Diffraction and Interference of Light

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Name: Eason Smith
Lab Partner: Kevin Jairam
Lab Instructor: Siyka I. Shopova

Introduction

The purpose of experiment 5 is to find the wavelength of a laser, the width a wire, the distance between two slits on a slide and to find and measure the diffraction grating produced by a laser.

Light is an electromagnetic field which can propagate through space. Light has both properties of particles and properties of waves. Because of its wave properties, light which arrives at the same point in space may add or subtract from each other, creating an interference pattern, also known as a diffraction pattern. This pattern can be described with the equation:

$$a * sin\theta = n * \lambda$$

Where (a) is the slit width in meters, sin(θ) is the angle of the beam, (n) is the order of interference minima, and (λ) is the wavelength, also in meters. For small angles such as the angles used in this experiment, sin(θ) may be simplified to:

$$sin\theta = \frac{y_n}{L}$$

Substituting this into the original equation and rearranging to solve for wavelength (λ), we may find:

$$\lambda = \frac{y_n * n * L}{a}$$

In addition to their use in finding wavelengths, diffraction patterns are often used in mass spectrometry. Diffraction grating maxima occur when:

$$d_g * sin\theta = n * \lambda$$

Where (d_g) is the distance between maxima in meters, (n) is order of maxima, and (λ) lambda is the wavelength in meters, and sin(θ) is the angle of the laser. This also may be reduced to:

$$sin\theta = \frac{y_n}{L}$$

Where (y_n) is the distance between maxima in meters, and L is the distance from the slit to the screen, also in meters. From these equations we may find the diffraction grating constant (d_g) as:

$$d_g = n\lambda\sqrt{\left(\frac{L}{y_n}\right)^2 + 1}$$

Analysis

Initial Data

In Tables 1 through 4, the initial data for Part A is presented as well as the initial data for part B (Tables 5-7).

Table 1 | Part A Basic Measurements

Laser wavelength (as indicated by the manufacturer)	650	nm
Slide to screen distance	150	cm
Uncertainty	0.1	cm

Table 2 | Part A-1 Single slit

Slide width*	0.16	mm
Uncertainty	0.08	mm

	y_n, cm	Uncertainty, cm
n=-3	-1.67	0.1
n=-2	-1.07	0.1
n=-1	-0.506	0.1
n=1	0.474	0.1
n=2	0.927	0.1
n=3	1.514	0.1

*calculated value. See section: preliminary analysis

Table 3 | Part A-2 Thin wire

Slide to screen distance	150	cm
Uncertainty	0.1	cm

	y_n, cm	Uncertainty, cm
n=-3	-2.16	0.1
n=-2	-1.334	0.1
n=-1	-0.61	0.1
n=1	0.747	0.1
n=2	1.328	0.1
n=3	2.106	0.1

Table 4 | Part A-3 Double slit

Slide to screen distance	150	cm
Uncertainty	0.1	cm

	Y_n, cm	Uncertainty, cm
n=-4	-1.433	0.1
n=-3	-1.049	0.1
n=-2	-0.745	0.1
n=-1	-0.36	0.1
n=1	0.35	0.1
n=2	0.81	0.1
n=3	0.99	0.1
n=4	1.358	0.1

Table 5 | Part B Spectrometer Basic Measurements

Distance from Meter Stick, cm	33	cm
Uncertainty	0.1	cm

Table 6 | Part B Mercury lamp

	Distance to the left, cm	Uncertainty, cm	Distance to the right, cm	Uncertainty, cm
Yellow (578 nm)	14.5	0.2	14.7	0.2
Green (546.1 nm)	13.5	0.2	13.7	0.2
Blue (435.8 nm)	10.7	0.2	10.4	0.2

Table 7 | Part B Hydrogen lamp

	Distance to the left, cm	Uncertainty, cm	Distance to the right, cm	Uncertainty, cm
Red (656.3 nm)	16.7	0.2	17	0.2
Green (486.1 nm)	12	0.2	12	0.2
Violet (434.1 nm)	10.7	0.2	10.3	0.2

Preliminary Analysis

Before beginning it was noted that the slit width (a) for the Part A-1 single slit side ***was not given or marked on the slide itself*** and therefore unlike simultaneus experiments done by students at adjacent tables, the slit width for our first slide had to be calculated by hand using the formula below, with Y_n / L substituting as a close approximation of sin θ:

$$a * sin\theta = n * L$$

$$a = n * \left(\frac{L}{y_n}\right) * \lambda$$

Where (a) is the slit width in meters, (n) is the nth order minimum, (y_n) is the distance to the first minimum, and L is the length from the slit to the sheet of paper. The result of that calculation was:

$$a = \frac{n * L * \lambda}{y_n} = \frac{1 * 1.5m * (650 \times 10^{-9}m)}{.00506m} = .00019m$$

However, upon inspection there was no option listed for .19 mm on the slide. The closest option listed on the slide was .16mm, and the second closest option was .08 mm, so .16mm was temporarily chosen for slit width and input into Table 2.*

*Please see: '*Slit width: .16mm vs .19mm*' in the conclusion section for further analysis on this particular error.

Experiment | Part A-1

The Objective for part (A – 1) was to find the value of the wavelength of the laser using the single slit slide. Before beginning analysis, the initial measurements taken for A-1 were converted to meters. The (n) values (unitless) and the minima (y_n) distances (in meters) collected were tabulated along with their uncertainties (also in meters), as seen in table 8. Also presented are the values for screen distance (L) and its uncertainty (ΔL), both in meters.

Table 8 | Tabulated n and yn data

n	y_n, m	Δy_n, m
-3	-0.0167	0.001
-2	-0.0107	0.001
-1	-0.00506	0.001
1	0.00474	0.001
2	0.00927	0.001
3	0.01514	0.001

L, m	1.5
ΔL, m	0.001

A graph of the data from Table 8 was then plotted and the slope was obtained using Excel's Linest function (Table 9). Also presented are best and worst fit lines, along with their respective error bars and the calculations for uncertainty in error bars.

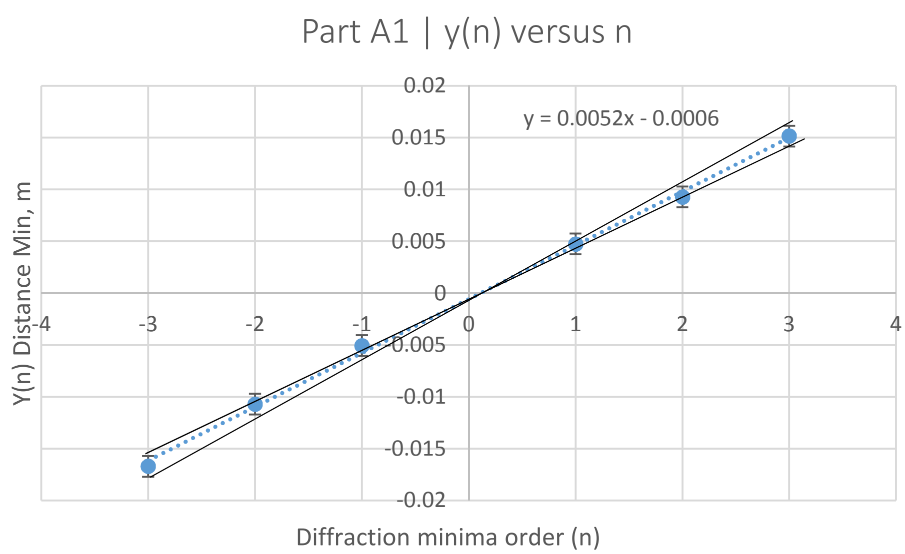


Table 9 | Linest Data

	Slope	Intercept
Value	0.005187857	-0.0005517
Uncertainty	0.000103058	0.00022263

Calculation of uncertainty in error bars (Δm_{error}):

Using $m = \left|\frac{y_2 - y_1}{x_2 - x_1}\right|$ and $b = \left|\frac{x_2 y_1 - x_1 y_2}{x_2 - x_1}\right|$ with the data in Table 8

The calculation for steepest line:

$$x1 = -3$$

$$y1 = (-0.0167 - .001) = -.0107$$

$$x2 = 3$$

$$y2 = (.01514 + .001) = .8703$$

$$m_{steep} = .00564 \quad \text{and} \quad b_{steep} = .00078$$

The calculation for shallowest line:

$$x1 = -3$$

$$y1 = (-.0167 + .001) = -.0157$$

$$x2 = 3$$

$$y2 = (.01514 - .001) = .01414$$

$$m_{shallow} = .0049 \quad \text{and} \quad b_{shallow} = .00078$$

$$\Delta m_{error} = |\frac{m_{shallow} - m_{steep}}{2}| = .00033m$$

Total uncertainty in the slope (Δm) was then calculated as:

$$\Delta m = \sqrt{\Delta m_{lin}^2 + \Delta m_{error}^2} = \sqrt{.0001m^2 + .00033m^2} = .0003489$$

Once the slope (m) has been obtained, the calculation for the wavelength of the laser, lambda (λ), may be found as:

$$\lambda = m * \frac{a}{L} = .0051m * \frac{.00016m}{1.5m} = 553 \times 10^{-9}m$$

Where (m) is the slope in meters, (a) is the slit width in meters, and (L) is the distance to the screen, also in meters.

Calculations for Uncertainty in wavelength (Δλ)

Uncertainty due to slope (m):

$$\Delta\lambda_m = \left|\frac{\delta}{\delta m}\left(\frac{m * a}{L}\right) * \Delta m\right| = \left|\frac{a}{L} * \Delta m\right| = \left|\frac{.00016m}{1.5m} * .00034\right| = 3.72 \times 10^{-8} m$$

Uncertainty due to screen distance (L):

$$\Delta\lambda_L = \left|\frac{\delta}{\delta L}\left(\frac{m * a}{L}\right) * \Delta L\right| = \left|\frac{-ma}{L^2} * \Delta L\right| = \left|\frac{-.0051m * .00016m}{1.5^2 m} * .001m\right| = 3.69 \times 10^{-10} m$$

Uncertainty due to slit width (a):

$$\Delta\lambda_a = \left|\frac{\delta}{\delta a}\left(\frac{m * a}{L}\right) * \Delta a\right| = \left|\frac{m}{L} * \Delta a\right| = \left|\frac{.0051m}{1.5m} * .00008m\right| = 2.77 \times 10^{-7} m$$

Total Uncertainty in lambda (Δλ):

$$\Delta\lambda = \sqrt{\Delta\lambda_m^2 + \Delta\lambda_L^2 + \Delta\lambda_a^2} = \sqrt{(3.72 \times 10^{-8} m)^2 + (3.69 \times 10^{-10} m)^2 + (2.77 \times 10^{-7} m)^2}$$

$$= 2.79 \times 10^{-7} m$$

Result for Part A-1:

Table 10 | Part A-1 Results

Lambda (λ), m	**Uncertainty (Δλ), m**
5.53371E-07	2.79178E-07

$$\lambda = 553 \times 10^{-9}\, m, \quad \Delta\lambda = 2.79 \times 10^{-7} m$$

Experiment | Part A-2

The objective of part A-2 is similar to that of experiment part A-1. Students must find the wire width, measured in meters, of a wire placed on a slide (w) and its uncertainty (Δw) using the diffraction pattern it produces when hit by a laser, except in this part of the experiment the wire width is substituted in place of slit width (a) used in the previous experiment. The Procedure for Part A-2 is nearly identical to that of part-A-1.

Table 11 | Part A-2 tabulated n and yn data

n	y_n, m	Δy_n, m
-3	-0.0216	0.001
-2	-0.01334	0.001
-1	-0.0061	0.001
1	0.00747	0.001
2	0.01328	0.001
3	0.02106	0.001

L, m	1.5
ΔL, m	0.001

A graph of the data from Table 11 was then plotted and the slope was obtained using Excel's Linest function (Table 12). Also presented are best and worst fit lines, along with the error bars and the calculations for uncertainty in error bars.

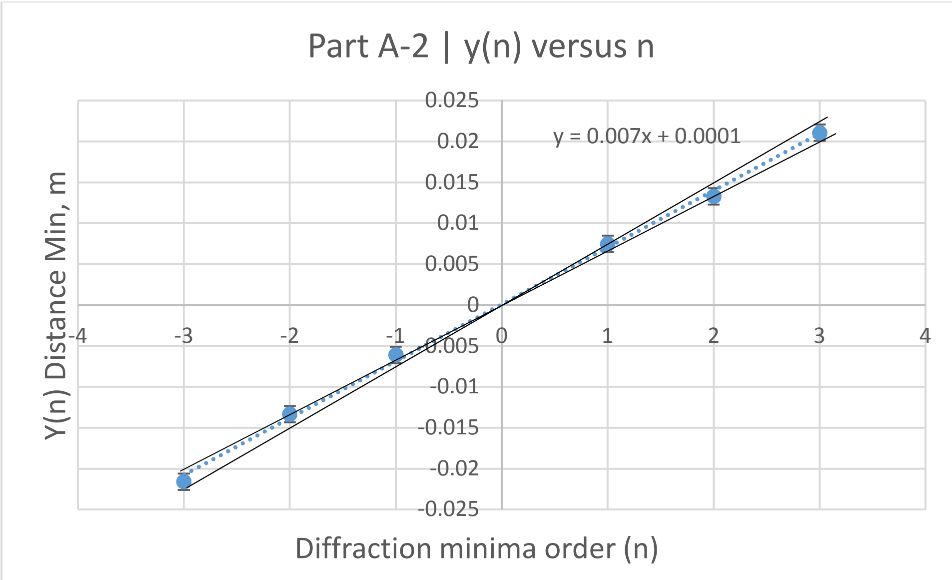


Table 12 | Linest Data

	Slope	Intercept
Value	0.006956786	0.00012833
Uncertainty	0.00014007	0.00030259

Calculation of uncertainty in error bars (Δm_{error}):

Using $m = \left|\frac{y_2 - y_1}{x_2 - x_1}\right|$ and $b = \left|\frac{x_2 y_1 - x_1 y_2}{x_2 - x_1}\right|$ with the data in Table 11

The calculation for steepest line:

$$x1 = -3$$

$$y1 = (-0.0216 - .001) = -.0226$$

$$x2 = 3$$

$$y2 = (.0210 + .001) = .8703$$

$$m_{steep} = .0074 \quad \text{and} \quad b_{steep} = .00027$$

The calculation for shallowest line:

$$x1 = -3$$

$$y1 = (-.0216 + .001) = -.0206$$

$$x2 = 3$$

$$y2 = (.0210 - .001) = .02$$

$$m_{shallow} = .0067 \text{ and } b_{shallow} = .00027$$

$$\Delta m_{error} = |\frac{m_{shallow} - m_{steep}}{2}| = .00033m$$

Total uncertainty in the slope (Δm) is then calculated as:

$$\Delta m = \sqrt{\Delta m_{lin}^2 + \Delta m_{error}^2} = \sqrt{.00014m^2 + .00033m^2} = .00036m$$

Once the slope (m) has been obtained, the wavelength of the laser (λ) lambda and its least count uncertainty (Δλ), both in meters, were recorded from the manufacturers label and are presented below.

$$\lambda = 650 \times 10^{-9}m, \quad \Delta\lambda = 1 \times 10^{-8}m$$

The width of the wire (w) can now be found as:

$$w = \frac{nL\lambda}{y} = \frac{L*\lambda}{m} = \frac{1.5m * (650\times10^{-9}m)}{.0069m} = .00014m$$

Where (m) is the slope in meters, (λ) is the manufacturers listed wavelength of the laser in meters, (y) is the fringe distance in meters, (w) is the width of the wire in meters, (n) is an integer number corresponding to number of minima from the central fringe, and (L) is the distance to the screen, also in meters.

<u>Calculations for Uncertainty in wire width (Δw)</u>

Uncertainty due to slope (m):

$$\Delta w_m = \left|\frac{\delta}{\delta m}(\frac{L*\lambda}{m}) * \Delta m\right| = \left|\frac{-L\lambda}{m^2} * \Delta m\right| = \left|\frac{-1.5m \;*(650 \times 10^{-9}m)}{.0069^2 m} * .00036\right|$$

$$= 7.28 \times 10^{-6}m$$

Uncertainty due to screen distance (L):

$$\Delta w_L = \left|\frac{\delta}{\delta L}(\frac{L*\lambda}{m}) * \Delta L\right| = \left|\frac{\lambda}{m} * \Delta L\right| = \left|\frac{(650 \times 10^{-9}m)}{.0069} * .001m\right| = 9.34 \times 10^{-8}m$$

Uncertainty due to lambda (λ):

$$\Delta w_\lambda = \left|\frac{\delta}{\delta \lambda}(\frac{L*\lambda}{m}) * \Delta \lambda\right| = \left|\frac{L}{m} * \Delta \lambda\right| = \left|\frac{1.5m}{.0069m} * (1 \times 10^{-8})m\right| = 2.15 \times 10^{-6}m$$

Total Uncertainty in wire width (Δw):

$$\Delta w = \sqrt{\Delta w_m^2 + \Delta w_L^2 + \Delta w_\lambda^2} = \sqrt{(7.28 \times 10^{-6}m)^2 + (9.34 \times 10^{-8}m)^2 + (2.15 \times 10^{-6}m)^2}$$

$$= 7.59 \times 10^{-6}m$$

Result for Part A-2:

Table 13 | Part A-2 Results

Wire Width (w), m	Uncertainty (Δw), m
0.000140151	7.5971E-06

$$w = .00014m, \quad \Delta w = 7.59 \times 10^{-6}m$$

Experiment | Part A-3

Similar to parts A-1 and A-2, Experiment Part A-3 uses a double slit slide, and the objective is to find the slit spacing between the two slits (d) and its respective uncertainty. Unlike in experiment Parts A-1 and A-2, however, the maximum order (n) is used.

Table 14 | tabulated (n) and yn data

n	y_n, m	Δy_n, m
-4	-0.01433	0.001
-3	-0.01049	0.001
-2	-0.00745	0.001
-1	-0.0036	0.001
1	0.0035	0.001
2	0.0081	0.001
3	0.0099	0.001
4	0.01358	0.001

L, m	1.5
ΔL, m	0.001

A graph of the data from Table 14 was then plotted and the slope was obtained using Excel's Linest function (Table 15). Also presented are best and worst fit lines, along with the error bars and the calculations for uncertainty in error bars.

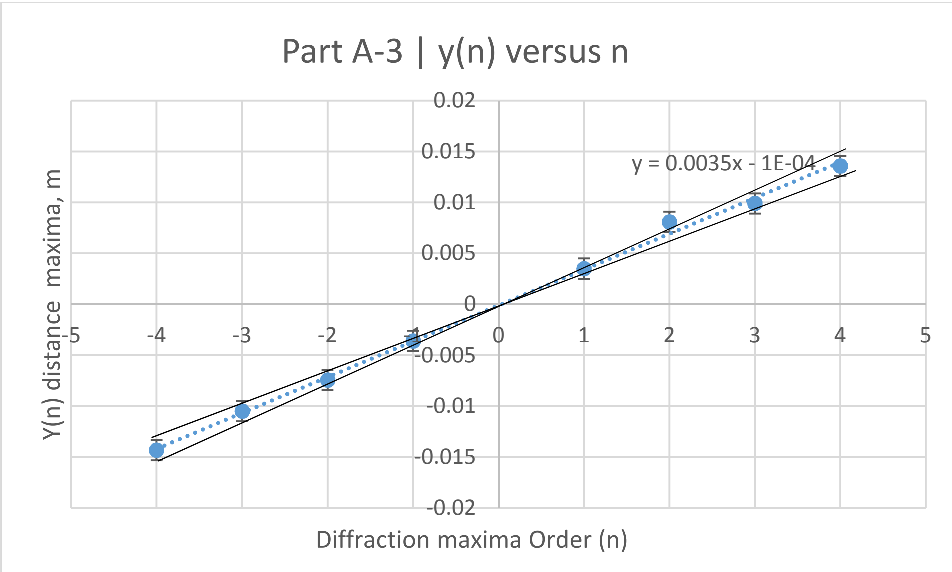


Table 15 | Linest Data

	Slope	Intercept
Value	0.003516833	-9.875E-05
Uncertainty	7.40286E-05	0.00020274

Calculation of uncertainty in error bars (Δm_{error}):

Using $m = \left|\frac{y_2 - y_1}{x_2 - x_1}\right|$ and $b = \left|\frac{x_2 y_1 - x_1 y_2}{x_2 - x_1}\right|$ with the data in Table 11

The calculation for steepest line would be:

$$x1 = -4$$

$$y1 = (-0.0143 - .001) = -.0153$$

$$x2 = 4$$

$$y2 = (.0135 + .001) = .0145$$

$$m_{steep} = .0037 \quad \text{and} \quad b_{steep} = .00037$$

The calculation for shallowest line would be:

$$x1 = -4$$

$$y1 = (-.0143 + .001) = -.0133$$

$$x2 = 4$$

$$y2 = (.0135 - .001) = .0125$$

$$m_{shallow} = .0032 \text{ and } b_{shallow} = .00037$$

$$\Delta m_{error} = |\frac{m_{shallow} - m_{steep}}{2}| = .00025m$$

Uncertainty in Slope due to Fluctuation:

$$\Delta m_{fluc} = \frac{stdev(y_n)}{\sqrt{(\#\ trials)}} = \frac{.0103m}{\sqrt{8}} = .0036m$$

Total uncertainty in the slope (Δm) is then calculated as:

$$\Delta m = \sqrt{\Delta m_{lin}^2 + \Delta m_{fluc}^2 + \Delta m_{error}^2} = \sqrt{(7.4 \times 10^{-5})^2 m + .0036^2 m + .00025^2 m}$$

$$= .0036m$$

Once the slope (m) has been obtained, the wavelength of the laser (λ) lambda and its least count uncertainty (Δλ), both in meters, were gained from the manufacturers label and are presented below.

$$\lambda = 650 \times 10^{-9} m, \quad \Delta\lambda = 1 \times 10^{-8} m$$

The slit seperation (d) can now be found as:

$$d = \frac{nL\lambda}{y_n} = \frac{L*\lambda}{m} = \frac{1.5m * (650 \times 10^{-9}m)}{.0035m} = .00027m$$

Where (m) is the slope in meters, (λ) is the wavelength in meters, (y) is the fringe distance in meters, (d) is the width between the slits in meters, (n) is an integer number corresponding to number of minima from the central fringe, and (L) is the distance to the screen, also in meters.

Uncertainty due to slope (m) :

$$\Delta d_m = \left|\frac{\delta}{\delta m}\left(\frac{L*\lambda}{m}\right) * \Delta m\right| = \left|\frac{-L\lambda}{m^2} * \Delta m\right| = \left|\frac{-1.5m \; * (650 \times 10^{-9}m)}{.0035^2 m} * .0036\right| = .00028m$$

Uncertainty due to screen distance (L):

$$\Delta d_L = \left|\frac{\delta}{\delta L}\left(\frac{L*\lambda}{m}\right) * \Delta L\right| = \left|\frac{\lambda}{m} * \Delta L\right| = \left|\frac{(650 \times 10^{-9}m)}{.0035m} * .001m\right| = 1.84 \times 10^{-7}m$$

Uncertainty due to lambda (λ):

$$\Delta d_\lambda = \left|\frac{\delta}{\delta \lambda}\left(\frac{L*\lambda}{m}\right) * \Delta\lambda\right| = \left|\frac{L}{m} * \Delta\lambda\right| = \left|\frac{1.5m}{.0035m} * (1 \times 10^{-8})m\right| = 4.26 \times 10^{-6}m$$

Total Uncertainty in slit separation (Δd):

$$\Delta d = \sqrt{\Delta d_m^2 + \Delta d_L^2 + \Delta d_\lambda^2} = \sqrt{.00028m^2 + (1.84 \times 10^{-7}m)^2 + (4.26 \times 10^{-6}m)^2}$$

$$= .00028m$$

Result for Part A-3:

Table 16 | Part A-3 Results

Slit Seperation (d), m	Uncertainty (Δd), m
0.000277238	0.000288116

$$d = .00027m, \quad \Delta d = .00028m$$

Experiment | Part B

The objective of experiment Part B is to use the distances between maxima interference patterns (Y_n) to calculate the diffraction grating constant (d_g) for a total of six colors.

Table 17 | Part B Spectrometer Basic Measurements

Distance from Meter Stick (L), m	0.33
Uncertainty (ΔL), m	0.001

Table 18 | Part B Mercury lamp

	λ, m	Y distance Left, m	ΔY, m	Y Distance right, m	Δy, m
Yellow (578 nm)	0.000000578	0.145	0.002	0.147	0.002
Green (546.1 nm)	5.461E-07	0.135	0.002	0.137	0.002
Blue (435.8 nm)	4.358E-07	0.107	0.002	0.104	0.002

Table 19 | Part B Hydrogen lamp

	λ, m	Y distance Left, m	ΔY, m	Y Distance right, m	Δy, m
Red (656.3 nm)	6.563E-07	0.167	0.002	0.17	0.002
Green (486.1 nm)	4.861E-07	0.12	0.002	0.12	0.002
Violet (434.1 nm)	4.341E-07	0.107	0.002	0.103	0.002

For each color, the positions of maxima are measured and a best estimate (Y_n) is calculated (in meters) as an average of the two, as:

$$(for\ yellow)\ Y_n = \frac{|Y_n| + |Y_{-n}|}{2} = \frac{|.145m| + |.147m|}{2} = .146m$$

Uncertainty calculations for (Y_n):

Fluctuation Uncertainty:

$$\Delta Y_{n\,fluc} = \frac{stdev(y_n)}{\sqrt{(\#\ trials)}} = \frac{.0248m}{\sqrt{6}} = .0101m$$

Instrumental Uncertainty:

$$\Delta Y_{n\,inst} = .002m$$

Total Uncertainty (ΔY_n):

$$\Delta Y_n = \sqrt{\Delta Y_{n\,fluc}^2 + \Delta Y_{n\,inst}^2} = \sqrt{.0101^2 m + .002^2 m} = .0103m$$

Once (Y_n) and it's respective uncertainty have been calculated for each color, (d_g) may then be calculated as:

$$(\,yellow) d_g = n\lambda\sqrt{\left(\frac{L}{y_n}\right)^2 + 1} = (650 \times 10^{-9}m)\sqrt{\left(\frac{1.5m}{.146m}\right)^2 + 1} = 1.42 \times 10^{-6}m$$

Uncertainty Calculations for (d_g):

Uncertainty due to Distance from Meter Stick (L):

$$\Delta d_{g,L} = \left|\frac{\delta}{\delta L} n\lambda\sqrt{\left(\frac{L}{y_n}\right)^2 + 1)} * \Delta L\right| = \frac{L\lambda}{y_n^2\sqrt{\left(\frac{L}{y_n}\right)^2 + 1)}} * \Delta L$$

$$= \left|\frac{1.5m * (650 \times 10^{-9}m)}{.146m^2\sqrt{\left(\frac{1.5m}{.146m}\right)^2 + 1}} * .001m\right| = 3.62 \times 10^{-9}m$$

Uncertainty due to Wavelength(λ):

$$\Delta d_{g,\lambda} = \left|\frac{\delta}{\delta\lambda} n\lambda\sqrt{\left(\frac{L}{y_n}\right)^2 + 1)} * \Delta\lambda\right| = \sqrt{\left(\frac{L}{y_n}\right)^2 + 1} * \Delta\lambda = \left|\sqrt{\left(\frac{1.5m}{.146m}\right)^2 + 1} * (1 \times 10^{-8}m)\right|$$

$$= 2.47 \times 10^{-8}m$$

Uncertainty due to distance of maxima (y):

$$\Delta d_{g,y} = \left|\frac{\delta}{\delta y} n\lambda\sqrt{\left(\frac{L}{y_n}\right)^2 + 1)} * \Delta y\right| = \left|\frac{-L^2\lambda}{y_n^3\sqrt{\left(\frac{L}{y_n}\right)^2 + 1)}} * \Delta y\right|$$

$$= \left|\frac{1.5m^2 * (650 \times 10^{-9}m)}{.146m^3\sqrt{\left(\frac{1.5m}{.146m}\right)^2 + 1}} * .0103m\right| = 2.56 \times 10^{-7}m$$

The results of these calculations are presented below in table 20:

Table 20| Part B Calculations

color	λ, m	y(n), m	dg, m	ΔL, m	Δλ, m	Δy, m	Δdg, m
yellow	5.8E-07	0.146	1.42859E-06	3.6204E-09	2.47161E-08	2.5688E-07	2.58089E-07
green	5.5E-07	0.136	1.43321E-06	3.71252E-09	2.62445E-08	2.8278E-07	2.84022E-07
blue	4.4E-07	0.1055	1.43113E-06	3.93463E-09	3.28392E-08	3.8634E-07	3.87756E-07
red	6.6E-07	0.1685	1.4432E-06	3.46891E-09	2.19899E-08	2.1326E-07	2.14422E-07
green	4.9E-07	0.12	1.20145E-06	3.80695E-09	2.92617E-08	3.2864E-07	3.2996E-07
violet	4.3E-07	0.105	1.43171E-06	3.93967E-09	3.29811E-08	3.8868E-07	3.90097E-07

Final Results

PART A-1

$$\lambda = (5.53 \pm 2.79) \times 10^{-7}\ m;\ \frac{\Delta\lambda}{\lambda} = .50\ (50\%)$$

PART A-2

$$w = (140 \pm 7.59) \times 10^{-6}\ m;\ \frac{\Delta w}{w} = .05\ (5\%)$$

PART A-3

$$d = (.00027 \pm .00028)\ m;\ \frac{\Delta d}{d} = 1.03\ (103\%)$$

PART B

$$d_g\ (yellow) = (1.42 \pm .258) \times 10^{-6}\ m;\ \frac{\Delta d_g}{d_g} = .18\ (18\%)$$

$$d_g\ (green) = (1.43 \pm .284) \times 10^{-6}\ m;\ \frac{\Delta d_g}{d_g} = .19\ (19\%)$$

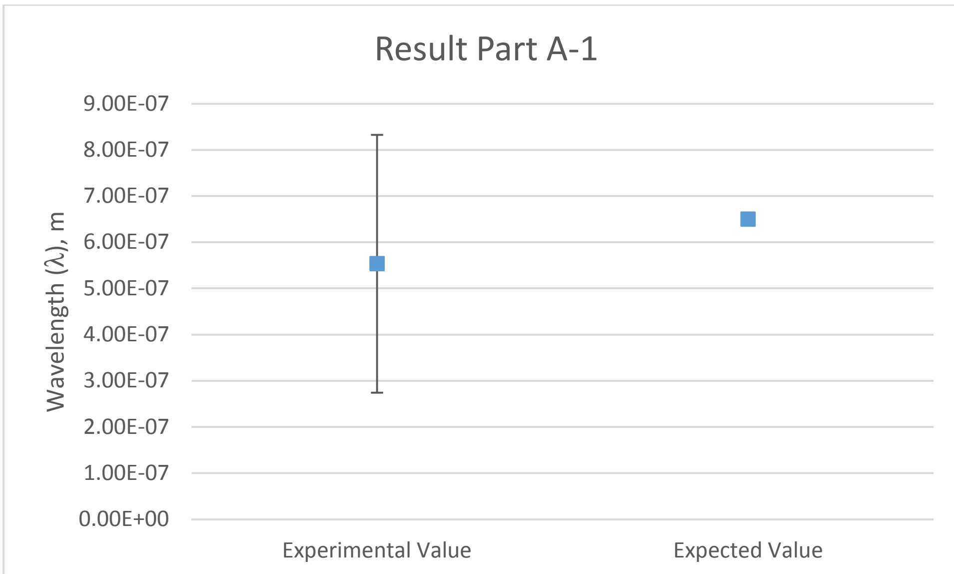
$$d_g\ (blue) = (1.43 \pm .387) \times 10^{-6}\ m;\ \frac{\Delta d_g}{d_g} = .27\ (27\%)$$

$$d_g\ (red) = (1.44 \pm .214) \times 10^{-6}\ m;\ \frac{\Delta d_g}{d_g} = .14\ (14\%)$$

$$d_g\ (green) = (1.2 \pm .329) \times 10^{-6}\ m;\ \frac{\Delta d_g}{d_g} = .27(27\%)$$

$$d_g\ (violet) = (1.43 \pm .390) \times 10^{-6}\ m;\ \frac{\Delta d_g}{d_g} = .27\ (27\%)$$

Conclusion



In part A-1, it was noted that the manufacturer's listed wavelength of the laser was 650nm, however as indicated by the results of the experiment, it seems that the true wavelength lies much closer to 550nm, roughly 100 nanometers less than indicated. The large uncertainty in this calculation (an error of 50%) does cover both values, so better equipment may be needed to attain a more definitive result with more certainty.

'Slit Width: .16mm versus .16mm'

In the preliminary analysis for experiment A-1, it was found algebraically that the slit width was .19mm, using the listed wavelength of 650nm for the laser. However upon inspecting the slide, the closest option listed for the slit width was not .19mm as expected, but instead was .16mm and did not match our repeated calculations. If we accept, however, an experimental result where the wavelength is out of calibration by 100nm and is instead actually a 550nm laser, we may redo our original calculation for this slit width from the preliminary analysis in Part A-1 finding:

$$a = \frac{n * L * \lambda}{y_n} = \frac{1 * 1.5m * (550 \times 10^{-9}m)}{.00506m} = .00016m$$

Which matches the listed slit width on the slide.

In Part B, the uncertainties for the value for the (d_g) constant all overlap for each color, with the largest error reaching 27%. Much of this error is due to contributions from a measurement with a human eye at a distance (from a ruler), which recorded results which may have been off by as much as a centimeter or two on either side. The ruler also was prone to not staying perfectly horizontal, and had to be readjusted constantly between measurements.