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# Gauss' Law ~~Lab Title~~

Name:

**PES 215 Report**

Lab Station:

## Objective

The purpose of this lab was to verify Gauss' Law for infinite planar and infinite cylindrical symmetries, by measuring potentials..

## Data and Calculations

### Part A – Infinite Planar Symmetry:

For this part of the lab, we set up the following circuit:

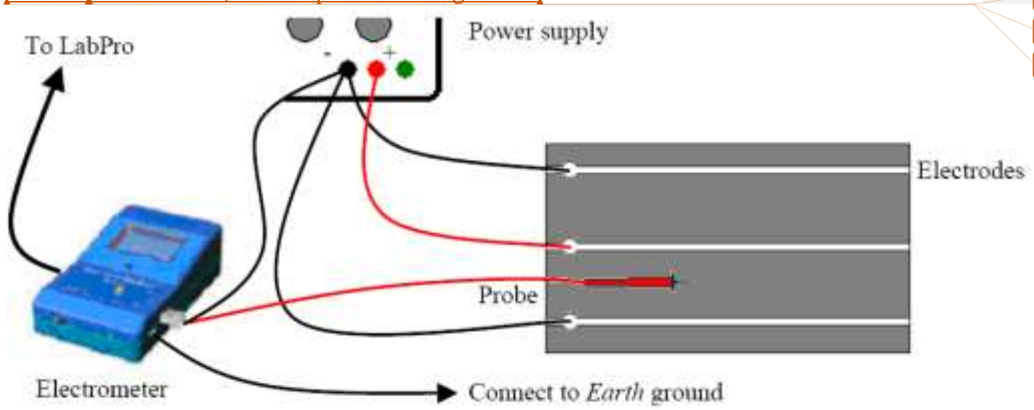


***Figure 1: Setup for Part A of Gauss' Law Lab***

Using the circuit setup with the pointing apparatus and the Electrometer, we were able to take sequential measurements across the conductive paper. The following figure shows the method by which we took the measurements.

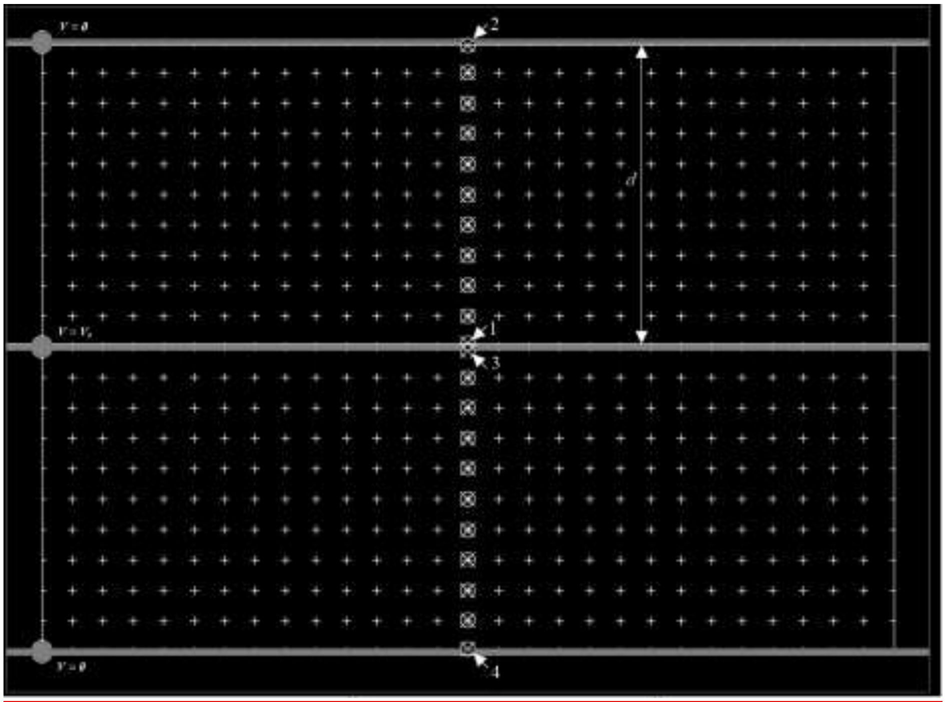


*Figure 2: Infinite Charged Plane Carbon Impregnated Paper*

First, we had to measure the distance from the charged plane to the zero potential line.

| Distance from the center plane to the 0 potential "*d*" [*m*] |
|---|
| 0.10 |

Next, we had to increase the power supply to provide a suitable surface charge.

| Surface Charge Potential [*V*] |
|---|
| 0.50 |

Now, we could begin the data collection. We measured the potential at each of the "+" points from 1 → 2 in the figure above and then repeated the process from 3 → 4. The following data table summarizes the data that we obtained from the experiment:

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| Distance from 1 → 2 [*m*] | Potential at the measured "+" [*V*] |
|---|---|
| 0.00 | 0.500 |
| -0.01 | 0.450121 |
| -0.02 | 0.391704 |
| -0.03 | 0.344097 |
| -0.04 | 0.29649 |
| -0.05 | 0.22821 |
| -0.06 | 0.182707 |
| -0.07 | 0.150105 |
| -0.08 | 0.09847 |
| -0.09 | 0.064862 |
| -0.10 | 0.005384 |

| Distance from 3 → 4 [*m*] | Potential at the measured "+" [*V*] |
|---|---|
| 0.00 | 0.478848 |
| 0.01 | 0.447701 |
| 0.02 | 0.378606 |
| 0.03 | 0.339473 |
| 0.04 | 0.2803 |
| 0.05 | 0.212562 |
| 0.06 | 0.163589 |
| 0.07 | 0.119959 |
| 0.08 | 0.055416 |
| 0.09 | 0.04787 |
| 0.10 | 0.003527 |

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We plotted the data obtained from the experiment and got a best fit line for both sides:

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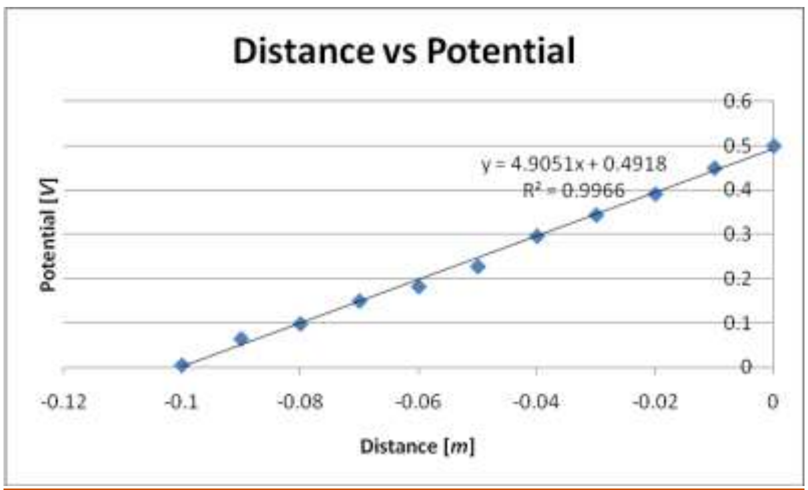


***Figure 3: Graph of Data Obtained via the Experiment for Part A 1 → 2***

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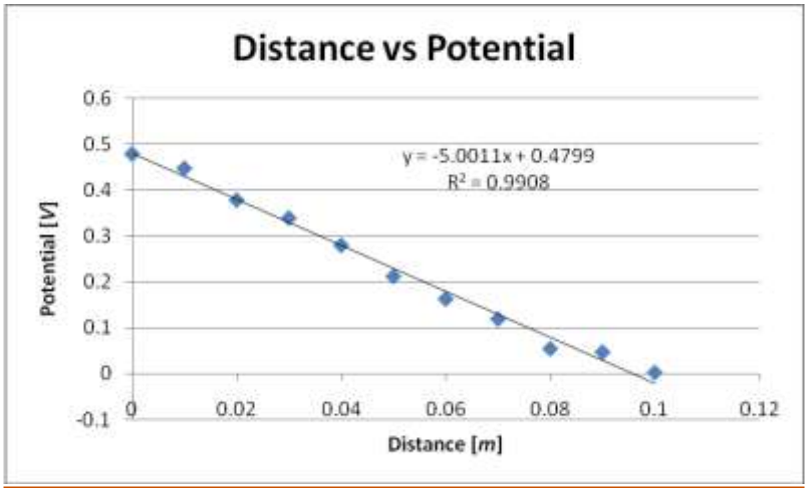


*Figure 4: Graph of Data Obtained via the Experiment for Part A 3→4*

From part B of the pre-lab, we saw that for the infinite plane:

$$V(x) = \left(-\frac{V_o}{d}\right)x + (V_o)$$

Hence, this means the slope and the y-intercept should be:

$$m = -\frac{V_o}{d} = -\frac{0.5V}{0.1m} = -5.0\frac{V}{m}$$

$$and$$

$$b = V_o = 0.5\ V$$

| | Slope [V/m] | Y-Intercept [V] |
|---|---|---|
| **From 1 → 2** | +4.9051 | 0.4918 |
| **From 3 → 4** | -5.0011 | 0.4799 |
| **Average** | -4.9531 | 0.48585 |
| **Theoretical** | -5.0 | 0.5 |
| **% Error** | 0.938% | 2.83% |

***How does a low percent error between the theoretical and experimental values support the validity of Gauss's Law? Explain thoroughly.***

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## Part B – Infinite Cylindrical Symmetry:

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For this part of the lab, we set up the following circuit:

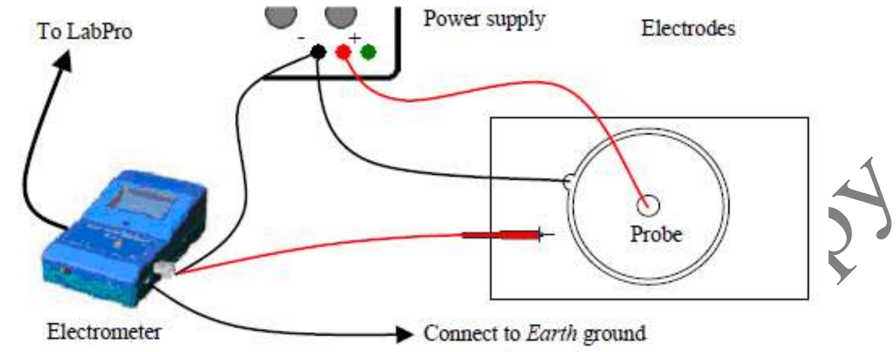


***Figure 5: Setup for Part B of Gauss' Law Lab***

Using the circuit setup with the pointing apparatus and the Electrometer, we were able to take sequential measurements across the conductive paper. The following figure shows the method by which we took the measurements.

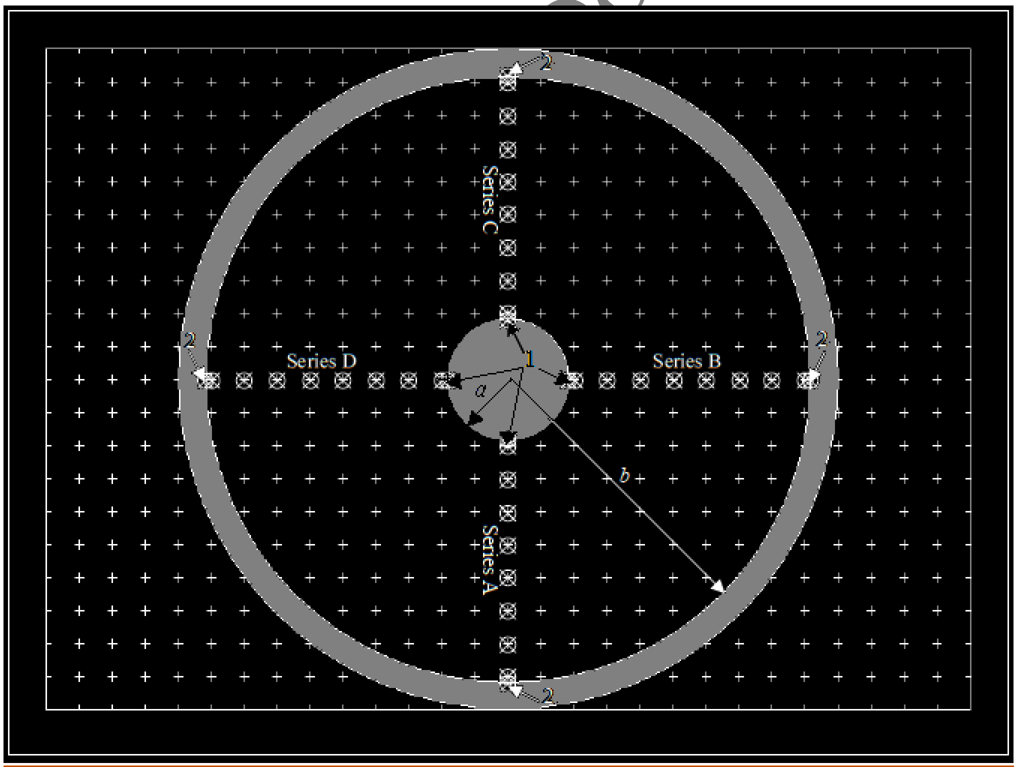


***Figure 6: Infinite Charged Plane Carbon Impregnated Paper***

First, we had to measure the distance from the charged plane to the zero potential line.

| Diameter of the Center Sphere "*a*" [*m*] |
|---|
| 0.0114 |

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Next, we had to increase the power supply to provide a suitable surface charge.

| Radius of the Outer Sphere "*b*" [*V*] |
|---|
| 0.1010 |

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Now, we could begin the data collection. We measured the potential at each of the "+" points from 1 → 2 in the figure above for Series A and then repeated the process for Series B → D. The following data tables summarize the data that we obtained from the experiment:

| Distance Series A [*m*] | Potential at the measured "+" [*V*] |
|---|---|
| 0.015 | 0.498136 |
| 0.02 | 0.391704 |
| 0.03 | 0.29649 |
| 0.04 | 0.22821 |
| 0.05 | 0.182707 |
| 0.06 | 0.140105 |
| 0.07 | 0.09847 |
| 0.08 | 0.064862 |
| 0.09 | 0.03314 |
| 0.1 | 0.005384 |

| Distance Series B [*m*] | Potential at the measured "+" [*V*] |
|---|---|
| 0.015 | 0.49683 |
| 0.02 | 0.37826 |
| 0.03 | 0.27086 |
| 0.04 | 0.201178 |
| 0.05 | 0.145472 |
| 0.06 | 0.10374 |
| 0.07 | 0.075113 |
| 0.08 | 0.045809 |
| 0.09 | 0.021631 |
| 0.1 | 0.0025 |

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| Distance Series C [*m*] | Potential at the measured "+" [*V*] |
|---|---|
| 0.015 | 0.484887 |
| 0.02 | 0.389334 |
| 0.03 | 0.290977 |
| 0.04 | 0.227872 |
| 0.05 | 0.176759 |
| 0.06 | 0.132948 |
| 0.07 | 0.098905 |
| 0.08 | 0.063121 |
| 0.09 | 0.034349 |
| 0.1 | 0.005045 |

| Distance Series D [*m*] | Potential at the measured "+" [*V*] |
|---|---|
| 0.015 | 0.500631 |
| 0.02 | 0.355127 |
| 0.03 | 0.264071 |
| 0.04 | 0.192987 |
| 0.05 | 0.149418 |
| 0.06 | 0.103044 |
| 0.07 | 0.075288 |
| 0.08 | 0.04787 |
| 0.09 | 0.021709 |
| 0.1 | 0.003527 |

We then averaged out all four series to generate a single table of distance versus potential:

| Distance Average [*m*] | Potential Average [*V*] |
|---|---|
| 0.015 | 0.495121 |
| 0.02 | 0.37860625 |
| 0.03 | 0.2805995 |
| 0.04 | 0.21256175 |
| 0.05 | 0.163589 |
| 0.06 | 0.11995925 |
| 0.07 | 0.086944 |
| 0.08 | 0.0554155 |
| 0.09 | 0.02770725 |
| 0.1 | 0.004114 |

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We plotted the data obtained from the experiment and got a best fit line:

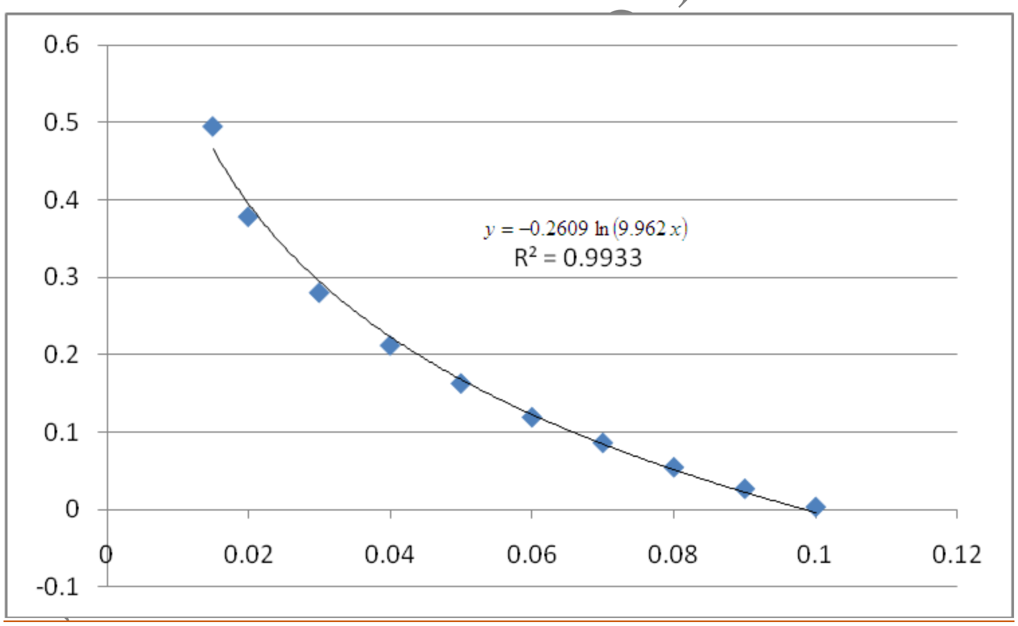


***Figure 7: Graph of Data Obtained via the Experiment for Part B a → b***

From part C of the pre-lab, we saw that for the infinite cylinder:

$$V(R) = A\ln(Br) = \left(\frac{V_o}{\ln\left(\frac{a}{b}\right)}\right)\ln\left(\frac{R}{b}\right)$$

$$y = -0.2609\ \ln(9.962\,x)$$

Hence, this means the constants in the best-fit should be:

$$A = \frac{V_o}{\ln\left(\frac{a}{b}\right)} \quad and \quad B = \frac{1}{b}$$

$$A = \frac{0.5V}{\ln\left(\frac{0.0114\,m}{0.1010\,m}\right)} = -0.2292V \quad and \quad B = \frac{1}{0.1010\,m} = 9.901m^{-1}$$

| | Constant A [V] | Constant B [1/m] |
|---|---|---|
| **Experimental** | -0.2609 | 9.962 |
| **Theoretical** | -0.2292 | 9.901 |
| **% Error** | 12.07% | 11.52% |

***How does a low percent error between the theoretical and experimental values support the validity of Gauss's Law? Explain thoroughly.***

## Conclusion

**You write the details. ← Include your answer here. Use complete sentences!!!!**

** NOTE: There are several components of error which could significantly modify the results of this experiment. Some of these are listed below:

- Holes in the Carbon Paper
- Bad power supply (recall we used the DMM to attempt to alleviate this problem.)
- Bad connections (in protoboard)
- Insulation
- Buckling, bending, etc… of paper
- ??



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It is recommended that you take these and explain the "***why"*** part of each for your results and conclusions sections – and possibly what could have been done (if anything) to minimize the effects of these errors.