***Item 1.*** *Explain and justify your procedure/method for assigning uncertainties to your measurements of x and D in all three parts of Lab 5. Also mention qualitatively any other sources of error. (4 points)*

The uncertainty of the Vernier caliper is 0.05 mm. The caliper is able to measure to 0.1 mm, thus the user must estimate the next 0.05 mm between two 0.1 mm markings.

The uncertainty associated with the linear scale mounted on the optical bench is 0.5 mm. The linear scale can measure down to 1 mm, so the user must estimate the next 0.5 mm between two 1 mm markings.

Other sources of error could be due to the imprecision of eyeballing the minima and maxima in all three parts. In particular, the distances where so small in part B and C so it was practically difficult to find the centers and mark them correctly. In addition, it was very difficult to accurately mark the positions because the shaking of the optical bench would alter the position of the laser and therefore the results.

***Item 2.*** *Answer Question 1 in the Lab 5 write up. (1.5 points)*

When , , and

In order to maximize , we must maximize

*m* may be ignored because for all integers m.

***Item 3.*** *Calculate λ and ∆λ from Part A data. Also compute ∆λ using error propagation calculation. Compare the two error values and pick the larger error as the uncertainty associated with the wavelength for Part A of the experiment. (3 points)*

𝑏𝑑𝑎 .:

***Item 4.*** *Answer Question 2 in the lab 5 write up. (1.5 points)*

*At a minimum, . To minimize , we must minimize .*

*In order to minimize , we must minimize .*

*at a minimum.*

*for all p.*

**Item 5**. Using the data from Part B, calculate the wavelength λ. There should be 12 values of the wavelength. Use those values to calculate the best value for the wavelength and the uncertainty (SDOM). (4 points)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| A (m) | p | distance between peaks(m) | **Distance**(m) | **Sin(theta)**  (Radians) | **Wavelength**  (m) (nm) | |
| .0002 | 1 | 0.0029 | 1.1145 | 0.002602 | 5.2041E-07 | 520.4103921 |
| 2 | 0.00705 | 1.1145 | 0.006326 | 6.32554E-07 | 632.5537854 |
| 1 | 0.0031 | 1.1145 | 0.002782 | 5.563E-07 | 556.3004057 |
| 2 | 0.0067 | 1.1145 | 0.006012 | 6.01152E-07 | 601.1519587 |
| .0003 | 1 | 0.0013 | 1.1145 | 0.001166 | 3.49932E-07 | 349.9323878 |
| 2 | 0.0029 | 1.1145 | 0.002602 | 3.90308E-07 | 390.3077941 |
| 1 | 0.0018 | 1.1145 | 0.001615 | 4.84521E-07 | 484.5213647 |
| 2 | 0.0051 | 1.1145 | 0.004576 | 6.86397E-07 | 686.3968782 |
| .0004 | 1 | 0.0014 | 1.1145 | 0.001256 | 5.02467E-07 | 502.4669456 |
| 2 | 0.0029 | 1.1145 | 0.002602 | 5.2041E-07 | 520.4103921 |
| 1 | 0.001 | 1.1145 | 0.000897 | 3.58905E-07 | 358.9051461 |
| 2 | 0.0031 | 1.1145 | 0.002782 | 5.563E-07 | 556.3004057 |
| **Instrumental**  **Error** | | .00005 | .0005 |  |  |  |
| **Wavelength** = 513.3030.44 nm | | | | | | |

The average wavelength based on the 12 measurements was found to be 513.3030.44 nm. Since the laser was red the expected value would have been between 625–7001 nm. Since the calculated wavelength is not within the known range for wavelength there seems to be error present. Which could be due to the imprecision of marking the minima of the slits produced. It was also observed that every time the optical bench moved or shook slightly the diffraction pattern changed, therefore systematic error was present in this experiment due to the apparatuses used.

The calculations done to find this were as follows.

To find the wavelength of each data point ,

The average was then taken of all the wavelengths. The error was based on the standard deviation of the 12 measurements.

[1https://www.rp-photonics.com/red\_lasers.html](https://www.rp-photonics.com/red_lasers.html)

***Item 6.*** *Do the wavelength values from Part A and Part B overlap within experimental uncertainties? Display your results graphically. (2 points)*

As can be seen from the above graph the wavelength of the laser does not overlap within experimental uncertainties, which is likely due to a systematic error in Part B that was not present in Part A because Part A is within the expected value range. This error could be due to the method of marking the minima on paper and eyeballing the centers of the gaps, for such a small range it was very difficult to find the true center and mark it carefully.

**Item 7. What was the diameter of the human hair in Part C? What was the uncertainty? Show your calculation. Is the value you have found for the diameter of the hair consistent with known values? (4 points)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| p | distance btw peaks(m) | distance(m) | Sin(angle) | Wavelength (m) | Calculated Width (a) (nm) |
| 1 | 0.0091 | 1.1145 | 0.008165 | 6.39897E-07 | 7.83733E-05 |
| 2 | 0.0164 | 1.1145 | 0.014713 | 6.39897E-07 | 8.69839E-05 |
| 3 | 0.0222 | 1.1145 | 0.019914 | 6.39897E-07 | 9.63991E-05 |
| 1 | 0.0062 | 1.1145 | 0.005563 | 6.39897E-07 | 0.000115029 |
| 2 | 0.0114 | 1.1145 | 0.010228 | 6.39897E-07 | 0.000125125 |
| 3 | 0.0184 | 1.1145 | 0.016507 | 6.39897E-07 | 0.000116298 |
| Error | .006(SDOM) | .0005 | .005(SDOM) | .1602 \*10-5 | 2.63\*10-5 |

Calculation where done based on the calculation in part A since that was determined to be the more accurate of the 2 values, based on the analysis stated in Item 6.

The Average width based on the above data the average of the width of hair was determined to be . The known hair is between 60~802. The calculated hair width margin of error is with in the known range of hair width, but the calculated answer does appear to me an over estimate of the actual result.

The calculations done to find this where as follows:

Error analysis:

2 https://hypertextbook.com/facts/1999/BrianLey.shtml

***Item 8.*** *What was the wavelength of the green laser of Part D-1? What were two sources and their wavelengths that you observed through the spectroscope in Part D-2? (1 point extra credit)*

The Wavelengths of the green laser was found to be 454 nm which is within the known range of the wavelength of green laser light which is 450-500nm.

This was found using the measured distance of first order minima’s, and the calculated width of a hair from above. The method used was the same as the previous items.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| a | distance btw peaks | distance(m) | arctan | Sin | Wavelength | a |
| 1 | 0.00010323 | 0.0049 | 1.1145 | 0.251903639 | 0.004396534 | 4.53856E-07 |

Three monochromatic colors were measured using the spectroscope, this was done by using a full screen image on the computer and looking at it through the spectroscope.

|  |  |
| --- | --- |
| 450 nm | Blue |
| 650nm | red |
| 520nm | green |