Lab 9

Electric Field Lines

Experimental Objectives: Experimental Objectives

- In this experiment, you will map out the equipotential lines for a couple of given electric field configurations and determine the pattern of the electric lines of force for these configurations. You will then give a physical explanation of the terms "electric field" and "electric potential" and their relationship.

The effects of electric charges (positive and negative) can be seen in many electronic devices, like the radio. The effects of static electricity can be seen when clothing is pulled out of a dryer on a winter day. There is a force exerted on one charge by another charge and this can be either attractive or repulsive. This force is called the Coulomb force and is named after Charles Coulomb (1736-1806).

Physics relies on abstractions (new quantities and new names), with pictures to help convey information and ideas. The English scientist Michael Faraday (1791-1867) introduced the concept of lines of force, a force field, as an aid in visualizing the interactions of charges. These lines of force are a mental abstraction, but they can be visualized with the use of iron filings placed near a charge or a group of charges. These lines of force convey a picture of the interaction between one charge and another. The iron filings will align themselves when in the presence of a single charge. This conceptualizes the idea of the electric field strength E (electric force per unit charge) because it is convenient to know the electric force per unit charge at any point in space due to a nearby set of electric charges. The electric field strength though can not be easily measured with a meter.

It requires work to move a charge against an electric field. The ratio of the work done to the charge strength is called the potential difference (voltage) and it is measured in units of joules/coulomb and is called a volt. This potential difference is easily measured with a voltmeter. If the charge is moved along a path perpendicular to the electric field lines then there is no work done, it takes zero energy. This is because there is no force component in the direction of the path. The potential (voltage) is then constant along paths which are perpendicular to the field lines. Such paths are called equipotential lines. These equipotential lines can be measured with a simple voltmeter, and then from these the electric field lines can be deduced.

9.1 Pre-Lab Work

- Define Coulomb's law.
- Give a definition of electric field, both mathematical and pictorial.
- Show a picture of the electric field near:

  a) a point charge,

  b) two equal and opposite point charges, and

  c) two equal positive point charges.

- Show from the above three cases (pictures), places where the electric field is zero.
- Show in a picture, the electric field inside and outside of a positively charged conductor (show that electric field lines will start from the surface of the charged conductor).
- Give an argument why two electric field lines can never cross.
- Give an argument why an electric field line is perpendicular to the equipotential line.

9.2 Procedure

- A special conducting plate with metal terminals will serve as the charge configuration. This plate should be fastened beneath the field-mapping board, without observing the specific charge configuration.
- An electric field is produced when a power supply (battery) is connected between the two terminals (points X and Y). Set the power supply at 10 volts.
- Points of equal potential (voltage) are found using a movable U-shaped probe which is connected to a voltmeter. Plot a series of points on your own graph paper which are at a constant potential (an equipotential line). Then repeat this for different potentials in steps of one volt. In this way the entire field is explored.
- Obtain an equipotential map and the electric field lines map (on graph paper) for three different charge configurations. Be sure to indicate the direction of the electric field lines on your maps.

9.3 Analysis

- Discuss the relationships between the voltage measurements and the electric field lines, and between the electric field lines and the charge configuration. Estimate the magnitude of the electric field at a few points on each map. Please write the electric field intensities in units of volts/meter.
- Discuss any irregularities in the field patterns which you have found.
- Discuss the spacing and what it represents, for the equipotential lines, and for the electric field lines.
- Indicate on your maps the location of the positive and negative charge distributions and their approximate shapes.

9.4 Questions

1. Can equipotential lines cross? Can electric field lines cross? Explain.

2. Why are there direction arrows on electric field lines but not on equipotential lines?

3. Why are the lines of force always perpendicular to the equipotential lines?

4. How is the electric potential affected by an insulator, and by a conductor, when they are placed in the electric field?

5. How is the electric field affected inside an insulator, and inside a conductor, when they are placed in the field?

Last revised: (March, 1997)
A PDF version might be found at EField.pdf (67 kB)