Exp. 1: Equipotential Plotting

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Abstract

A study was done to determine the shape and strength of the electric field of several differently shaped electrodes. After mapping out the shape of the electric field with a field mapping board and DC power supply, the equations and were used to determine the electric field strength and dipole moment, respectively. The value for the electric field strength was 28.6 N/C, and the value for the dipole moment was 1.36E-13 C-m for the two circular electrodes. Meanwhile, the electric field strength was slightly larger for the two straight electrodes at 30.8 N/C.

Introduction

When a point charge is positively charged, it radiates a relatively constant electric field directly outward in all directions. At the same time, there are equipotential lines that radiate outward from the point charge along with the electric field lines. Because these lines run parallel to the electric field lines, any test charge placed along the equipotential lines will have no change in work done and no change in potential, hence the name “equipotential lines.”

The shape of the electric field lines and equipotential lines change with the shape of whatever charge they originate from, in this case, a metal electrode. While a circular electrode’s equipotential lines would appear circular, a rectangular electrode would have much differently shaped equipotential lines. These lines’ locations vary by a particular radius, *r*, and can be mathematically predicted.

By using a DC power supply and field mapping board, these lines can be located. To determine the electric field strength, the equation , where *a* is the half the distance between points of equal and opposite charge *q*. The dipole moment can then be calculated using the equation .

Procedure

In this experiment, a DC power supply was used to supply two volts of power to a field mapping board. This board had one of three differently shaped electrodes attached to it. One electrode consisted of a statically charged dipole, the second had two parallel plates, and the third had a point charge and faraday cup. For each electrode, a voltmeter was connected to a probe which was used to locate the points where the board read zero volts. These points were where the potential of the electric field was zero. By continually tracing the probe around the paper, the equipotential lines were marked until a sufficient graph of the lines could be drawn. This procedure was repeated with all three different electrodes.

Results

The electric field strength for the dipole electrode was 28.6 N/C, while the dipole moment was 1.3E-13 C-m. It was not very difficult to reach 0 volts on the voltmeter. Once the general shape of the equipotential lines was understood, the predicted lines could be roughly traced to find the next location of 0 volts. The uncertainty in finding the points was relatively low, seeming to be within 0.05 volts. It also seemed to depend on the distance from the electrode, with the uncertainty increasing with the distance from the electrode.

For the parallel plates, the electric field strength was 30.8 N/C. The electric field lines are roughly perpendicular to the faces of the plates. They form an ovular shape with respect to each other. The electric field strength is strongest between the plates and gets weaker the farther away from the center they get.

For the faraday cup, the electric field appears to weaken as it approaches the cup from the point charge, with it completely going around the cup once it reaches the cup’s “lip.” The value for the electric field would be 0 if the cup were a box.

Questions to Answer

1. The sphere is charged largely at the edges, with little charge remaining in the center of the sphere.
2. This is because all the charges in the conductor have come to rest, canceling out any internal electric charge.
3. The potential difference would be zero, because the charges would have settled to be at rest uniformly along the surface of the sphere. This means that the potential would be equal anywhere on the surface of the sphere.
4. It was necessary to use the inside-to-inside measurement because the potential of the electrode was concentrated towards the edges, leaving the center of the electrodes chargeless.