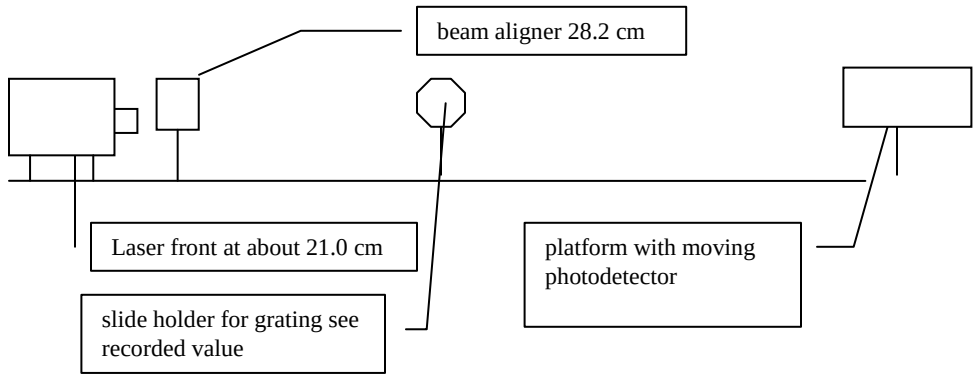
Procedure:
On the optic track we set up a Helium Neon laser and beam aligner with a slide holder as indicated below. The distance between the beam aligner and the slide holder is adjusted for the trials so that position is recorded separately. At the end of the track there was a stand holding a moving photodetector and behind that was a screen that was used just to determine when the diffraction patterns were in focus. Often I used the back wall of the lab instead of the screen to focus the diffraction patterns. The distance between the slide and the moving platform with the photodetector is recorded for each trail since this distance fluctuated based on the needs of the trial. The diagram below indicates basic set up for the lab:



Please note that the slides 4 slits or sets of slits labeled a,b,c, and d. Each slide had a notation of the width of the slit and the distance between the slits. These numbers were recorded to compare our measurements against. We looked at slides that had single slits, double slits which changed the width of the individual slits and the distance between the slits but each slide contained just single or double slits/slit sets. The last slide we looked at had multiple slits, 3, 4, and 5 slits with indication of the width of each slit and the distance between the slits for each slit set. In addition to examining the diffraction pattern of these slit slides I also looked at the diffraction pattern produced by the edge of a razor blade and by a piece of my own hair.

Part 1: Examination of Single Slit Diffraction Patterns
The first day we did the lab I placed the single slit slide into the slide holder which was positioned at 60.2 cm on the optic track. The photodetector was placed at about 6 cm beyond the end of the scale on the optic track which has a max reading of 115cm. The Helium Neon laser beam was shown onto a slit of the slide and the slide was adjusted until the diffraction pattern seemed level and the intensity coming through the slit seemed at its maximum. Then the beam was adjusted to get the clearest diffraction pattern possible before running the photodetector through the projected pattern and taking readings of the voltage versus time for the beam. Please note for all of these experiments the gain on the Voltage reading was 100. Data was taken for slit b and c on the slide, I did not take data for a or d because they were close to the edge of the slide and I was having difficulty keeping the beam straight and the slide level and oriented immediately in front of the beam. Ideally in future set ups of this experiment we will have the ability to level the slide in the slide holder than just adjust the slide left and right to project through the different sample slits. Nevertheless the data for each trial was saved in a text file

which was later exported to Mathematica for fitting. Copies of the graphs from loggerpro were copied and placed into excel. Below is a complete list of the number of trials for each slit, the labeled slit width and distance between the slits (if appropriate), along with the location of the slide and the photodetector for each trial.

Data Table 1:	Record of Slit Trials				
Slide Label	No of trials	Labeld slit width (mm)	Labeled distance between the slits (mm)	location of the slide (cm)	location of the photodetector (cm)
single slit b	2 (saved text files)	.04	n/a	60.2	115+6
single slit c	2	.08	n/a	60.2	115+6
double slit b	2	.04	.5	46.5	115+6
double slit c	2	.08	.25	38.4	115+34
multi slit d – 5 slits	2	.04	.125	38.4	115+34

Logger Pro – graphs of each of the slit trials:

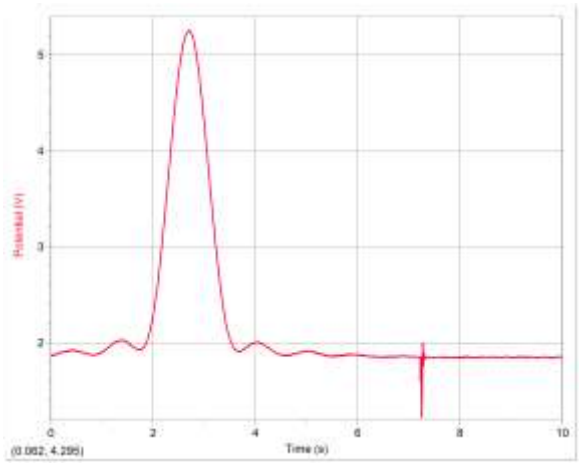


Figure 1: Potential vs Time graph for Single Slit B trial 1, the data for which was inadvertently not saved. This is the graph of the entire run.

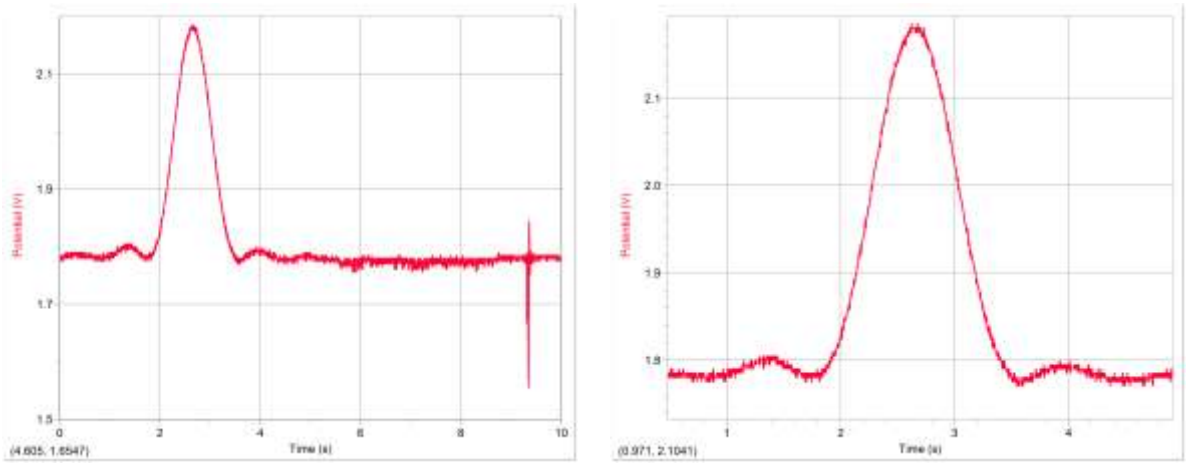


Figure 2: Potential vs. Time data graphs for Single Slit B trial 2, the data file for which was inadvertently not saved. On the left we see the entire graph of the trial run, on the right we see a close up of the graph over the time where the diffraction pattern from the beam was recognizable.

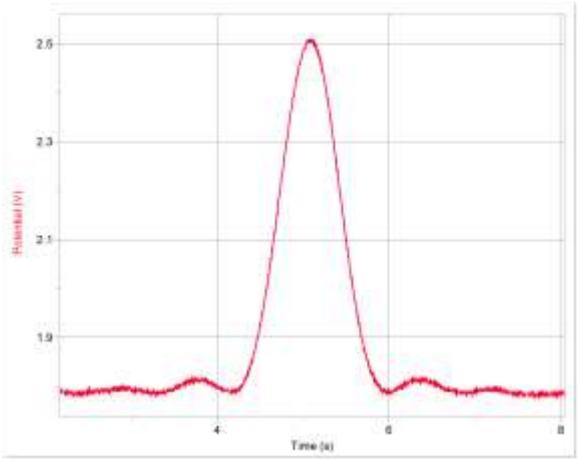


Figure 3: Potential vs. Time data graphs for Single Slit B trial 3, this is the first data trial that the text files were imported from Loggerpro.

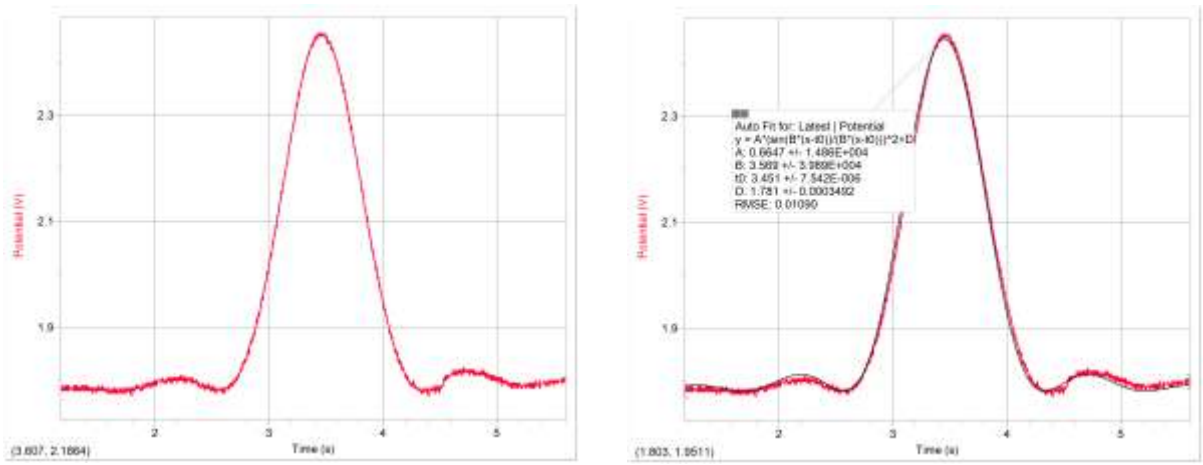


Figure 4: Potential vs. Time data graphs for Single Slit B trial 4, this is the second trial for which data on this particular slit was imported from Loggerpro. On the left we see a close up of the graph over the time where the diffraction pattern from the beam was recognizable. On the right is the line of fit created with Logger pro, the fit function used was the sinc function. The black line is the line of fit and the red line is the graph from the data recorded.

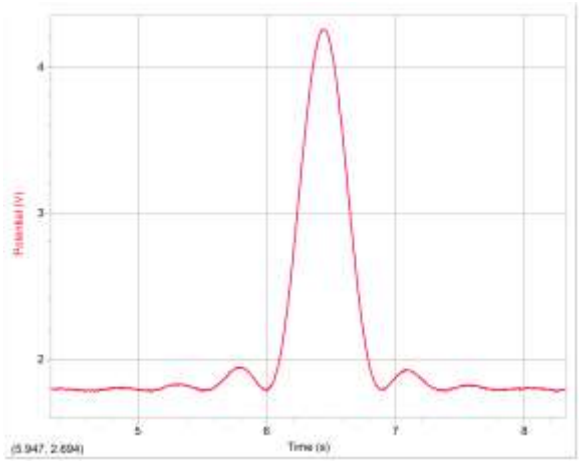


Figure 5: Potential vs. Time data graphs for Single Slit C trial 1.

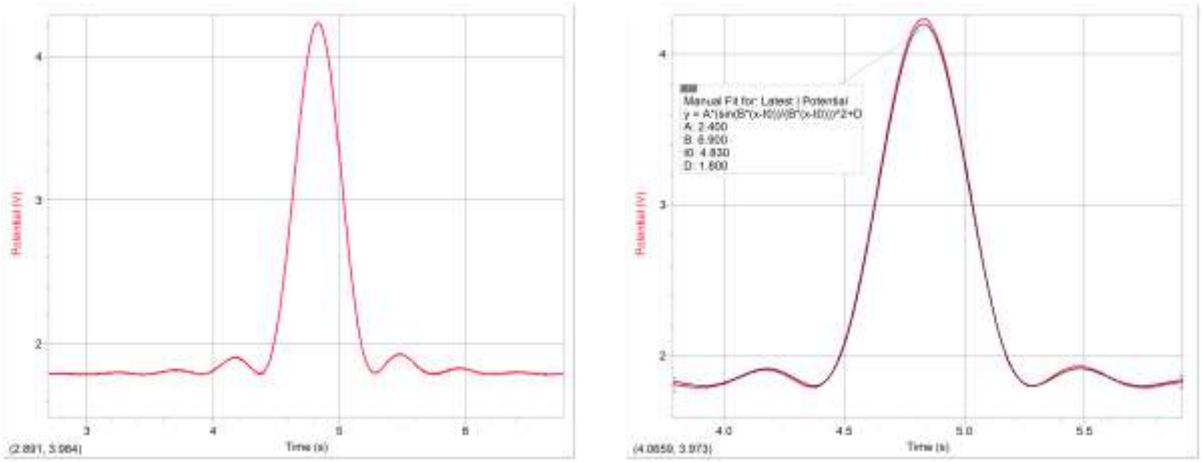


Figure 6: Potential vs. Time data graphs for Single Slit C trial 2. On the left we see a close up of the graph over the time where the diffraction pattern from the beam was recognizable. On the right is the line of fit created with Logger pro, the fit function used was the sinc function. The black line is the line of fit and the red line is the graph from the data recorded.

Double Slit B Potential vs Time
Trial 1

Double Slit B Potential vs Time
Trial 2

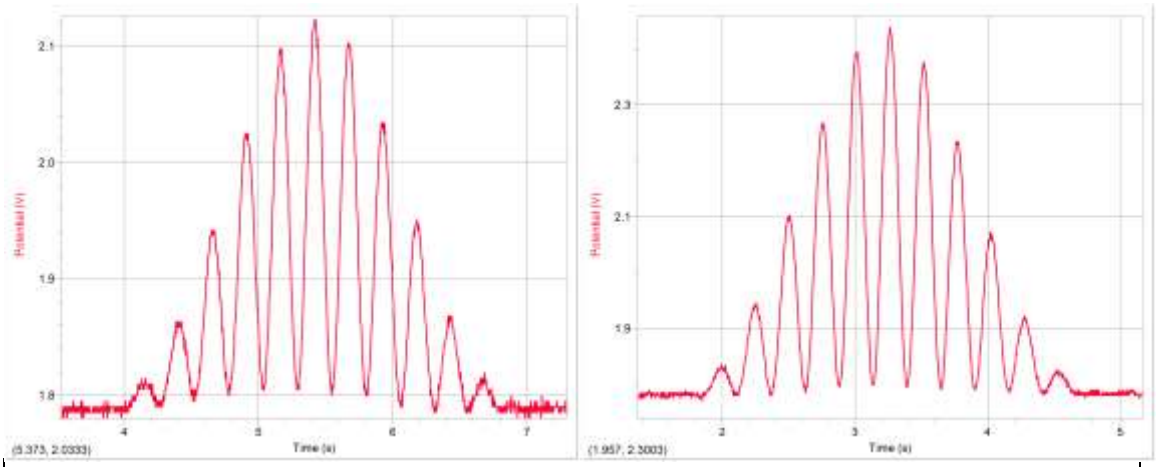


Figure 7: Potential vs. Time data graphs for Double Slit B. Close up graphs of the section of the data reading where the diffraction patterns were read by the photodetector. As labeled the graph on the left is the first trial and the graph on the right is the second trial.

Double Slit C Potential vs Time
Trial 1

Double Slit C Potential vs Time
Trial 2

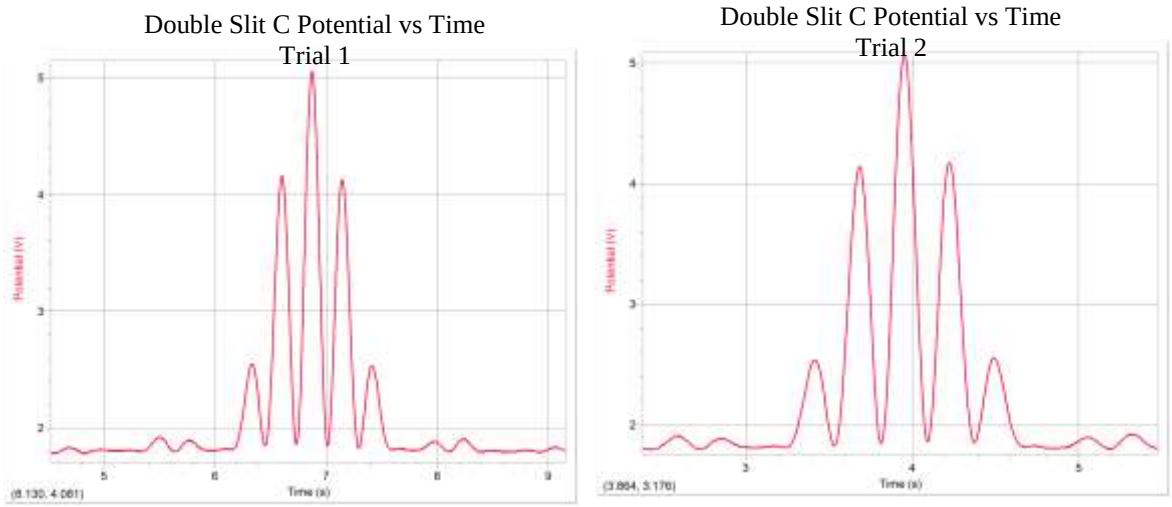
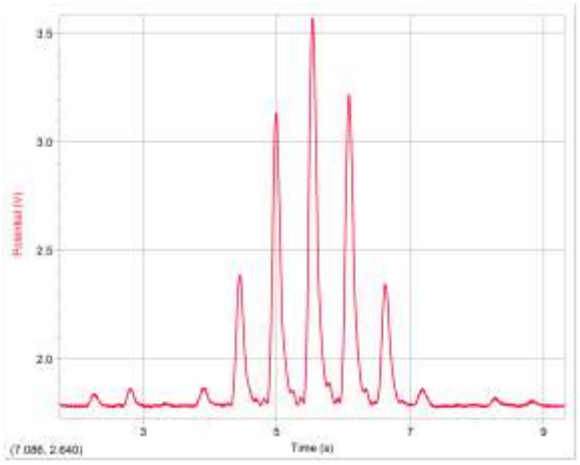


Figure 8: Potential vs. Time data graphs for Double Slit C. Close up graphs of the section of the data reading where the diffraction patterns were read by the photodetector. As labeled the graph on the left is the first trial and the graph on the right is the second trial.

Five Slit D – Potential vs Time
Trial 1



Five Slit D – Potential vs Time
Trial 1

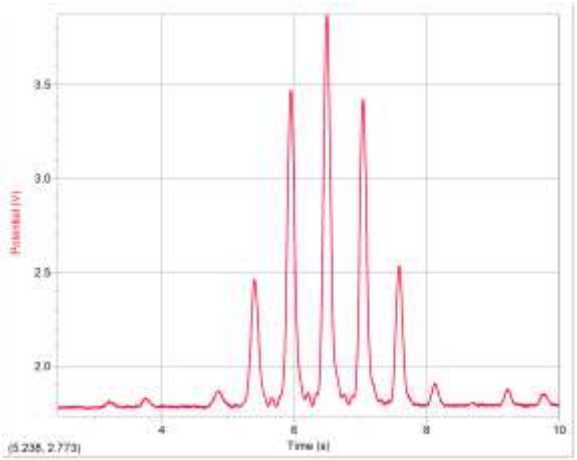


Figure 9: Potential vs. Time data graphs for Five Slit D. Close up graphs of the section of the data reading where the diffraction patterns were read by the photodetector. As labeled the graph on the left is the first trial and the graph on the right is the second trial.

Part 2:
After data was taken for the slit diffraction patterns I mounted a razor blade on the slide holder. I mounted the blade by aligning the bottom of the blade with the top of the slide and then clipping it to the slide stand with a small metal clamp (the black kind typically used for clipping small stacks of paper together). As diagramed below.

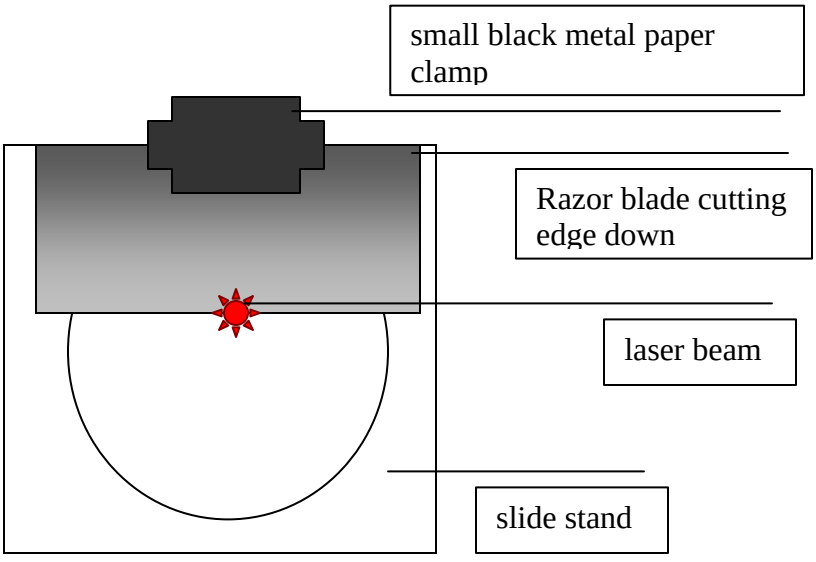
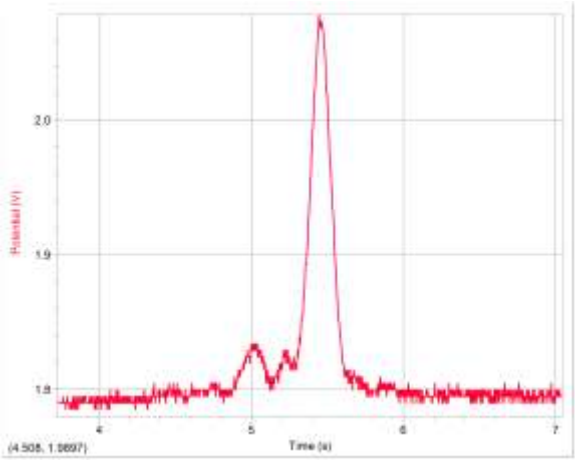


Figure 10: Figure of razor blade mounting set up from the source side.

Initially I had mounted the razor blade sideways and of course the diffraction pattern was then vertical which would have made it impossible to read with the photodetector. So the razor blade was rotated and then the beam was adjusted so that it just skimmed the blade of the razor and the diffraction pattern was measured by the photodetector. The graphs from Loggerpro are below.

Potential vs Time for Razor Blade Diffraction Pattern – Trial 1



Potential vs Time for Razor Blade Diffraction Pattern – Trial 2

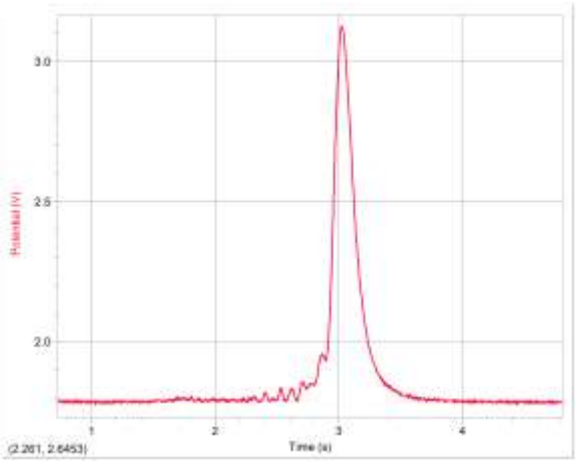


Figure 11: Potential vs Time graphs from loggerpro of the first and second trials from the razor blade experiment. As noted the first trial is on the left and the second trial is on the right..

Part 3: For the last trial I removed a single strand of blonde hair from my head and using two black clips I attached the strand of hair vertically to the slide stand then projected the beam of light onto the hair so that it was nice and bright and a clear diffraction pattern could be seen. The diagram of the mount from the source side is below. Please note that the bottom of the stand has a small lip at the bottom of the stand (as shown in side view), so the hair was actually mounted at a very slight angle (note the angle is exaggerated in this drawing).

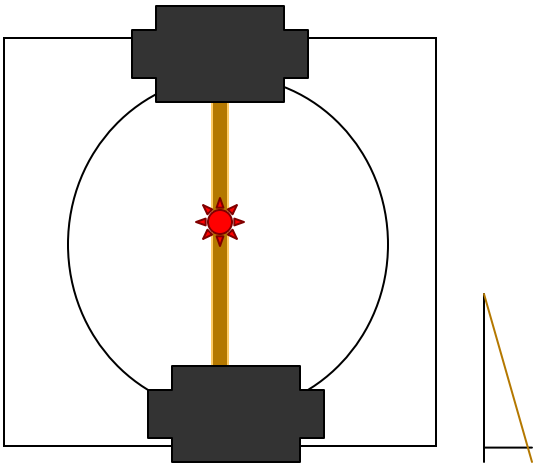


Figure 12: Diagram of the mounted hair from the source side of the set up. Small side image included to the right which illustrates that there was a small lip at the bottom of the slide holder this is actually the area to which the bottom of the hair was attached. As a result the hair made a slight angle from the perpendicular to the stand.

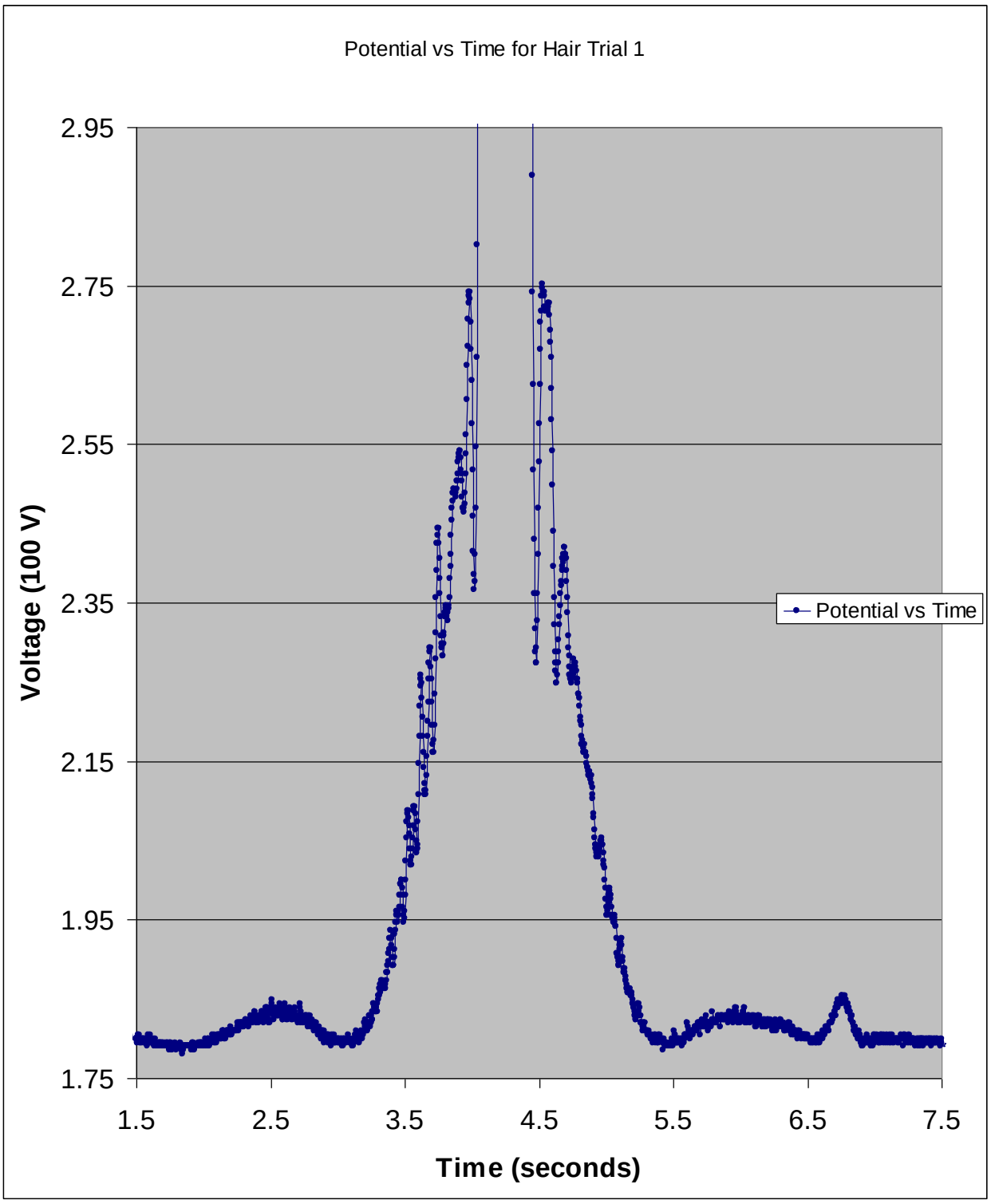


Figure 13: Close up of potential versus time graph from the hair trial. Please note that this graph was created from the raw data saved from logger pro into a text file. The graph was re-created in Excel. The original graph was inadvertently not saved.

Day 2:

Before I began making any of the measurements of diffraction patterns I put the slit slides under the traveling microscope and recorded measurements to try to determine the accuracy of the printed labels on the slit slides. Below is the recorded measurements I made. When I was looking under the microscope, I made certain that I could see the entire slit clearly, I aligned the left side of the opening of the slit with the line in the eyepiece of the microscope and recorded the reading, then I moved the line in the eyepiece to align with the right side and recorded the reading.

Data Table :2		Slit Width and Spacing Measurements made with Traveling Telescope																
Slit Type	Average slit width (micrometers ±0.007)	average distance between slits (micrometers ±0.007)	First Slit (position in Micrometers ±0.005)			Second Slit (position in micrometers ±0.005)			Third Slit (position in micrometers ±0.005)			Fourth Slit (position in micrometers ±0.005)			Fifth Slit (position in micrometers ±0.005)		
			L	R	Δ	L	R	Δ	L	R	Δ	L	R	Δ	L	R	Δ
Single Slit B	6.020	n/a	8.00	1.98	6.02												
Single Slit C	7.100	n/a	8.98	1.88	7.10												
Double Slit B	0.535	4.61	8.74	8.21	0.53	3.60	3.06	0.54									
Double Slit C	0.845	1.66	7.89	7.05	0.84	5.39	4.54	0.85									
Multi Slit C (4)	0.445	0.87	7.23	6.81	0.42	5.93	5.51	0.42	4.60	4.11	0.49	3.29	2.84	0.45			
Multi Slit D (5)	0.364	0.9	8.88	8.52	0.36	7.66	7.29	0.37	6.38	6.02	0.36	5.08	4.74	0.34	3.85	3.46	0.39

I noticed when I was taking the readings that I occasionally had difficulty seeing the numbers inside the scope, so I tried to double check the numbers prior to recording them. The error in these readings would be to ½ of the smallest measurement as recorded. Looking at the numbers it seems clear that perhaps there is a magnification factor that I neglected in recording or that there was an significant error in either the reading from the microscope or the manufacturer printed lables. Single slit b should be .04 micrometers, c should be .08 micrometers etcetera (refer to data tables 1 and 3 for remaining manufacturer expected values). Unfortunately, there doesn't seem to even be a trend from which we can say that the data has been skewed, which means that this without redoing this piece of the experiment the data is not useful. On a future lab I would need some assistance (at least initially) to ensure that I was reading the micrometers properly.

After I made the measurements with the traveling microscope I set up my optic track just like I did on the first day, see initial diagram in day 1.

Data Table 3:	Record of Slit Trials from day 2				
Slide Label	No of trials	Labeled slit width (mm)	Labeled distance between the slits (mm)	location of the slide (cm)	location of the photodetector (cm)
double slit C	1	.08	.25	34.3	115+6
Four slit C	2	.08	Not recorded	34.3	115+6
Five slit D	2	.04	.125	38.4	115+34

Potential vs Time for Single Slit C
Diffraction Pattern – Trial 1

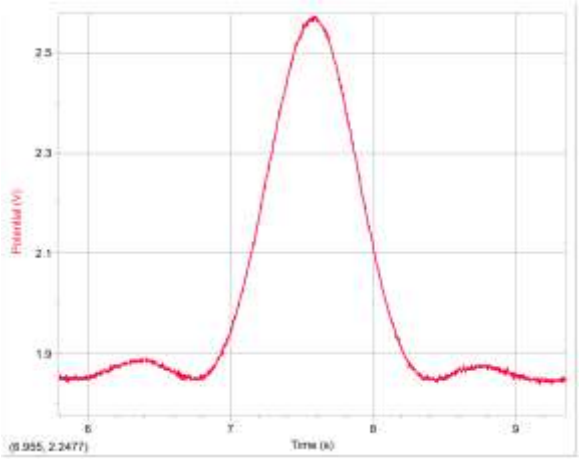
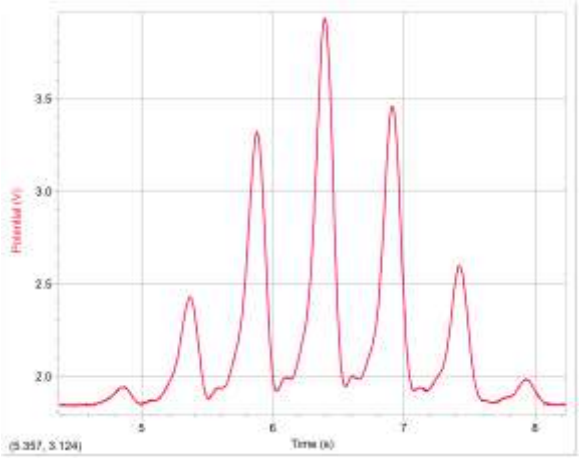


Figure 14: Potential vs Time graphs from loggerpro of the first trial single slit C.

Potential vs Time for Four Slit D – Trial 1



Potential vs Time for Four Slit D– Trial 2

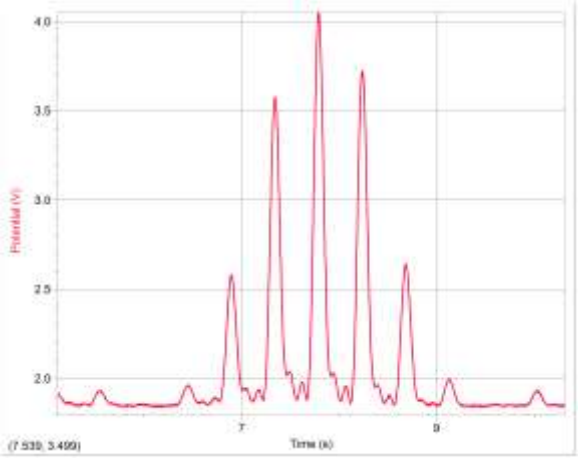
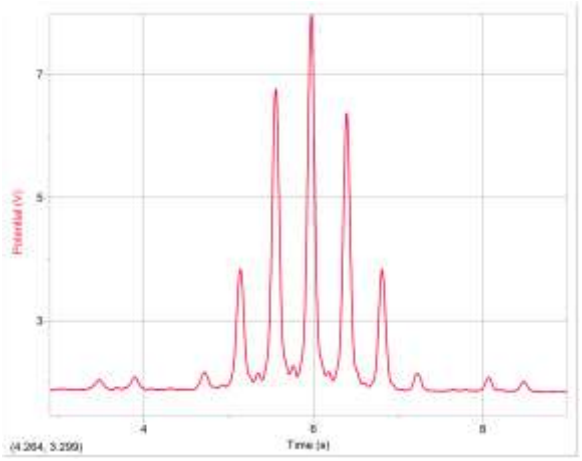


Figure 15: Potential vs Time graphs from loggerpro of the first trial four slit D.

Potential vs Time for Five Slit D– Trial 1



Potential vs Time for Four Slit D– Trial 2

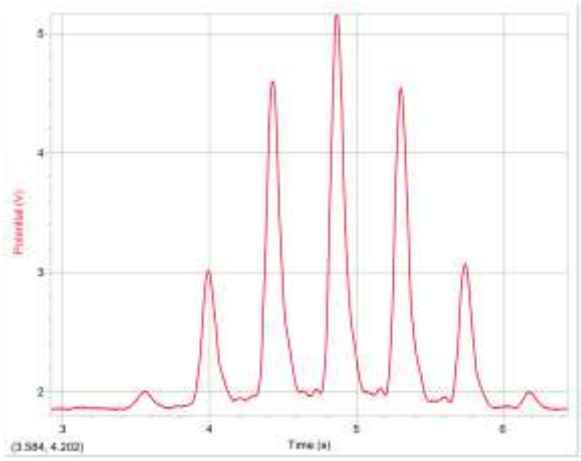


Figure 16: Potential vs Time graphs from loggerpro of the five slit D.

After measurements were made of the five slit diffraction pattern the slide holder was placed at 44.6 cm and a small converging lens was placed at 50.6 cm. an image of the individual slits (not the diffraction pattern) was then visible on the wall which was a little more than 17 tiles away from where the lens was on the optic track. Each tile is 227±.1 cm. In addition to the 17 tiles there were two partial tiles measured at 110±.1cm and 160±.1 cm. So the total distance from the lens to the wall was 4129 ±.1 cm. The photodetector was run through this patter at 110 cm + 6 cm.

Potential vs Time for Five Slit D with lens– Trial 1

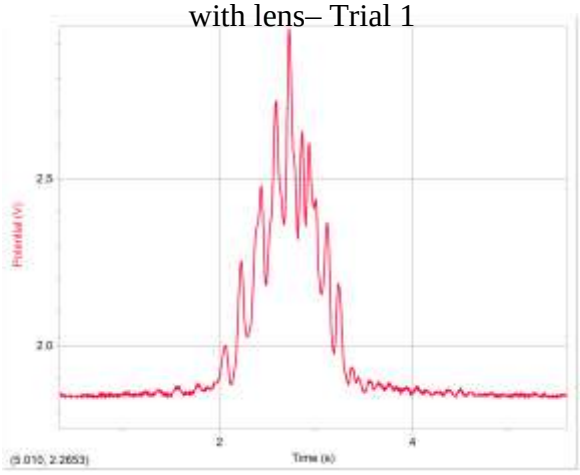
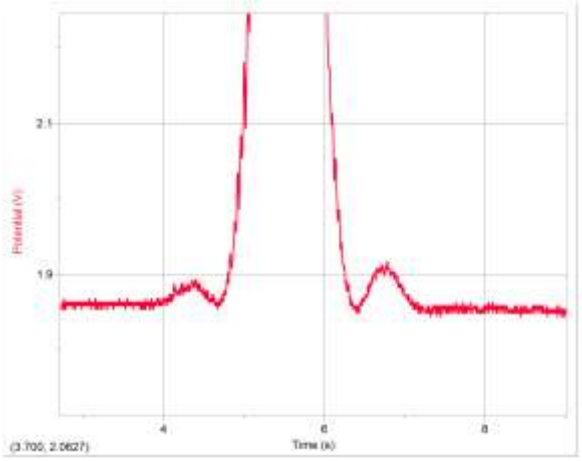


Figure 17: Potential vs Time graphs from loggerpro of the five slit D with small converging lens

Part 3:
I redid the measurements of the diffraction pattern created by the hair. The set up was the same as the first day with the exception that this time I wrapped the hair around the bottom lip of the slide holder and pushed the clamp on the lip so that it held the hair straight against the opening of the slide holder thereby eliminating the angle that the sample had been held at the first day. Two readings were taken.

Close up of hair diffraction pattern
Potential vs Time Trial 1



Close up of hair diffraction pattern
Potential vs Time Trial 2

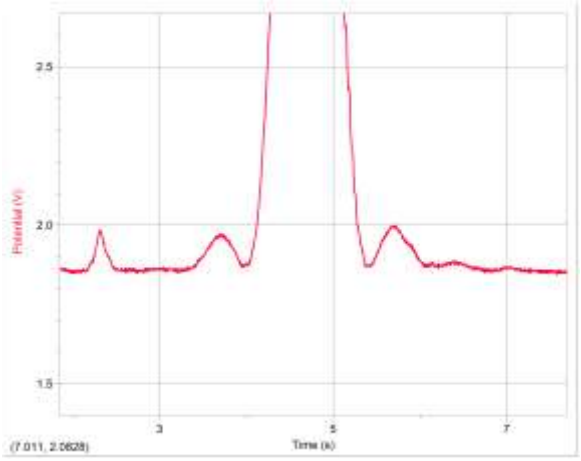


Figure 18: Potential vs Time graphs from loggerpro of the hair.

Analysis of Data:
For the first part of the lab we were tasked to see how well the single slit data fit the sinc function in the far field and from that data determine the slit parameters. Then we were to verify the N^2 dependence for the multiple slit diffraction patterns and compare our results with the measurements made under the traveling microscope. Mathematica was used to fit the data obtained from logger pro.

Day 1 Fitted Graphs from Mathematica:
Note for all of the graphs – the pink line is the fitted line calculated by Mathematica the blue line is the graph created from the text file of the data taken from loggerpro. For the single slit data the graphs are fitted to sinc function.

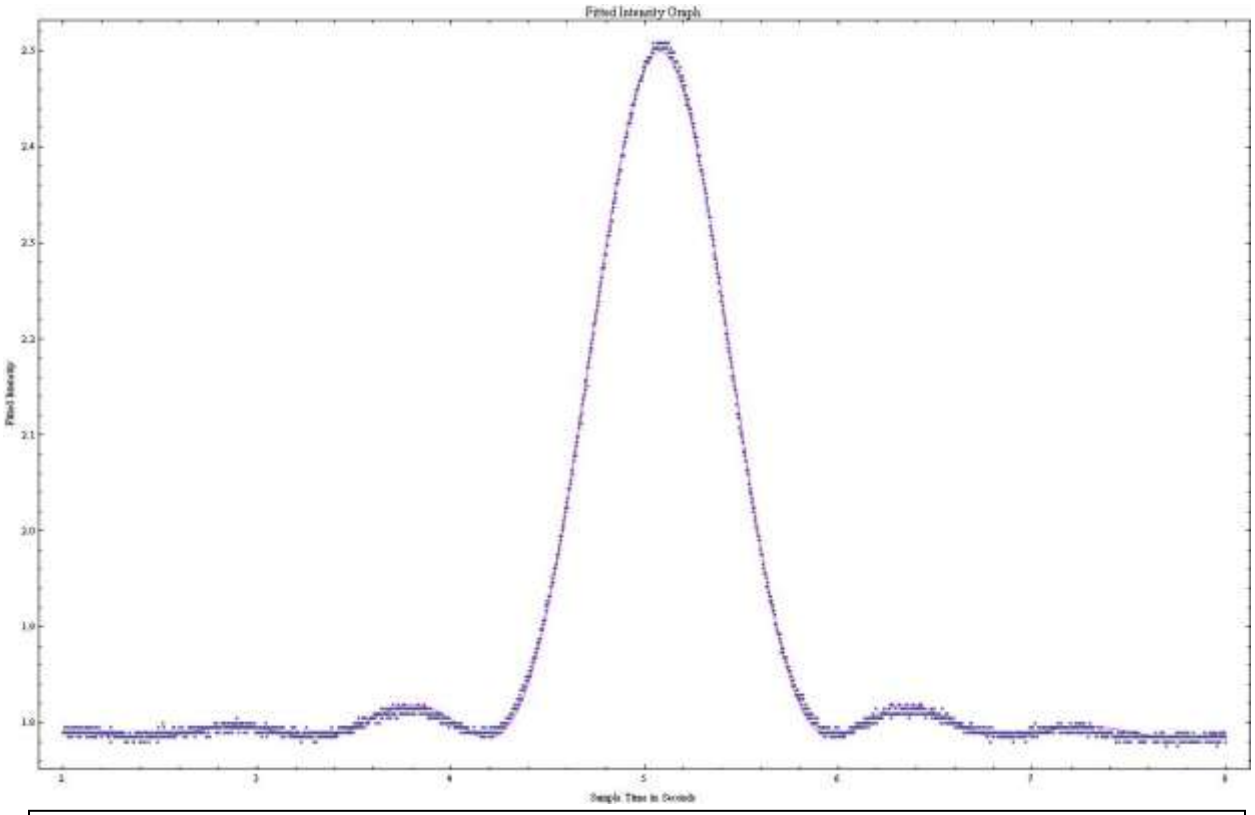


Figure 19: Single Slit B Trial 3 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.172,{BestFit→1.78463 +(0.71562 (1.×10^-9+Sin[3.53388 (-5.07908+t)]^2))/(1.×10^-9+12.4883 (-
5.07908+t)^2),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 0.71562, 0.000453658, {0.71473,0.716509}},
    {k, 3.53388, 0.00227683, {3.52941,3.53834}},
    {c, 5.07908, 0.000232678, {5.07862,5.07953}},
    {offset, 1.78463, 0.000136728, {1.78436,1.7849}}
            }
```

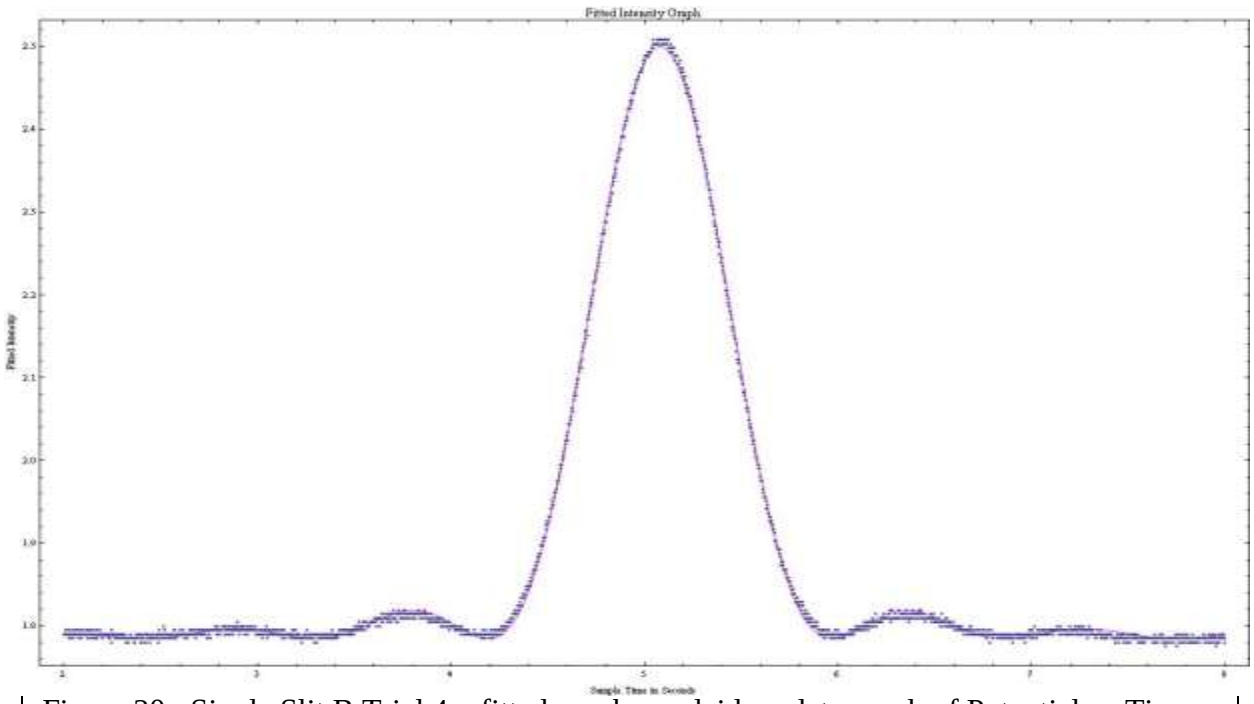


Figure 20: Single Slit B Trial 4 – fitted graph overlaid on data graph of Potential vs Time.

{0.188,{BestFit→1.7844 +(0.661547 (1.×10^-9+Sin[3.5797 (-3.46655+t)]^2))/(1.×10^-9+12.8143 (-3.46655+t)^2),ParameterCITable→{
{\[Null], Estimate, Asymptotic SE, CI},
{i0, 0.661547, 0.000618587, {0.660334,0.66276}},
{k, 3.5797, 0.00340238, {3.57303,3.58637}},
{c, 3.46655, 0.000343422, {3.46587,3.46722}},
{offset, 1.7844, 0.000162377, {1.78408,1.78472}}}}}

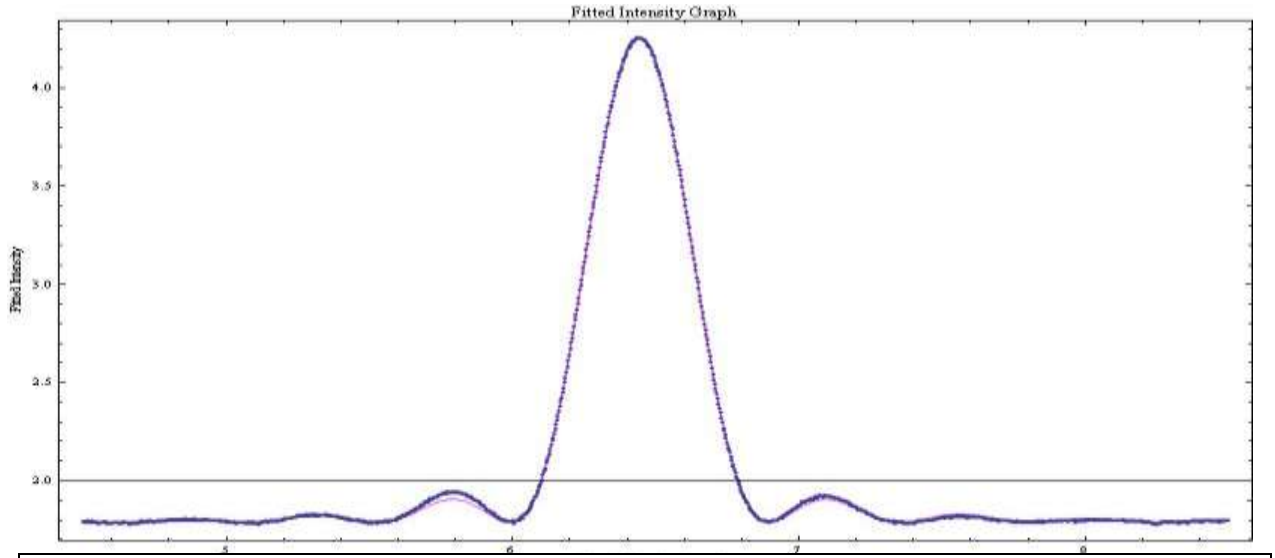


Figure 21: Single Slit C Trial 1 – fitted graph overlaid on data graph of Potential vs Time.

{0.109,{BestFit→1.78833 +(2.47285 (1.×10^-9+Sin[6.90122 (-6.44248+t)]^2))/(1.×10^-9+47.6268 (-6.44248+t)^2),ParameterCITable→{
{\[Null], Estimate, Asymptotic SE, CI},
{i0, 2.47285, 0.00133106, {2.47024,2.47546}},
{k, 6.90122, 0.00376699, {6.89383,6.90861}},
{c, 6.44248, 0.000102642, {6.44228,6.44268}},
{offset, 1.78833, 0.000343489, {1.78766,1.78901}}}}}

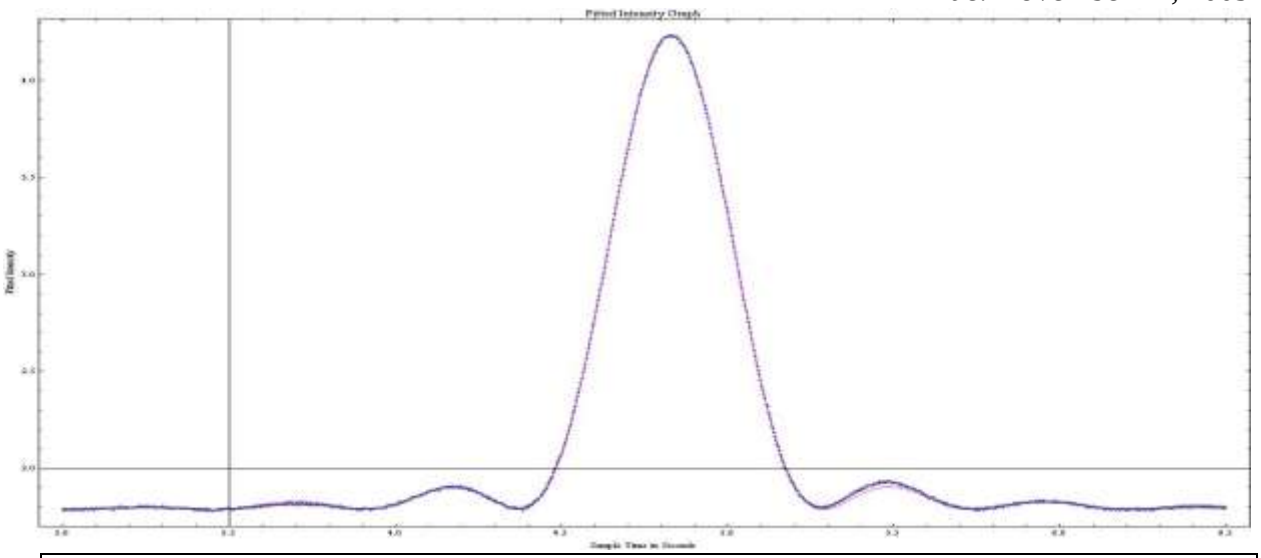


Figure 22: Single Slit C Trial 2 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.094,{BestFit→1.78891 +(2.44726 (1.×10^-9+Sin[6.85262 (-4.8294+t)]^2))/(1.×10^-9+46.9583 (-
4.8294+t)^2),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 2.44726, 0.00104213, {2.44521,2.4493}},
    {k, 6.85262, 0.00297717, {6.84677,6.85846}},
    {c, 4.8294, 0.0000812929, {4.82924,4.82956}},
      {offset, 1.78891, 0.000293339, {1.78834,1.78949}} }}}
```

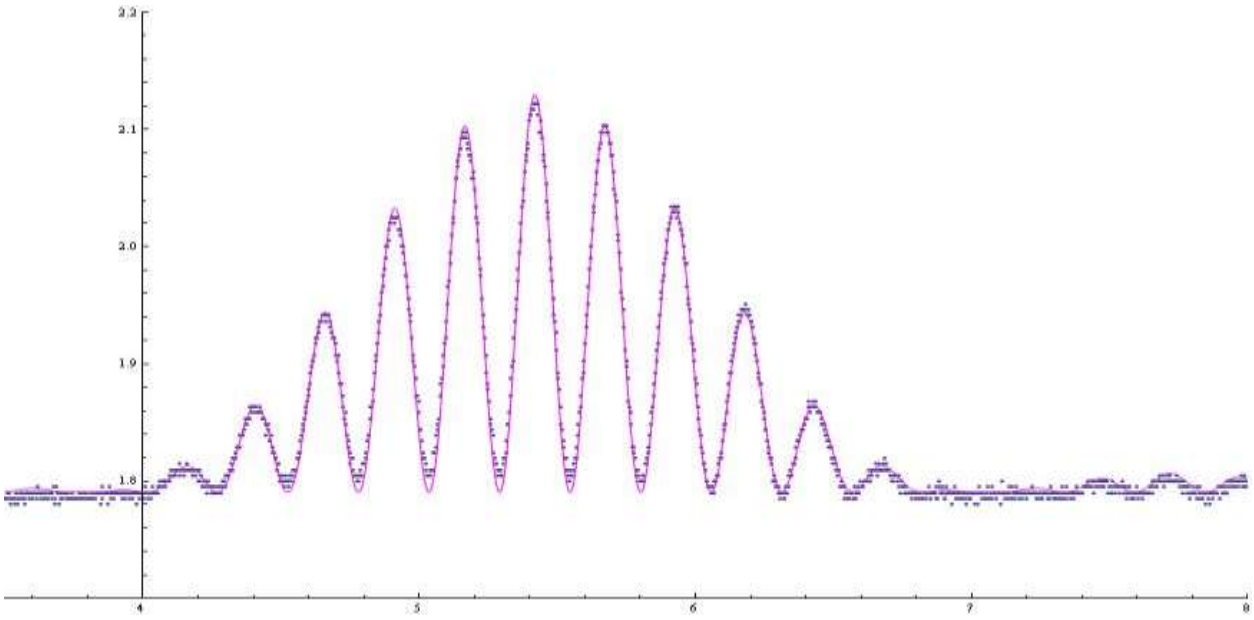


Figure 23: Double Slit B Trial 1 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.328,{BestFit→1.79047 +(0.0847703 (1.×10^-9+Sin[1.93906 (-5.41867+t)]^2) (4.×10^-9+Sin[24.5858
(-5.41867+t)]^2))/((1.×10^-9+3.75995 (-5.41867+t)^2) (1.×10^-9+Sin[12.2929 (-
5.41867+t)]^2)),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 0.0847703, 0.000178919, {0.0844193,0.0851212}},
    {kα, 1.93906, 0.00430745, {1.93061,1.94751}},
      {kβ, 12.2929, 0.0034183, {12.2862,12.2996}},
    {c, 5.41867, 0.000116378, {5.41844,5.4189}},
    {bgd, 1.79047, 0.000215645, {1.79005,1.7909}} } } }
```

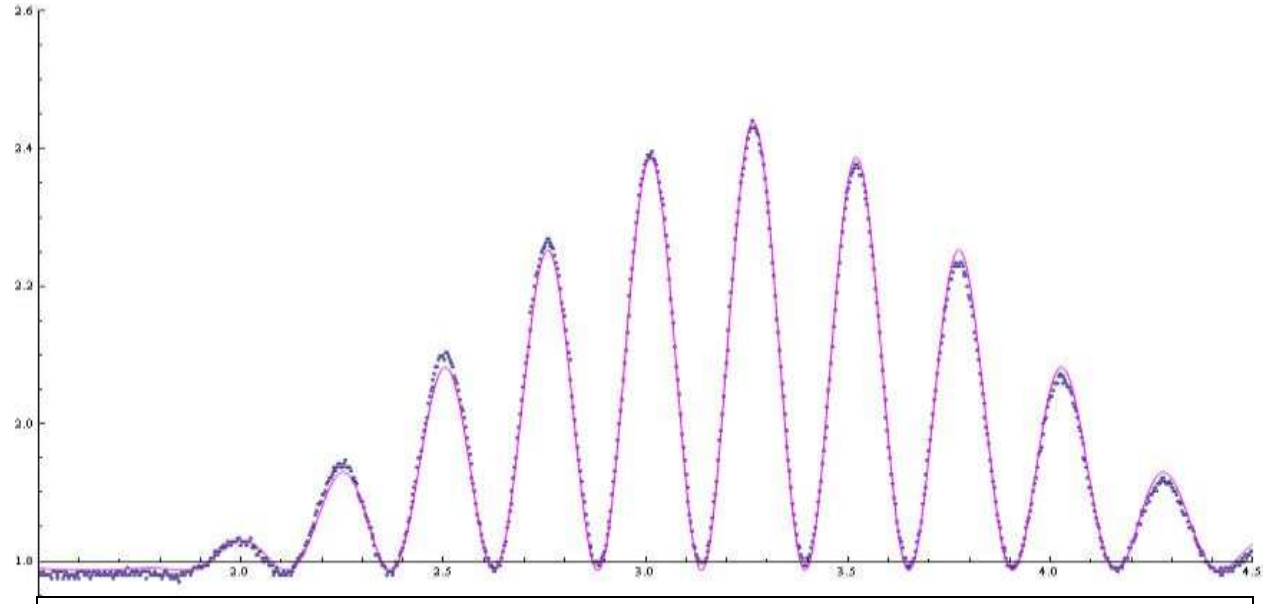


Figure 24: Double Slit B Trial 2 – fitted graph overlaid on data graph of Potential vs Time.

{0.219,{BestFit→1.7871 +(0.162668 (1.×10^{-9}+Sin[1.93263 (-3.26531+t)]^2) (4.×10^{-9}+Sin[24.5239 (-3.26531+t)]^2))/((1.×10^{-9}+3.73504 (-3.26531+t)^2) (1.×10^{-9}+Sin[12.2619 (-3.26531+t)]^2)),ParameterCITable→{
{\[Null], Estimate, Asymptotic SE, CI},
{i0, 0.162668, 0.000286998, {0.162105,0.163231}},
{kα, 1.93263, 0.00386357, {1.92504,1.94021}},
{kβ, 12.2619, 0.00271697, {12.2566,12.2673}},
{c, 3.26531, 0.0000914981, {3.26513,3.26548}},
{bgd, 1.7871, 0.000474164, {1.78617,1.78803}} }}}

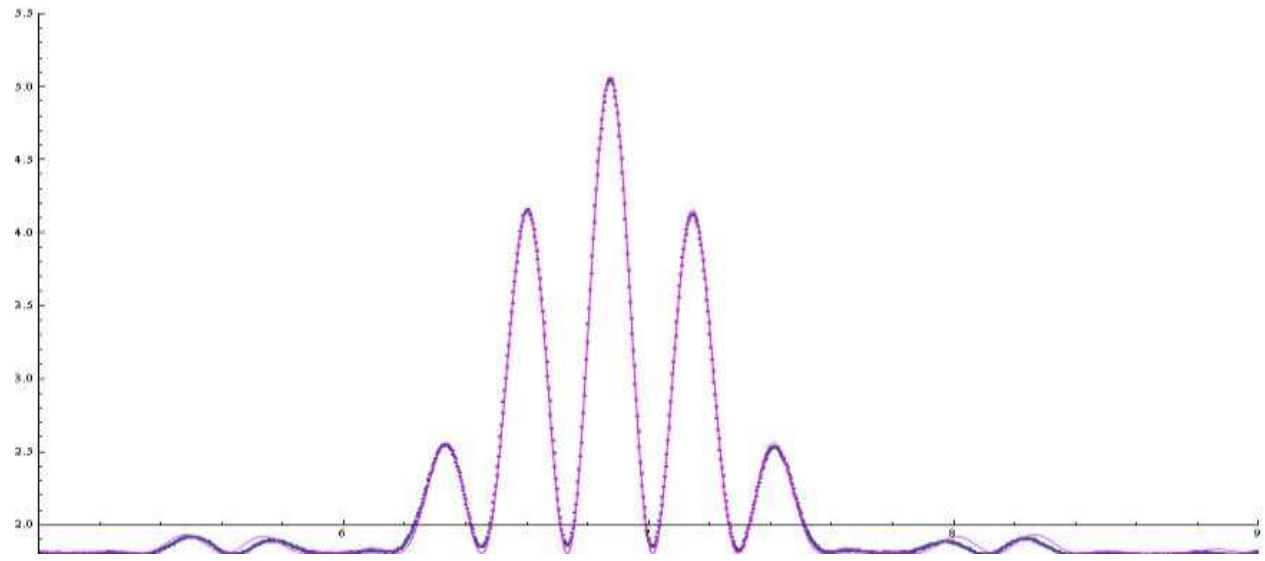


Figure 25: Double Slit C Trial 1 – fitted graph overlaid on data graph of Potential vs Time.

{0.328,{BestFit→1.80229 +(0.815576 (1.×10^{-9}+Sin[3.53141 (-6.87294+t)]^2) (4.×10^{-9}+Sin[22.4035 (-6.87294+t)]^2))/((1.×10^{-9}+12.4709 (-6.87294+t)^2) (1.×10^{-9}+Sin[11.2017 (-6.87294+t)]^2)),ParameterCITable→{
{\[Null], Estimate, Asymptotic SE, CI},
{i0, 0.815576, 0.000934389, {0.813743,0.817409}},
{kα, 3.53141, 0.00418983, {3.52319,3.53963}},
{kβ, 11.2017, 0.00344461, {11.195,11.2085}},
{c, 6.87294, 0.0000715927, {6.8728,6.87308}},
{bgd, 1.80229, 0.000842506, {1.80064,1.80395}} }}}

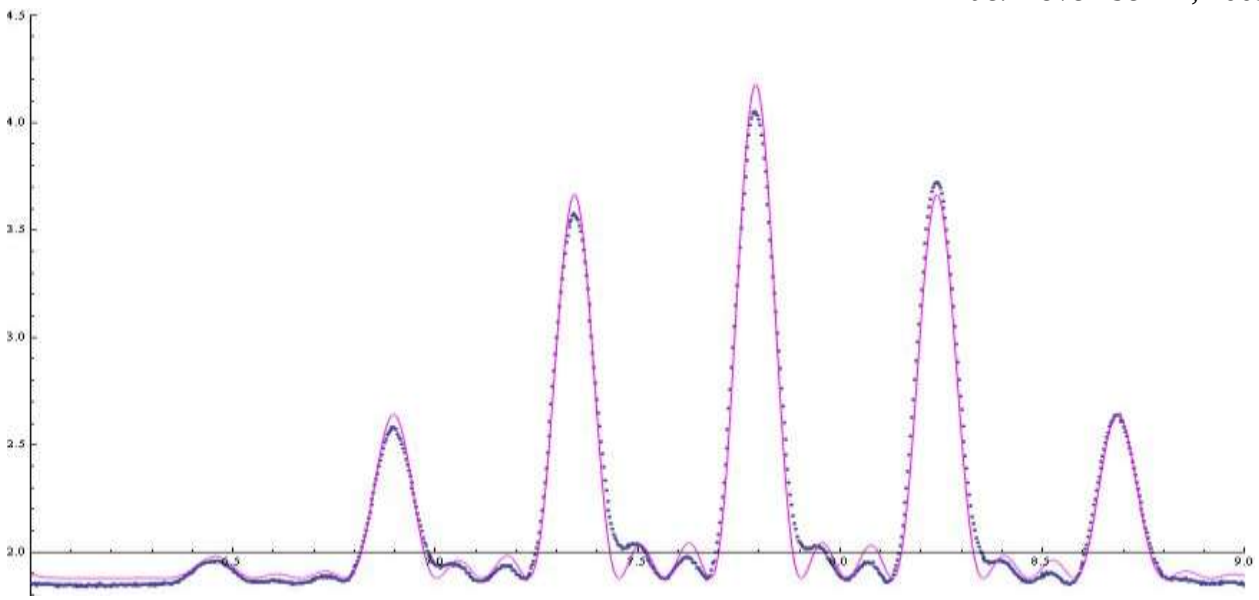


Figure 26: Double Slit C Trial 2 – fitted graph overlaid on data graph of Potential vs Time.

{0.234,{BestFit→1.80681 +(0.818975 (1.×10^-9+Sin[3.54469 (-3.95315+t)]^2) (4.×10^-9+Sin[22.4389 (-3.95315+t)]^2))/((1.×10^-9+12.5648 (-3.95315+t)^2) (1.×10^-9+Sin[11.2195 (-3.95315+t)]^2)),ParameterCITable→{
{\[Null], Estimate, Asymptotic SE, CI},
{i0, 0.818975, 0.00101064, {0.816992,0.820958}},
{kα, 3.54469, 0.00457372, {3.53572,3.55367}},
{kβ, 11.2195, 0.00368673, {11.2122,11.2267}},
{c, 3.95315, 0.0000758995, {3.953,3.9533}},
{bgd, 1.80681, 0.00103575, {1.80478,1.80884}}}}}

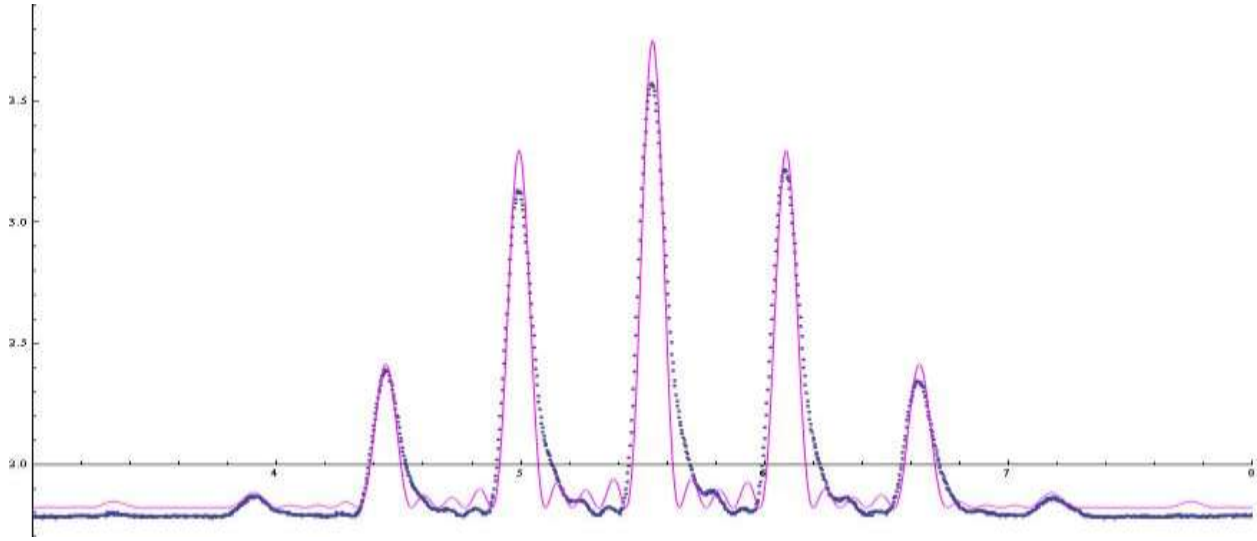


Figure 27: Five Slit Slit D Trial 1 – fitted graph overlaid on data graph of Potential vs Time.

{0.375,{BestFit→1.82137 +(0.0772131 (1.×10^-9+Sin[1.61518 (-5.54031+t)]^2) (2.5×10^-8+Sin[28.6124 (-5.54031+t)]^2))/((1.×10^-9+2.60882 (-5.54031+t)^2) (1.×10^-9+Sin[5.72249 (-5.54031+t)]^2)),ParameterCITable→{
{\[Null], Estimate, Asymptotic SE, CI},
{i0, 0.0772131, 0.000599584, {0.076037,0.0783892}},
{kα, 1.61518, 0.0132469, {1.5892,1.64117}},
{kβ, 5.72249, 0.00411292, {5.71442,5.73056}},
{c, 5.54031, 0.000356968, {5.53961,5.54101}},
{bgd, 1.82137, 0.00255559, {1.81636,1.82639}}}}}

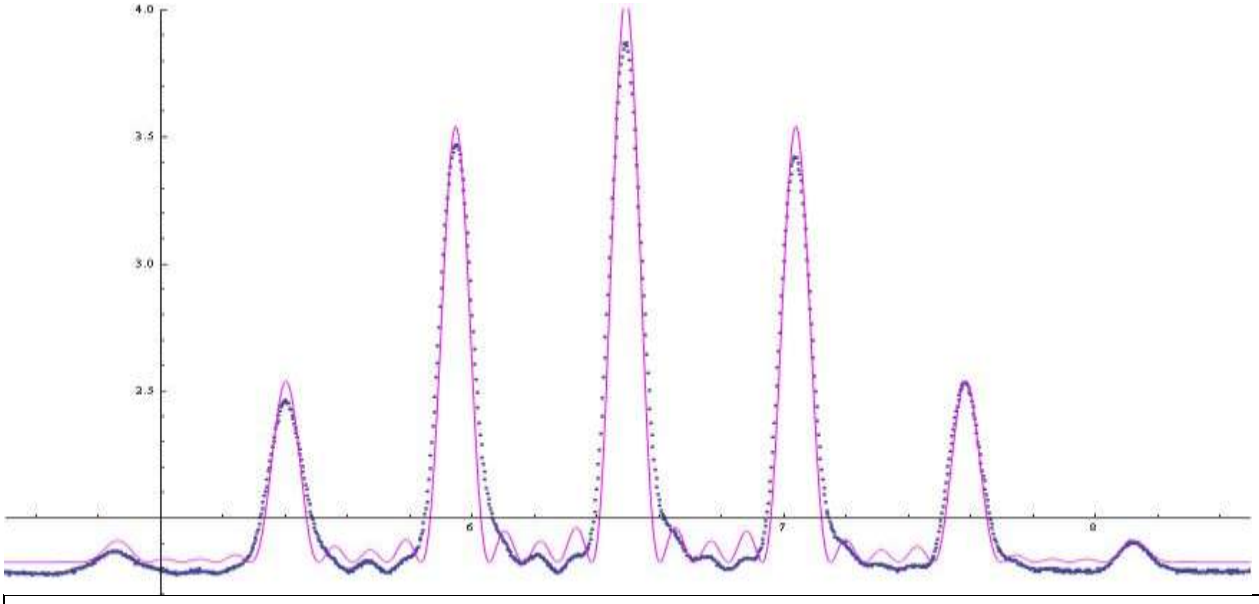


Figure 28: Five Slit Slit D Trial 2 – fitted graph overlaid on data graph of Potential vs Time.

{0.312,{BestFit→1.82602 +(0.0889411 (1.×10^{-9}+Sin[1.59387 (-6.49268+t)]^2) (2.5×10^{-8}+Sin[28.6862 (-6.49268+t)]^2))/((1.×10^{-9}+2.54042 (-6.49268+t)^2) (1.×10^{-9}+Sin[5.73724 (-6.49268+t)]^2)),ParameterCITable→{
{\[Null], Estimate, Asymptotic SE, CI},
{i0, 0.0889411, 0.000562696, {0.0878372,0.0900451}},
{kα, -1.59387, 0.0111202, {-1.61569,-1.57205}},
{kβ, 5.73724, 0.00329094, {5.73078,5.74369}},
{c, 6.49268, 0.000288274, {6.49212,6.49325}},
{bgd, 1.82602, 0.00281541, {1.82049,1.83154}} }}}

Day 2 Mathematica Fitted Graphs

Figure 29: Double Slit Slit C Trial 1 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.219,{BestFit→1.87946 +(0.143645 (1.×10^-9+Sin[1.91428 (-7.79101+t)]^2) (1.6×10^-8+Sin[27.9161 (-
7.79101+t)]^2))/((1.×10^-9+3.66447 (-7.79101+t)^2) (1.×10^-9+Sin[6.97903 (-7.79101+t)]^2)),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 0.143645, 0.000616035, {0.142436,0.144854}},
    {kα, 1.91428, 0.00924127, {1.89614,1.93242}},
    {kβ, 6.97903, 0.00327786, {6.9726,6.98546}},
    {c, 7.79101, 0.000195555, {7.79063,7.7914}},
    {bgd, 1.87946, 0.00234159, {1.87486,1.88405}} } } }
```

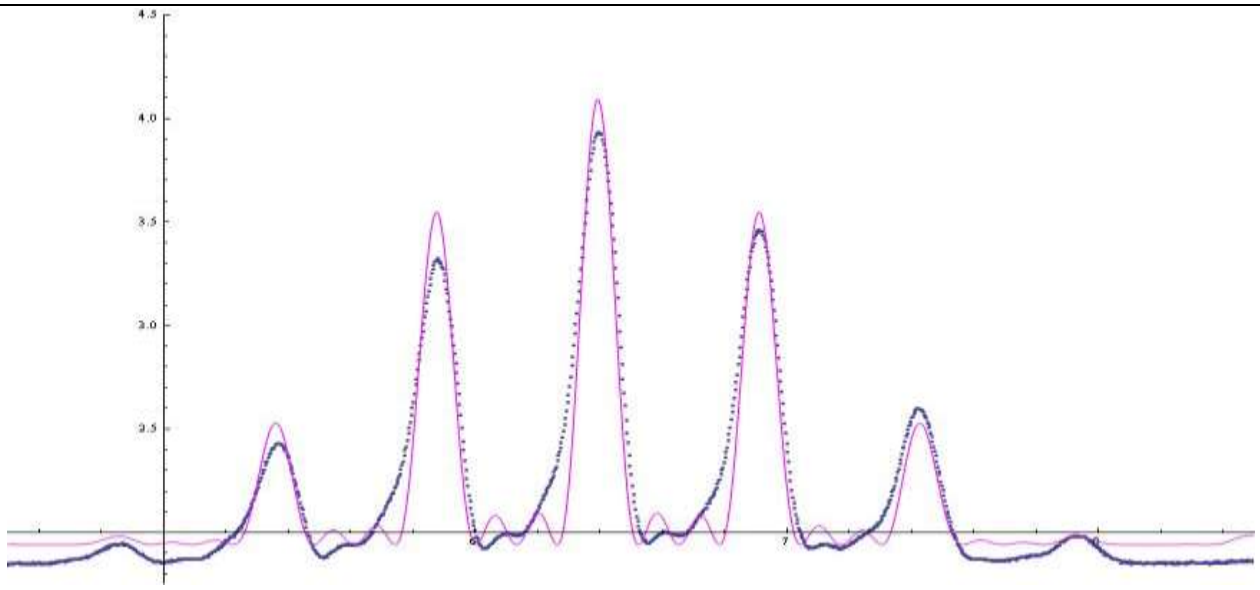


Figure 30: Four Slit Slit C Trial 1 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.312,{BestFit→1.94057 +(0.13446 (1.×10^-9+Sin[1.77643 (-6.39319+t)]^2) (1.6×10^-8+Sin[24.1305 (-
6.39319+t)]^2))/((1.×10^-9+3.1557 (-6.39319+t)^2) (1.×10^-9+Sin[6.03261 (-6.39319+t)]^2)),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 0.13446, 0.00120353, {0.132099,0.136821}},
    {kα, -1.77643, 0.0172451, {-1.81026,-1.7426}},
      {kβ, 6.03261, 0.00648564, {6.01989,6.04534}},
    {c, 6.39319, 0.000484546, {6.39224,6.39414}},
    {bgd, 1.94057, 0.00411679, {1.93249,1.94864}} } } }
```

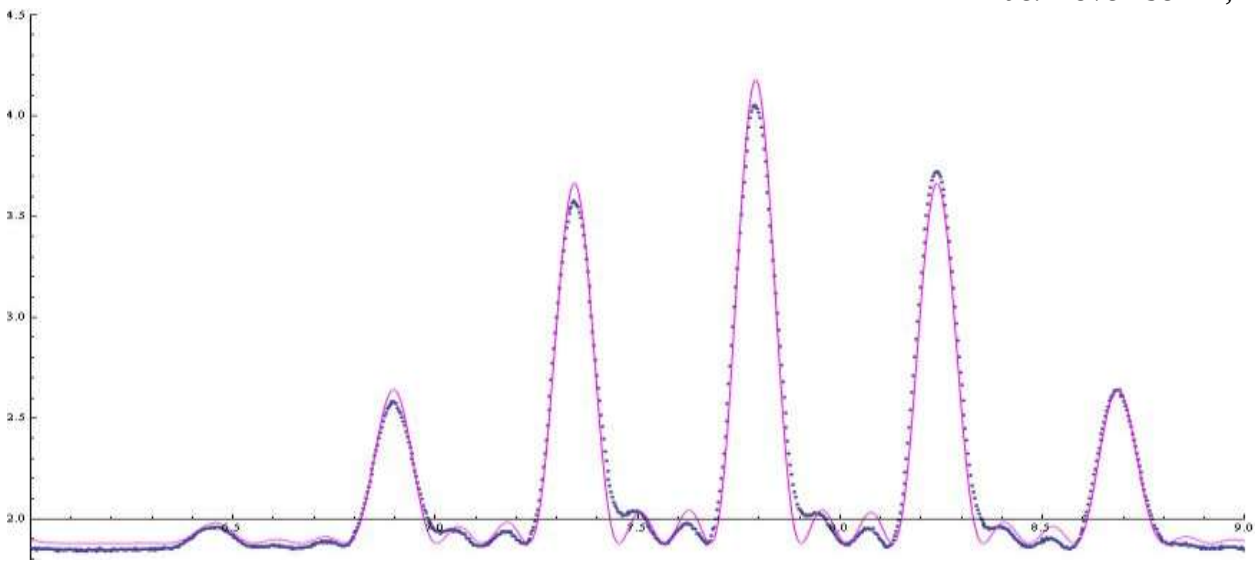


Figure 31: Four Slit Slit C Trial 2 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.234,{BestFit→1.87946 +(0.143645 (1.×10^-9+Sin[1.91428 (-7.79101+t)]^2) (1.6×10^-8+Sin[27.9161 (-
7.79101+t)]^2))/((1.×10^-9+3.66447 (-7.79101+t)^2) (1.×10^-9+Sin[6.97903 (-7.79101+t)]^2)),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 0.143645, 0.000616035, {0.142436,0.144854}},
    {kα, 1.91428, 0.00924127, {1.89614,1.93242}},
    {kβ, 6.97903, 0.00327786, {6.9726,6.98546}},
    {c, 7.79101, 0.000195555, {7.79063,7.7914}},
    {bgd, 1.87946, 0.00234159, {1.87486,1.88405}}   } } }
```

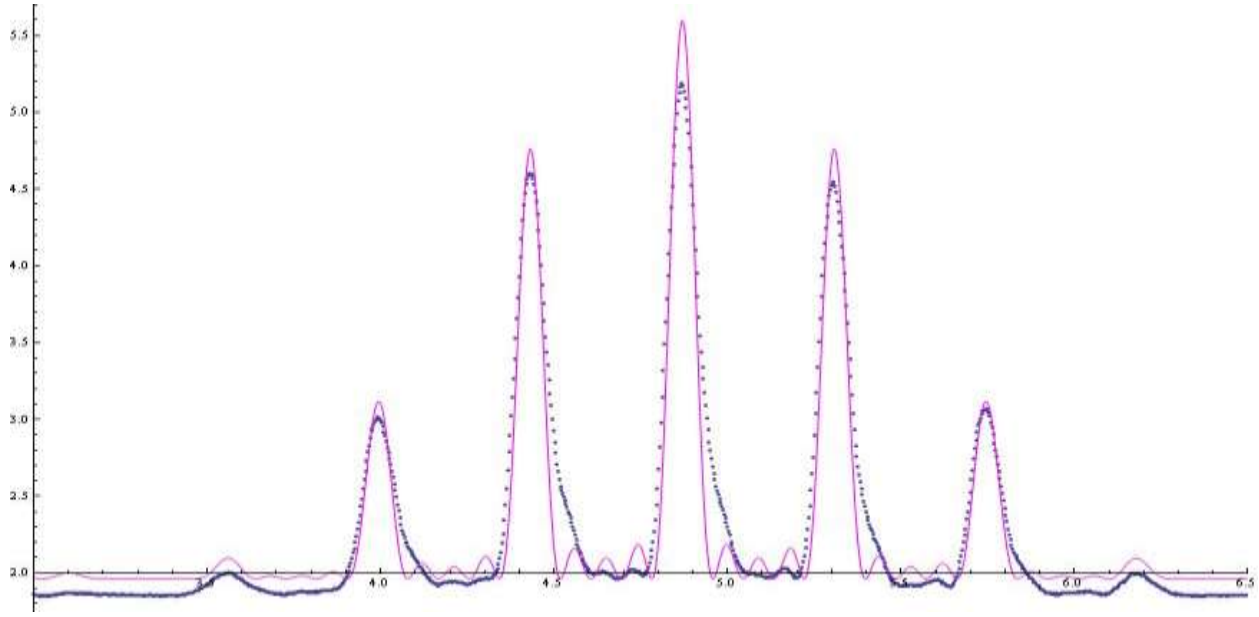


Figure 32: Five Slit Slit D Trial 2 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.266,{BestFit→1.96235 +(0.145325 (1.×10^-9+Sin[1.99154 (-4.86962+t)]^2) (2.5×10^-8+Sin[35.7446 (-
4.86962+t)]^2))/((1.×10^-9+3.96624 (-4.86962+t)^2) (1.×10^-9+Sin[7.14892 (-4.86962+t)]^2)),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 0.145325, 0.00139619, {0.142586,0.148065}},
    {kα, -1.99154, 0.0206471, {-2.03206,-1.95103}},
    {kβ, 7.14892, 0.00625484, {7.13665,7.16119}},
    {c, 4.86962, 0.000352075, {4.86893,4.87031}},
    {bgd, 1.96235, 0.00654727, {1.94951,1.9752}} } } }
```

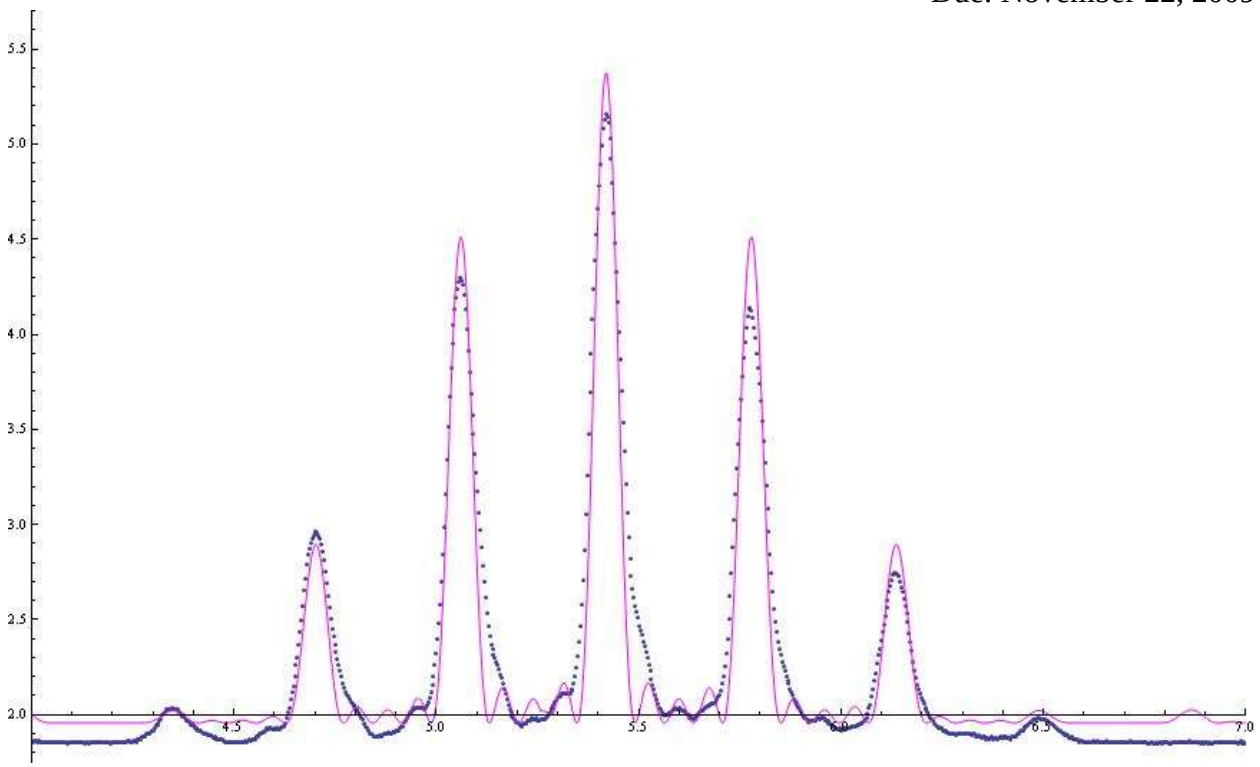


Figure 33: Five Slit Slit D Trial 3 – fitted graph overlaid on data graph of Potential vs Time.

```
{0.234,{BestFit→1.95665 +(0.13672 (1.×10^-9+Sin[2.56036 (-5.4189+t)]^2) (2.5×10^-8+Sin[43.6133 (-
5.4189+t)]^2))/((1.×10^-9+6.55542 (-5.4189+t)^2) (1.×10^-9+Sin[8.72266 (-5.4189+t)]^2)),ParameterCITable→{
    {\[Null], Estimate, Asymptotic SE, CI},
    {i0, 0.13672, 0.00141875, {0.133935,0.139504}},
    {kα, 2.56036, 0.0284005, {2.50462,2.61609}},
      {kβ, 8.72266, 0.00868795, {8.70561,8.73971}},
    {c, 5.4189, 0.000312353, {5.41829,5.41952}},
    {bgd, 1.95665, 0.0062465, {1.94439,1.96891}}  } } }
```

Single Slit Data Analysis:

For fitting the single slit diffraction patterns we expect the data to fit a graph of the function: $I(x)=I(0)(\text{Sin}(\pi ax/\lambda D)/(\pi ax/\lambda D))^2$ or $I(0)(\sin\theta/\theta)^2$ where θ is the diffraction angle (half of the distance of the central peak). We expect the central peak to be a width W which is equal to $2L\lambda/a$ where L is the distance from the slit to the photodetector, λ is the wavelength of the source light, and a is the aperture width. For our experiment we are using a helium neon laser with a wavelength of light at 632.8 nanometers or .6328 μm. So for our single slit diffraction patterns we anticipate that $a=1.2656L/W$. From the first lab we did on the Gaussian beam we determined that the speed of the photodetector was 1.00±.06 cm/second. Because we are determining the width of the diffraction pattern based on the time reading from our graphs, the width of the central peak is the difference between the times at the first two minimum times the speed of our photo detector. This calculation will give us the number of centimeters between the minimum. We can then calculate the slit width (please refer to data table 5 for calculations of single slit widths).

For the fitting of the single slit diffraction patterns we used

$$\text{model} = \text{offset} + I_0\,(\text{Sin}[k(t-c)]^2 + 1.\times 10^{-9})/((k(t-c))^2 + 1.\times 10^{-9});$$

Where k is the wave number – t is the time for the central peak, and c half the width of the central peak.

Please refer to data table 4 for the parameters from the Mathematica fitted graphs.

Data Table 4: Analysis of Single Slit Data

		Labeled						From Fitted Graphs			
Lab Day	Trial #	slit width (mm)	distance between the slits (mm)	location of the slide (cm)	location of the photodetector (cm)	distance between slide and detector (cm)	σ (cm)	Io (100 V)	k	c	offset
day 1B	trial 3	0.04	n/a	60.2	121	60.8	0.5	0.71562	3.5388	5.07908	1.78463
day 1B	trial 4	0.04	n/a	60.2	121	60.8	0.5	0.661547	3.5797	3.46655	1.7844
day 1C	trial 1	0.08	n/a	60.2	121	60.8	0.5	2.47285	6.90122	6.44248	1.78833
day 1C	trial 2	0.08	n/a	60.2	121	60.8	0.5	2.44726	6.85262	4.8294	1.78891

Data Table 5: Calculated Single Slit Width

	time readings (seconds)						Calculated based on physical readings from graph					
Lab Day	t1	σ	t2	σ	Δt	σ	width of central max (μm)	σ (μμ)	apeture width (μm)	σ (m)	apeture width in mm	σ (mm)
day 1B	4.2	0.05	5.9	0.05	1.7	0.070711	1700	105	45.3	0.01212681	0.045	0.005
day 1B	2.6	0.05	4.3	0.05	1.7	0.070711	1700	105	45.3	0.01212681	0.045	0.005
day 1C	5.9	0.05	6.8	0.05	0.9	0.070711	900	91	85.5	0.01666668	0.085	0.005
day 1C	4.3	0.05	5.3	0.05	1	0.070711	1000	93	76.9	0.01581140	0.077	0.005

Looking at the Mathematica fitted graphs there is a very good agreement with our data and the fitting to the sinc function. Additionally, as we look at the position of our first minimums

from these graphs we obtain that the width of slit b should be .045±.005mm. The error calculated in data table 5 (which is in meters) is obviously too large it is an artifact from the distance calculations that come from the time on the graph. The .003mm comes from calculating how big of a distance there was at the minimum position to try to determine the absolute position of the zero on the graph using the pointer in Mathematica. This is more likely a better estimate of the error in the measurement. I do not know what the manufacturer expected error was and as noted before there is a problem with the measurements taken from the traveling microscope so we can say that we are likely to have fair agreement with single slit b. Our calculated slit widths for slit c seem to have a little better agreement if our true value is .08mm. Our calculated values are .077 and .085 ±.05mm which seem to center nicely over the expected value. A couple of things to watch for as we repeat this lab, our offset is very high which would seem to mean that the aperture we placed on the front of the photodetector to limit the amount of light coming in was perhaps too big. We anticipate that at the minimums the photodetector will go much closer to zero so either we were likely to be picking up some ambient light (which I would assume is caused by bright reflections you can see off the side of the photodetector cover). The other thing that still need to be perfected is the alignment of the beam and the photodetector at the maximum position. Certainly if the detector is offcenter it is likely to cause an error in our measurements. Since the photodetector is not physically able to be on the optic track for this experiment this is something I would want to look at more carefully during the set up period where the lab is lit though it does not seem as though it has made a significant impact on my data.

Multi- Slit Analysis:

For fitting the multiple slit diffraction patterns we expect the data to fit a graph of the function: $I(x)=N^2I(0)\ (\text{Sin}\ (\pi ax/\lambda D)/\ (\pi ax/\lambda D))^2\ (\text{Sin}(N\pi dx/\lambda D)/N\text{sin}(\pi dx/\lambda D))^2$ where

a- Aperture width
d – the distance between the slits
D – is the distance to the photodetector
N – is the number of slits
I(0) – is our initial intensity

Mathematica uses the following fitting model to fit the data:

$$\text{model} = I_0((\text{Sin}[k\alpha(t-c)]^2 + 1.\times 10^{-9})/((k\alpha(t-c))^2 + 1.\times 10^{-9})) * ((\text{Sin}[n(k\beta(t-c))]^2 + n^2\,1.\times 10^{-9})/(\text{Sin}[k\beta(t-c)]\text{^}2 + 1.\times 10^{-9})) + \text{bgd};$$

Where bgd – is our background called offset in my lab notes. Refer to data table 6 for parameters from each trial run. In essence we expect that I(x=0) is approximately N^2.

Data table 6: Multi Slit Data Fitting											
			Labeled				Io (100 V)	k α	kβ	c	offset
Slit Type	Lab Day	Trial #	slit width (mm)	distance between the slits (mm)	location of the slide (cm)	location of the photodetector (cm)	fit	fit	fit	fit	fit
2-double slit b	day 1	trial 1	0.04	0.5	46.5	121	0.08477	1.93906	12.2929	5.41867	1.79047
2-double slit b	day 1	trial 2	0.04	0.5	46.5	121	0.162668	1.93263	12.2619	3.26531	1.7871
2double slit c	day 1	trial 1	0.08	0.25	38.4	149	0.815576	3.53141	11.2017	6.87294	1.80229
2-double slit c	day 1	trial 2	0.08	0.25	38.4	149	0.818975	3.54469	11.2195	3.95315	1.80681
4-Four slit C	day 2	trial 1	0.08	Not recorded	34.3	121	0.13446	-1.77643	6.03261	6.39319	1.94057
4-Four slit C	day 2	trial 2	0.08	Not recorded	34.3	121	0.143645	1.91428	6.97903	7.79101	1.87946
5-Five slit D	day 2	trial 1	0.04	0.125	38.4	149	0.077213	1.61518	5.72219	5.54031	1.82137
5-Five slit D	day 2	trial 2	0.04	0.125	38.4	149	-0.088941	1.59387	5.73724	6.49268	1.82602
5-Five slits D	day 1	trial 1	0.04	0.125	38.4	149	-0.145325	1.99154	7.14892	4.86962	1.96235
5-Five slits D	day 1	trial 2	0.04	0.125	38.4	149	0.13672	2.56036	8.72266	5.4189	1.95665
2-double slit C	day 2	Trial 1	0.08	0.25	34.3	121	0.143645	1.91428	6.97903	7.79101	1.87946

Looking at the results from our data our intensities are rather consistent which poses a problem when trying to compare to the N^2 law. For the double slit data, which is included in data table 7, our error in taking the reading off the graphs is about .002V (recall that the units on this side were actually in 100 V so that gives us an error of 2 V) within this error the numbers do not agree for the second trial on either of the day one readings. However, the first ones seem to agree. The only changes made in between trials were to confirm that the diffraction pattern looked straight and small adjustments may have been made to correct this on a few trials. This should make the second reading more precise than the first not less. We took 300 samples per second which should have been high enough considering that the photodetector moves about 1 cm/second so there were readings taken about every 3 microns. Perhaps in future trials we could increase this to 500 to get a little more clarity but I don't think that is what is affecting our data here.

For the multislit data I only analyzed a couple of trials, the reason for this is that you can see quite clearly that the intensity of these graphs does not increase the way we expected they are all around the same intensity that we produced with the 2 double slit slide. A couple things I think affected this. The first is that I had a tremendous amount of trouble determining when we had even illumination of the slits (this is visible in the missing peaks and the edges are sort of "pulled' to the side a little). It is noticeable when the pattern shifts left to right as you move the beam across the slide and I attempted to find that perfect position just in between. However, it is very difficult. The second is that the position where the intermediate peaks is clear is a very large distance away from the slide as we move away of course the intensity also falls off. As a result it is probable that we had the photodetector too far away from the slide to clearly read the increase in intensity. In future attempts I would move the photodetector closer. Data table 7 holds the few trials that calculations were made off of. It should be noted on the five slit data that this is one of the trials that I had difficulty getting a straight signal and indeed the second trial is better than the first as is expected.

Data Table 7 : Intensity analysis

Slit Type	Lab Day	Trial #	offset	I(x=0)	N	offset	fitted I(x=0)	N
2-double slit b	day 1	trial 1	1.784	5.414	1.905256	1.792	5.549	1.938298
2-double slit b	day 1	trial 2	1.638	3.263	1.274755	1.656	3.266	1.268858
2double slit c	day 1	trial 1	1.809	6.874	2.250555	1.809	6.874	2.250555
2-double slit c	day 1	trial 2	1.805	3.954	1.465947	1.805	3.954	1.465947
5-Five slits D	day 1	trial 1	1.777	5.537	1.939072	1.823	5.543	1.92873
5-Five slits D	day 1	trial 2	1.775	6.5	2.54951	1.826	6.494	2.548333

Part 2: Razor Blade

For the razor blade we expect to see a bright peak where the light brushed the blade then the amplitude of the intensity should fall off exponentially. The first trial with the razor blade on day one had a lot of noise and does not appear to be lined up properly. The second trial we get the peak but the fall off is much more rapid than I expected based on the pre-lab readings and lecture.

Potential vs Time Graph for Razor Blade – Day 1 Trial 2

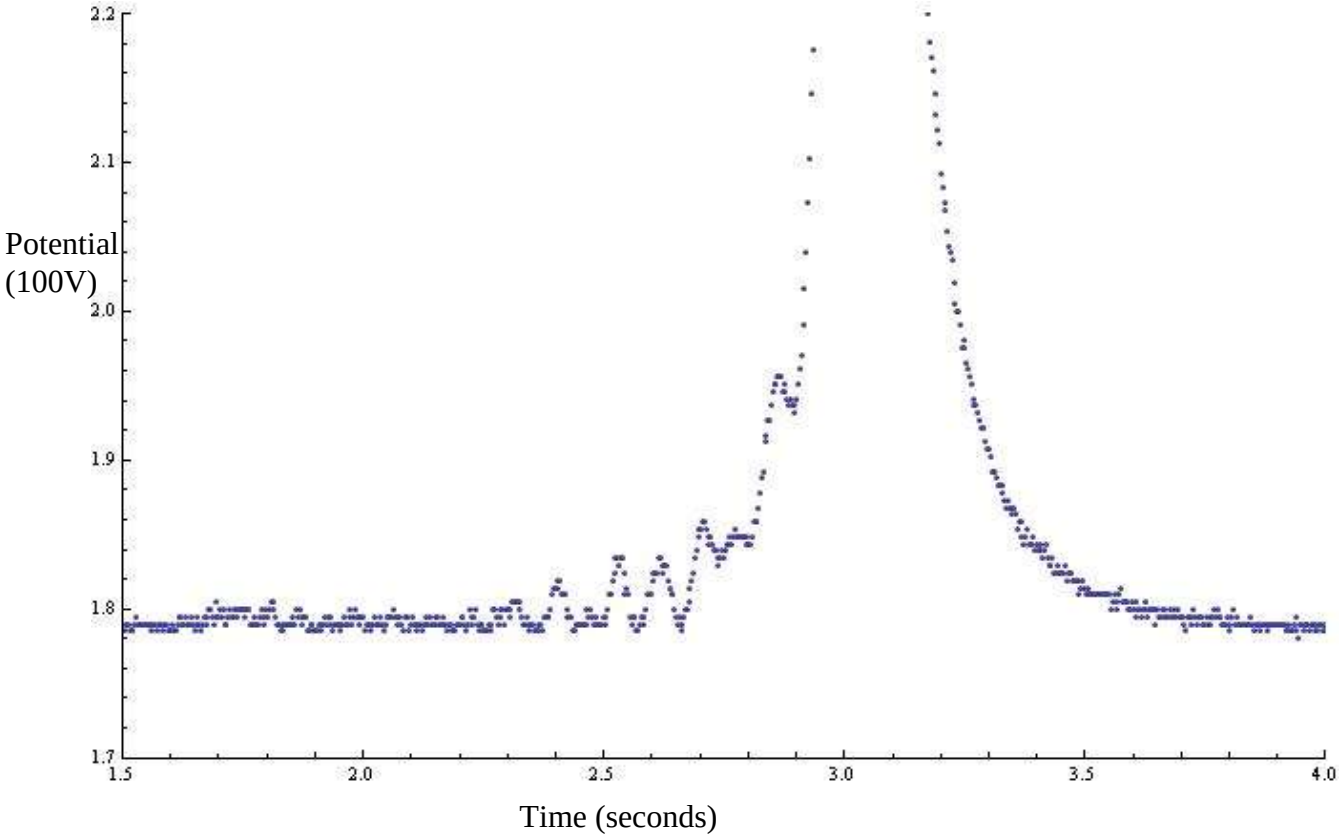


Figure 34: This graph was plotted in Mathematica from the text file of the data taken on the first lab day.

We see a very sharp drop off after the initial peak then it looks as though the voltage drops off by about 50% then one more drop of about 10 % before there are a couple of little peaks of consistent intensity then background noise that we see on both sides. Perhaps a higher sampling rate and a better method of identifying the optimum position of the laser on the razor blade. In future trials I might want to put the blades of two razor blades together to make a thin slit then remove one of the razor blades. This way I could ensure that the beam was centered in the gap additionally the two patterns could be compared to emphasize the difference between the pattern we see in the slit and the pattern we see off the edge of a material.

Part 3: Human Hair
We expected our hair sample to come out like the single slit patterns and there was a fairly reasonable match to the graph on the first day.

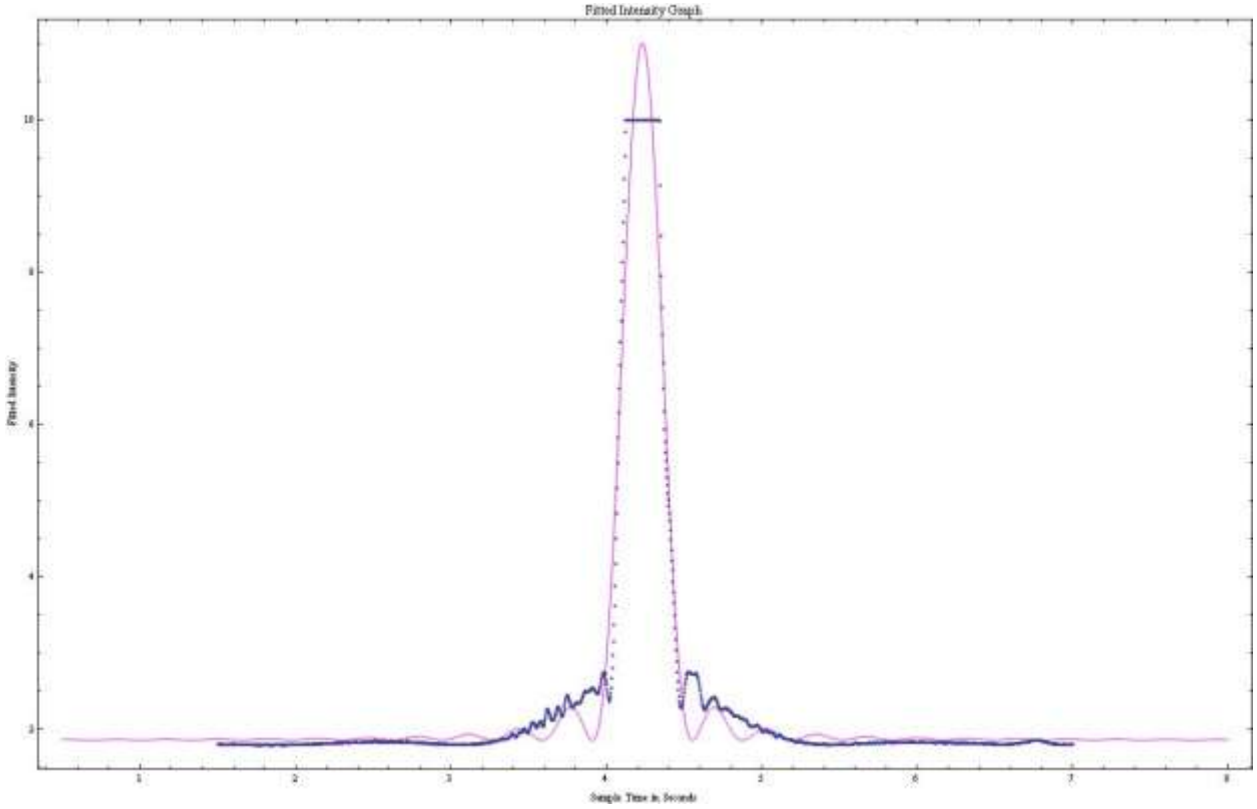


Figure 35: Day 1 trial 1 Potential vs time for the hair sample. With mathematica fitted graph of sinc function in pink overlaid with blue graph from data file.

Please note that the top part of the graph is cut off so that we can see the detail in the bottom of the graph. The width of the central maximum is .461 seconds for the data graph and .944 seconds for the fitted graph. The distance between the sample and the photodetector was 88.8 cm. From the same calculations we used for the single slit – the data plot would have the thickness of the hair at 284 micrometers and the fitted graph 119 micrometers. Both numbers seem high and since the graph was not really clear on the bottom and the sample were not mounted straight on the slide holder the procedure was repeated on the second day. The fact that the sample was not straight I did not anticipate to make a big difference since we were looking at a very small linear section of the sample. However it is possible that this skewed the results.

The data on day two looked a lot more uniform. The distance between the sample and the photodetector was 86.7 cm, the time between the minimum on the sample data was .19 seconds. This would give us a diameter of 571 micrometers. This again is awfully big compared to what is expected 181 micrometers. The second trial had .188 seconds in between the minimum with the same distance so our results are 583 micrometers (Which is consistent with the first trial but again is not what was expected.) A couple of ideas come to mind when I look at the graphs they are not symmetric which means that I probably did not have the beam lined up quite right which could have caused a problem, additionally the distance from the beam may again have been too far. These are things that would need to be corrected in another trial. It should be noted that by the time I got to the razor and hair I was running short on lab time so these trials were more rushed that desirable.

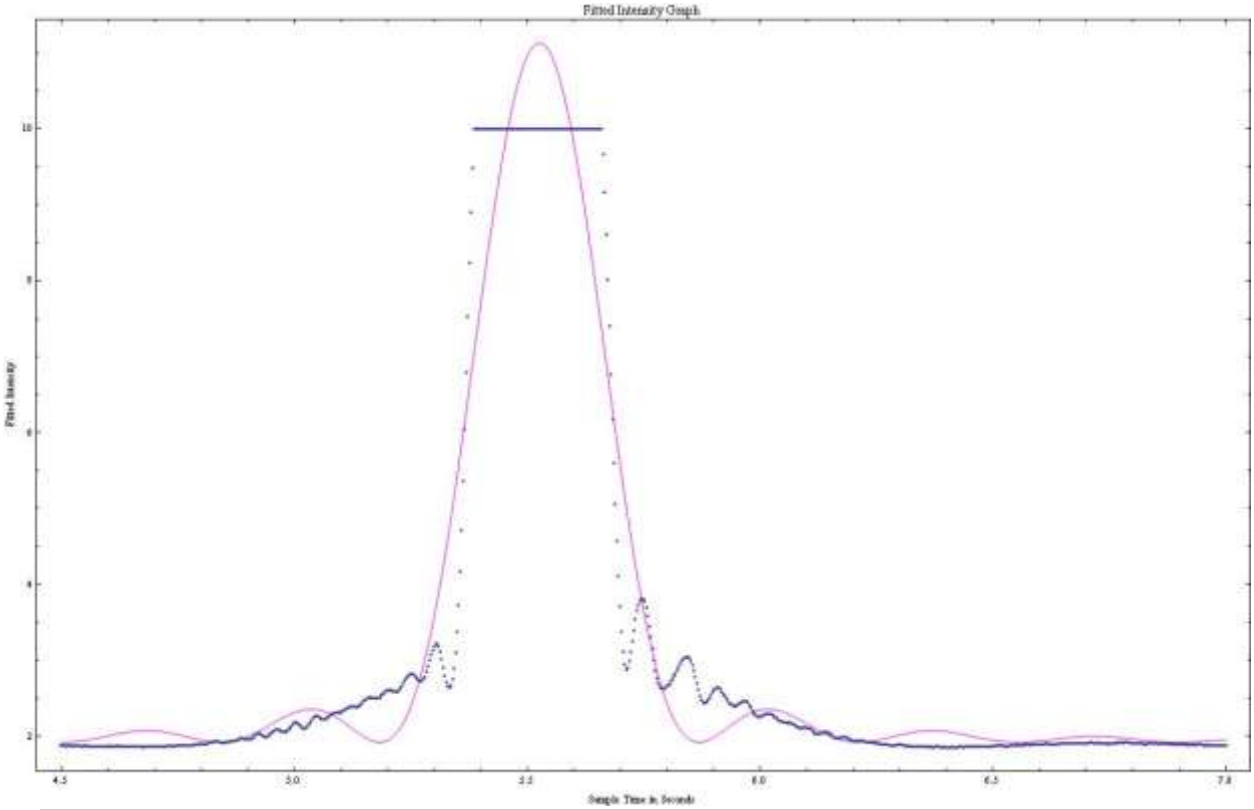


Figure 36: Day 2 trial 1 Potential vs time for the hair sample. With mathematica fitted graph of sinc function in pink overlaid with blue graph from data file.

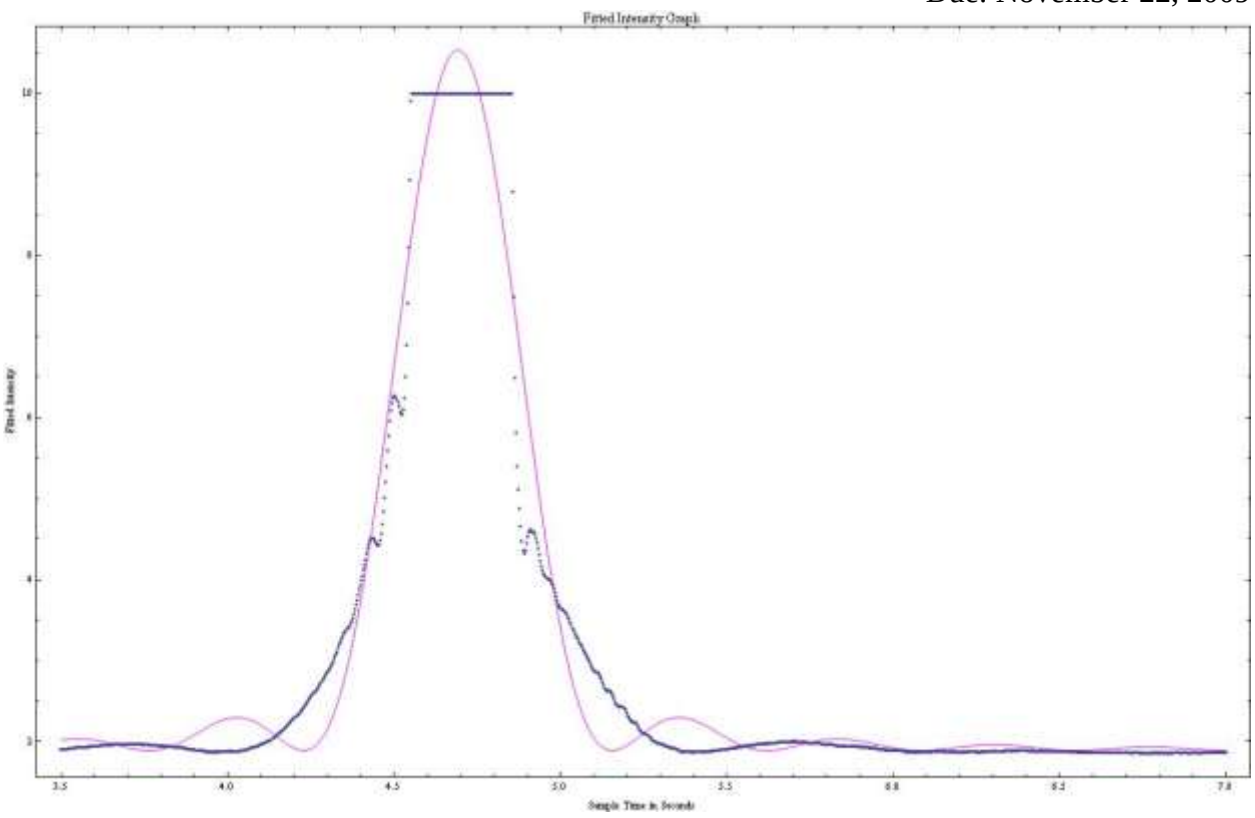


Figure 37: Day 2 trial 2 Potential vs time for the hair sample. With mathematica fitted graph of sinc function in pink overlaid with blue graph from data file.

Summary:

In our lab we were looking to identify the slit width from the diffraction pattern I was successful in determining this from the single slit patterns. Slit b .045±.005mm and slit c .081±.005. Both are in agreement within experimental error of what was stated by the manufacturer. A problem with taking the readings in the traveling microscope prevented me from being able to accurately compare the data with the physical measurements more practice with that device will help to eliminate this issue in the future. With the multi-slit diffraction patterns we saw reasonable agreement with the peak intensity equaling the number of slits squared (for those trials I got 2 within the experimental error). However, with the increased number of slits we did not see this agreement but the primary reason for this is likely to be that the photodetector was too far from the slide and the beam was not illuminating the slits evenly which is noticeable in the plots of the data. Regarding the razor we expected to see an exponential degradation of the signal strength and our pattern seemed to fall off more quickly again this is probably due to an issue of distance and beam alignment. The measurement of the hair using Babinet's principle was also not as successful as I would have hoped though the data on the second day seemed a little better this underlying issue of alignment and distance is most likely the account for our extremely large numbers here as well 583±5 micrometers. I made an attempt not to move the photodetector too much during the lab because it was difficult to align it with the optic track as well as accurately measuring the distances from the slit since the photodetector was not on the track itself but was self standing. Additionally, I did not move the slide around as much because I was having

trouble with the beam not being horizontally aligned this lack of alignment meant that each time I moved the slide I would have to start all over again with the diffraction patter and there were a number of times when I could not get a pattern at all if the slide was too far away. In future trials I think I would try to sit down before hand with the slides and try to anticipate the distances that were ideal and then try several trials near those distances and at extremes in both directions. I also would try to make certain that the laser is leveled in a manner that allows me to work with it and all the components on the optic track. I have had issues with this last piece throughout the semester and am not certain if it is a issue of requiring more experience with the equipment or the need for a physical vertical adjustment of the laser unit itself.