Lab Two Report:

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Abstract:

The ability to measure and map equipotential measurements is needed. It is necessary to prove that the voltage probe and given software are capable of accurately measuring the voltage and electric field. To achieve this, five different system configurations were created using various metal shapes. This included the dipole, point-plate charge, spherical conductor, sharp point and arbitrary configurations. A current was run through conductive paper and a voltage probe recorded the voltage and created a voltage map of a rectangle of space. Using the data gathered, the strength of the electric field was determined. Comparing the predictions of each to the configurations yielded that the predictions were correct with very few discrepancies.

Introduction:

The purpose of this lab was to take electric potential measurements, and then convert the information into electric fields for various configurations of charges used. In doing so an understanding of the relationship between electric potential and electric field will be attained. Based on the varying experimental setups, the electric potential representations will look different. As a result, correlations between how the positive and negative charges are separated and what shapes of conductors are used will also be discovered. Next in the ***Theory*** section, principles that guide the experiment are discussed. In the ***Experimental Procedure*** section, the experimental setup and steps are outlined. Next, in the ***Results*** section, each of the five potential plots and two electric field plots are analysed. Finally in the ***Conclusion*** a summary of the results is found.

Theory:

Electric potential is defined as the magnitude of the amount of work needed to move a unit charge from a reference point to a specific point against an electric field. In essence, this means electric potential describes the stored energy of a charge at an arbitrary point in an electric field, increasing in magnitude as it moves closer to the positive side of the field and decreasing in magnitude as it moves closer to the negative side of the field (*Fig 1)*.

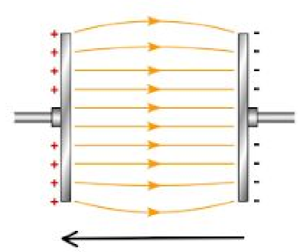


Fig. 1 Increasing potential

Electric field is a region of space where electrical forces caused by the repulsive forces of an origin charge and charges of arbitrary distances away are observed. The strength of the electric field is measured in volts/meter.

To determine the strength of the electric field from the electric potential maps, a gradient $\nabla = (\frac{\partial}{\partial x}, \frac{\partial}{\partial y})$ is needed. Electric field is the gradient of electric potential, shown as $E = -\nabla V\,(eq.1)$. The partial derivatives within the gradient are calculated using the finite difference method in which the difference of electric potential of two arbitrary points are divided by the differences of the distances of the points in either the x or y direction *(eq2/3)*. The equations for the partial derivatives are found in the equations section.The gradient yields the x and y components of the electric field as a vector. Therefore, the magnitude of the electric field must be found using the equation $|E| = \sqrt{(\frac{\partial V}{\partial x})^2 + (\frac{\partial V}{\partial y})^2}$ *(eq.4)*.

A region in which the electric field remains constant is known as an equipotential surface. On an equipotential surface, zero work is required to move a charge through the regional. Conductors are equipotential surfaces since charges can flow freely without any work.

Equations:

1) $E = -\nabla V$

2) $\frac{\partial V}{\partial x} = \frac{V_2 - V_1}{x^2 - x^1}$

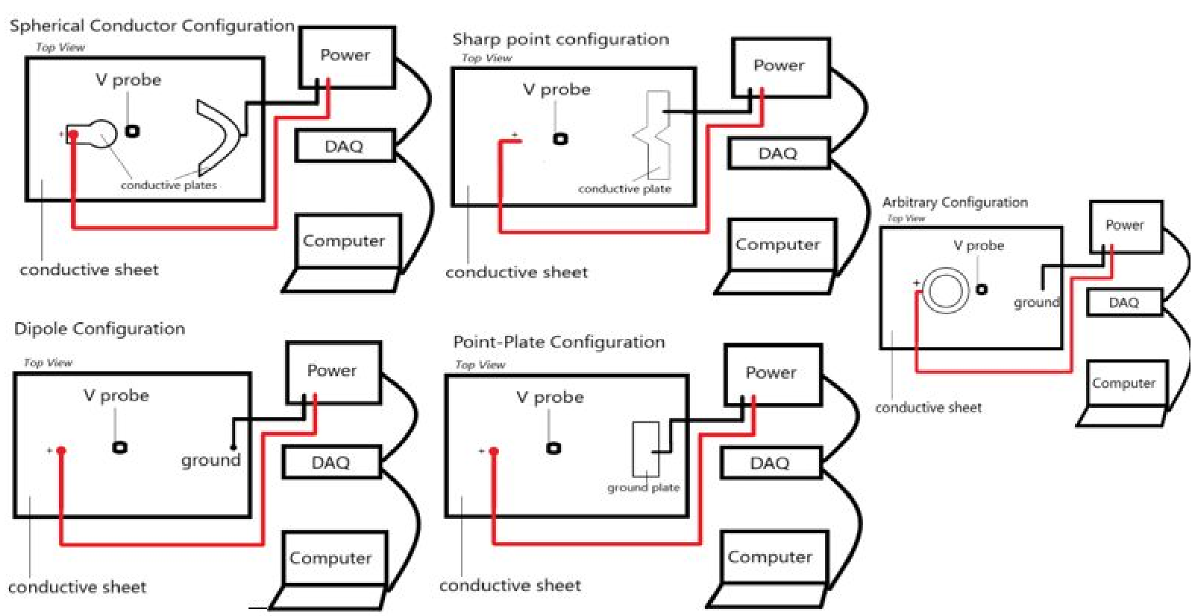
3) $\frac{\partial V}{\partial y} = \frac{V_2 - V_1}{y_2 - y_1}$

4) $|E| = \sqrt{(\frac{\partial V}{\partial x})^2 + (\frac{\partial V}{\partial y})^2}$

Experimental Procedure:

The first thing done by the team was setting up the dipole configuration. The two charges, one positive and one negative, were set more than six inches away from each other then the visual tracking software and the attached probe measured the electric potential between the two charges. The voltage from the ground was transported to the power then read by the DAQ and finally processed into data on the computer. After the voltage probe moved back and forth on the conductive sheet measuring the equipotential, it translated the data to the visual tracking system and then displayed the plot of the electric potential on the screen. Next, the same procedure was followed but with the point-plate charge configuration. This is seen in *Figure 2* below. Each of the 5 configurations used for the same procedure are seen below. These configurations were sharp point, spherical conductor, and one arbitrary arrangement.

Figure 2

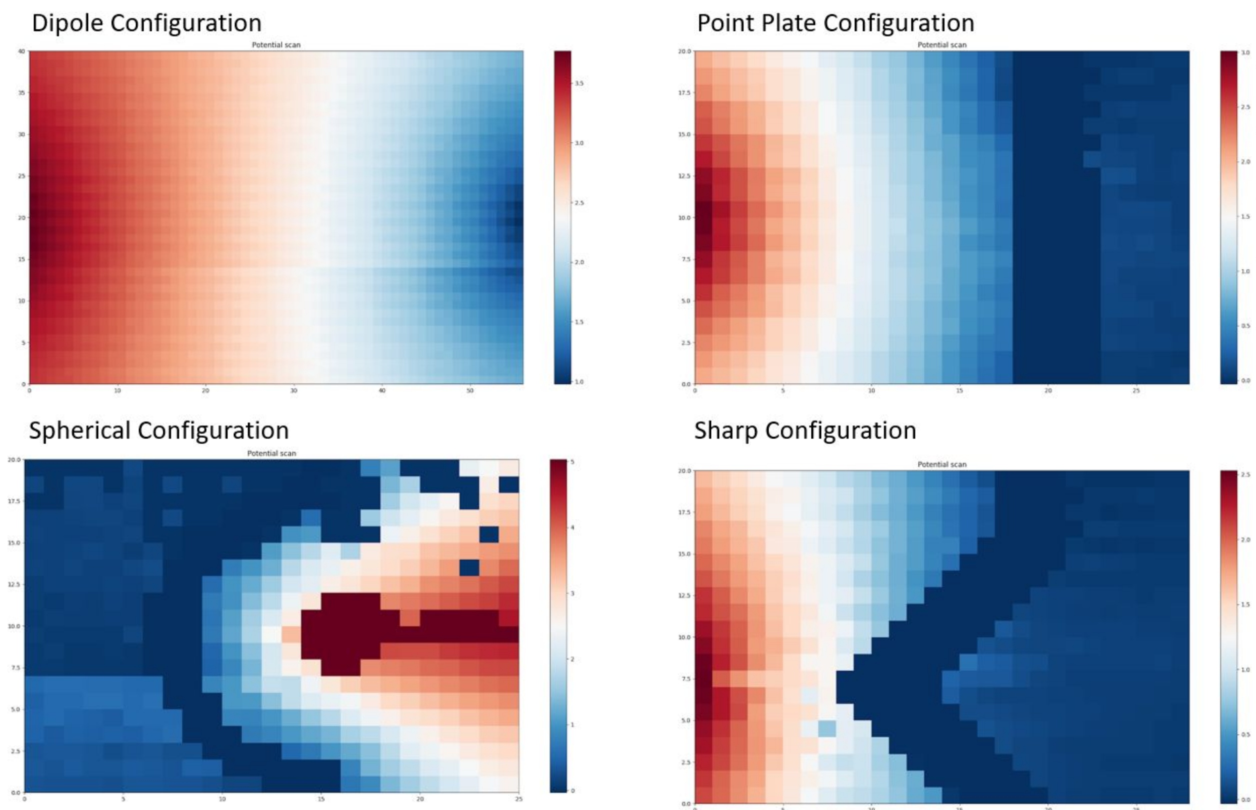


Results:

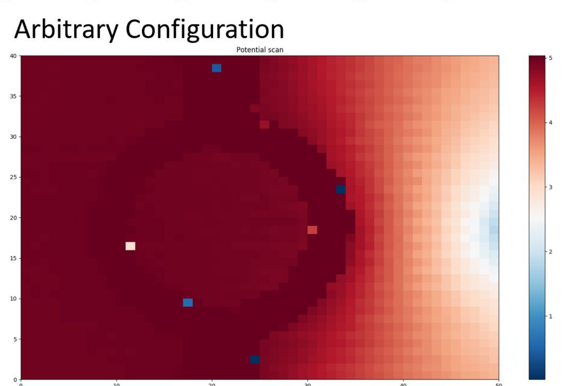
For the dipole configuration, it was predicted that the voltages would be high at the input wire, extend in outwards in an arch, then decrease in an arc around the ground wire. The point plate configuration was predicted to have high voltages at the input wire, extend outwards to the grounded metal plate in an arch, decreasing until ground. The spherical configuration was predicted to extend out in an arch from the dot-plate, and drop until reached the ground of the half-spherical plate. The sharp configuration was predicted to accumulate charge on the point. The arbitrary configuration was predicted to be red around the circle, and decrease in magnitude in the middle of the circle.

The voltage heat maps for the 5 configurations are shown below in *figure 3*. As predicted, the metal shapes are equipotential surfaces and show no change in voltage since they are conductors. The dipole configuration shows a diverging field away from the positive pole and a converging field towards the negative pole or ground. The potential outside of the plate charge makes a parallel gradient. For the spherical charge, the potential drops inside the sphere, stays constant in the conductor, and then decreases outside the sphere. The sharp charge shows the potential decreasing away from the point and lastly the arbitrary charge shows a similar phenomenon to the sphere charge.

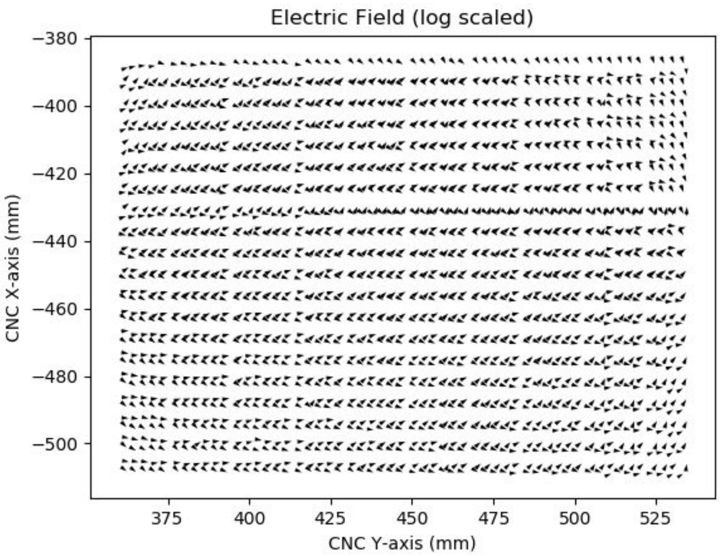
Figure 3

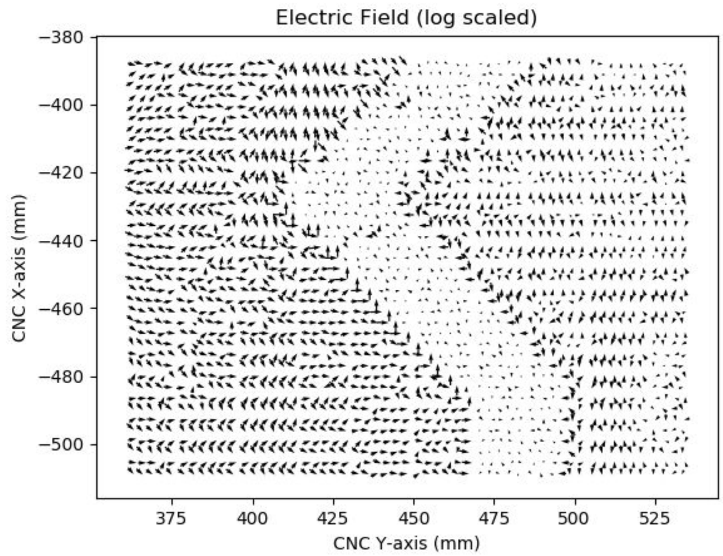


The electric show field plots show our dipole configuration and sharp point configuration. As expected, the dipole field shows the field lines traveling from the positive charge to the negative charge. For the sharp point charge, the field inside the conductor is zero, this is consistent with the fact that it is an equipotential surface so no force is exerted on a



charge inside a conductor. AdditionallyAdditionally, the field lines leaving the plate are parallel to the surface, except for at the point of plate where the field lines converge to the point. Implying that there is a build up of charge on the point of the conductor.





Conclusion:

The group took electric potential measurements using the voltage probe and visual tracking software, and then converted the information into electric fields for all five configurations. The shapes of aluminum are equipotential surfaces and show no change in voltage since they are conductors, as predicted before the experiment. The electric field behaved as we expected it to, with field lines pointing from positive to negative. Small deviations in our predictions, likely came from a small sample of inaccurate readings from the voltage probe, however, in general the results were as we expected them to be.