Name: ____________ Department: ____________ Student ID: ____________

Team No.: ____________ Date: ____________ Lecturer's Signature: ____________

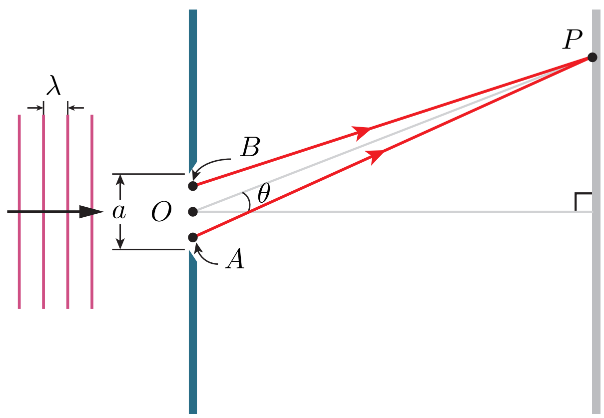
Introduction

Goals

- Measure the slit width (a) and the distance between two slits (d) of a double-slit.
- Understand the principles of diffraction gratings.

Theoretical Backgrounds

1. **Single-Slit Diffraction**



Consider a single-slit diffraction experiment. The width of the slit is a, and the wavelength of the light is λ. Let O and P be the central point of the slit and a point on the vertical screen, respectively. The angle between the line $\overline{OP}$ and the horizontal axis is θ.

(a) The diffraction pattern becomes wider as the slit width a becomes narrower.

(b) The phase difference $\Delta\phi$ of the light waves arriving P from two points A and B in the slit is

$$\Delta\phi = \frac{2\pi}{\lambda} a \sin\theta.$$

(c) The intensity of the diffraction pattern at any given angle θ is

$$I(\theta) = I_m \frac{\sin^2\alpha}{\alpha^2},$$

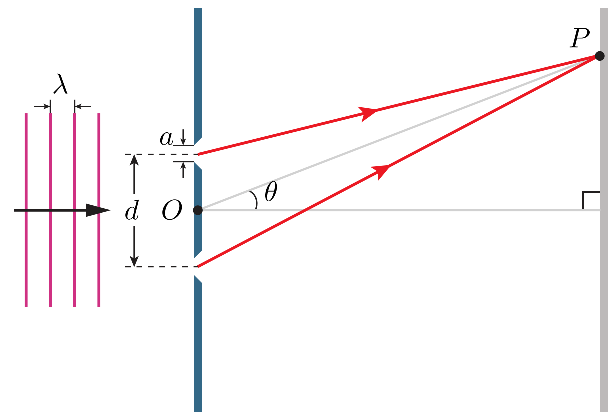
where I_m is a constant and the parameter α is defined by

$$\alpha = \frac{\pi a}{\lambda} \sin\theta.$$

(d) The function $I(\theta)$ is either positive or zero.

(e) There are countably infinite number of zeros for $I(\theta)$. Suppose that $I(\theta_i) = 0$ and $\theta_i < \theta_j$ for all $i < j$. The region between two adjacent points θ_i and θ_{i+1} is called an envelope.

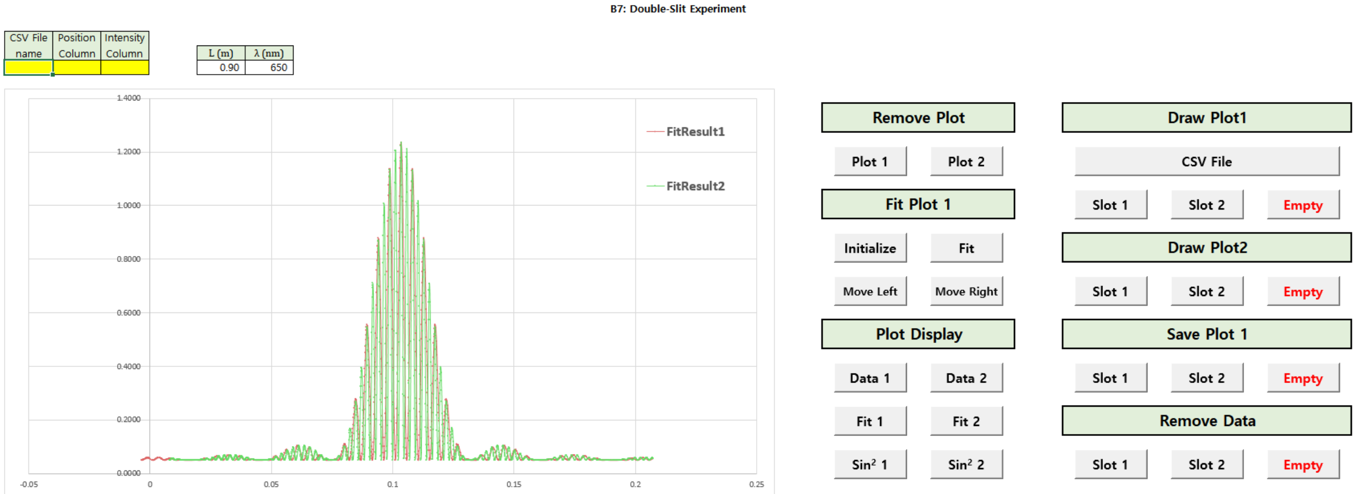
2. **Double-Slit Diffraction**



Consider a double-slit diffraction experiment. The width of each slit is a, the distance between the two slits is d, and the wavelength of the light is λ. Let O and P be the central point of the two slits and a point on the vertical screen, respectively. The angle between the line $\overline{OP}$ and the horizontal axis is θ.

(a) The diffraction envelope becomes wider as the slit width a becomes narrower.

(b) In each envelope, there are fringes. The width of each fringe pattern becomes wider as the slit distance d becomes narrower.



(c) The intensity of the double-slit fringe pattern at any given angle θ is

$$I(\theta) = I_m \frac{\sin^2 \alpha}{\alpha^2} \cos^2 \beta, \tag{1}$$

where I_m is a constant and the parameters α and β are defined by

$$\alpha = \frac{\pi a}{\lambda} \sin\theta, \tag{2a}$$

$$\beta = \frac{\pi d}{\lambda} \sin\theta. \tag{2b}$$

Instrumentation

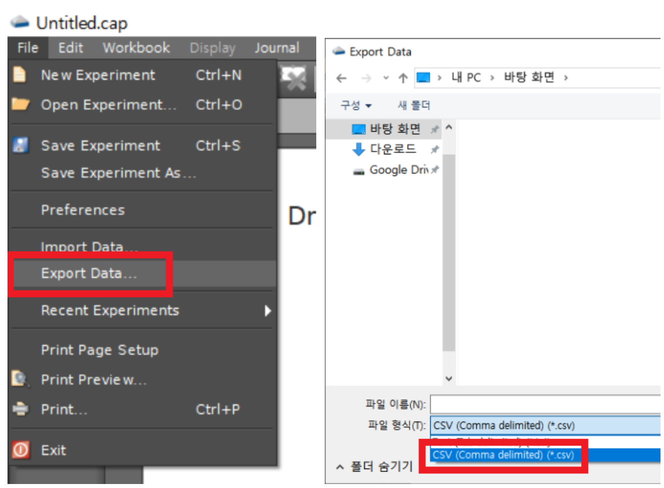
Multiple Slit Apparatus provides 5 options (mm):

option	1	2	3	4	5
a	0.04	0.04	0.04	0.08	0.08
d	0.125	0.25	0.50	0.25	0.50

Experimental Procedure

In this experiment, you will carry out the fit of the diffraction data to (1) and determine the values for a and d by making use of (2). The final results for a and d shall be compared with the manufacturer's data for a and d.

1. `Export Data` to CSV file.

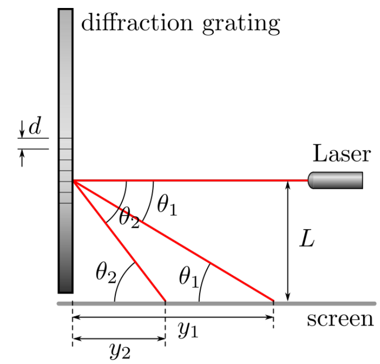


2. Open CSV file and `B8.xlsm`.
3. Fill in the file name and columns.
4. Press CSV File button.
5. Initialize the variables.

6. **Primary Fit**: Comparing the initial guess graph and data, adjust the desirable peaks.
7. **Fine-Tuned Fit**: Press Fitting button and wait about 15 minutes.
8. Press Slot buttons in save menu.

Appendix

1. **Diffraction Grating**



Consider an optical disc shown in above figure. The distance between the adjacent tracks is d, and the wavelength of the laser is λ. The angle between the incident laser and the diffracted ray is θ_m, and the distance between the disc and the diffraction pattern on the screen is y_m. L is the distance between the laser and the screen.

(a) Diffraction gratings can take the form of series of closely spaced grooves that reflect light.

(b) Expression for the angle of constructive interference from a diffraction grating is

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

where $m = 0,\ 1,\ 2, \ldots$.

(c) The angle θ_m can be expressed as

$$\sin\theta_m = \frac{m\lambda}{d} = \arctan\left(\frac{L}{y_m}\right),$$

and the spacing between the tracks in the disc is

$$d = \frac{m\lambda\sqrt{L^2 + y_m^2}}{L}$$

for $m \geq 1$.

References

[1] ***KPOP$\mathscr{E}$*** **Digital Library:**

[2] **Y20:** *Interference of Light Waves*

[3] **Y21:** *Diffraction*

