Electric Potential and Electric Fields

Jacob Alspaw

Department of Physics, Case Western Reserve University

Cleveland, OH 44016-7079

Abstract

The Electric Potential and Electric Fields lab instilled my lab partner, Kyle Johnson, and I to pursue the analysis and modeling of equipotential lines and electric field lines. This lab called for the use of three unique setups to define the electric field and equipotential lines directed through the equipment. The first of these setups was to represent dipoles, where two cylindrical conductors were placed a distance apart. The second of these setups was to represent parallel plates, where one rectangular prism was set parallel to its counterpart a distance away. The third of these setups was to represent the use of parallel plates with an additional hollow object within the plates' electric field. This hollow body disrupted the field, and my lab partner and I noted how this environmental change curved the paths of the produced electric field lines. With each setup, we were able to establish a relationship concerning our measured values to values supported by established theory. This process required use of a digital multimeter to record certain voltages, a pan of water for current to flow through, and graph paper to acquire distances. In the first setup, our proposed relationship proved moderately accurate because *Origin* compared our fitted values to known functions, related to point charges, and produced a chi squared value of 1.64. Along the x-axis, voltage should increase as we move toward the positive terminal of the power source. In the second setup, our proposed relationship proved greatly accurate because *Origin* compared our fitted values to known functions, related to parallel plates, and produced a chi squared value of 0.44. As values in the y-direction increase or decrease with respect to the origin, voltage will change because the path is not perpendicular to the electric field lines. As values in the x-direction increase or decrease with respect to the origin, no voltage change should occur when traveling along the equipotential lines of a parallel plate. In the third setup, our proposed relationship proved moderately accurate because *Origin* compared our fitted values to known functions, related interference within parallel plates, and produced a chi squared value of 1.4. The selected data points should model like that of a normal parallel plate and decrease in voltage as we have found. The chi squared values illuminate our experiment's overall, reasonable success based off the variance from our results to the theoretical values.

Conclusion

Overall, Kyle and I have succeeded in the purpose of the Electric Potential and Electric Fields lab. We have analyzed and modeled equipotential and electric field lines in a variety of situations. In the first setup for lab, concerning dipole charges, my partner and I calculated a chi squared value of 1.64. The low magnitude in this value ensures our results are well found and only little error may have occurred. Of the little error that occurred, it was most definitely between taking measurements with the digital multimeter at a ninety degree angle and counting the fading outlines of the one centimeter squares on the graph paper. In the second setup for lab, concerning two parallel plates, my partner and I calculated a chi squared value of 0.44. The extremely low magnitude in this value proves our measurements are nearly perfect. Error was again most likely contributed by the difficulty in taking ninety degree measurements with the digital multimeter and the fading graph lines. Our slope for setup two was -0.977 ± 0.005 V/cm, which conforms within each data point's error bars. The measured voltages will drop as the vertical position approaches the negative electrode, supporting our results. Also, our calculated electric field was 100 ± 5 N / C. This was very near the rest of the values and conforms to theory because electric field is constant between two parallel plates. In the third setup, concerning interference from a hollow object within parallel plates, my partner and I calculated a chi squared value of 1.4. The slope of this line, excluding the data points within the hollow cylinder, measured -0.98 ± 0.08 V/cm. This line should be linear and decrease along the same likes of setup two. Inside the conductor, the slope should be zero, but our data proved slightly skewed because we obtained a slope of -0.15 ± 0.01 V/cm. Inside of this hollow conductor should be zero change in voltage because it theoretically has a constant voltage throughout and no electric field. However, our analysis produced a value for electric field of 19 ± 4 N / C. This error may have been contributed by the difficulty to measure with the digital multimeter at a perfect ninety degree angle. Finally, the calculations to analyze an electric field between two dipoles produced a chi squared value of 29.327. This data was not entirely accurate, but conformed to the overall shape of a perfect theoretical model. We could not include all data points on this graph because my partner and I could not obtain a sufficient number of values to map on the graph. The perfect theoretical model is drawn in the analysis section. The error in this analysis is the result of perceived error in measurements while taking voltage readings which had compounded into larger error over the totality of the calculations to reach a value for electric field. As the position along the x axis increases in distance from both dipoles, electric field should get weaker. Our graph models this concept. In conjunction with our data, the calculated chi squared values, our logical interpretation, and our established theory, our results are considered generally accurate and this lab considered a success.