uncertainty: is the result what you expected? Does your measurement differ significantly from the expected result? If so, why? In your experiment, what was the worst percentage error introduced by using eq.1 (small angle approximation) and how does that compare to the typical percentage error of your result? Is it justified to use this approximation?

If you have time: measure the wavelength of a green laser. There are a few green-lasers available, which you can borrow from your TA.

About the notebook

Everything important that you and your partners do in the lab should be recorded in your lab notebook while you are doing the experiment. It should contain a description of your apparatus, methods, all your rough calculations or preliminary measurements, full details of any uncertainty calculations, any comments, records of successes or failures, etc. Bullet-form is quite sufficient, as long as it is complete and comprehensible to your TA. Because the lab book is a complete record, taken as the experiment is being done, it will not necessarily be overly neat.

- Diary format means that the record is written in the order in which a procedure, calculation or inspiration actually occurred. You should NOT leave blank pages to be filled in later.
- If you use python code or have computer drawn graphs, print and staple them in neatly beside the description of your experiment.
- Do not use liquid paper, or big blotchy marks, or torn-out pages to obscure parts of your work. If you have written down something that you later realize is wrong (which happens a lot), simply put a line through it and label it as “wrong”.

This Student Guide was written by Jason Harlow, Dept. of Physics, Univ. of Toronto in the Winter of 2014.
Last revision: March 26, 2015 by Jason J.B. Harlow.