Lab 2S

Electric Field Patterns and Equipotential Lines

(Physics 7, Experiment #2)

Equipment:

Conductive paper grid
Cork board for mounting
Conducting push pins
12 V DC power supply
Digital voltmeter and two leads
Wire leads and clips
Silver ink pen for drawing electrode shapes
Ruler and template or other circular item for drawing lines and circles.
Several sheets of metric graph paper (to be supplied by student)
Set Up Time ≈ 20 – 30 minutes, Performance Time ≈ 60 – 90 minutes

Purpose:

The objectives of this experiment are:

a) To determine the equipotential patterns produced by several different charged-electrode geometries.
b) To find the corresponding electric field patterns.

Principles:

An electrode is a conducting point or object that is held at a given potential. A pair of electrodes held at a constant potential difference will produce an electric field pattern in the space in and around them. In this experiment we will set up several pairs of electrodes on conductive paper and then map the electric field patterns and equipotential lines near the electrodes. Electrodes with the desired geometry are set up on the conductive paper and connected with wire and clips, as required, to the terminals of the DC power supply, which provides a constant potential difference between the electrodes (see diagram below for a typical arrangement). Charges on the electrodes to produce an electric field in the surrounding space. A voltmeter with a high internal resistance (as shown in diagram below) is then used to map the shape of equipotential lines (note that the voltmeter measures the potential of a point with respect to the negative electrode). Since the electric potential outside the conductors is a smooth continuous function of position, and the surfaces of the conductors are equipotential, the shape of the equipotential surfaces near a conductor must be similar to the shape of the conductor itself and change smoothly and continuously with distance from the surface of the conductor. The pattern of the lines of force can then be found from the nature of the relation $E = -\nabla V$. This relation requires that the lines of force (electric field lines) must also be smooth and continuous and everywhere perpendicular to the equipotential lines, including the surfaces of the electrodes.

Procedures:

(a) Set up the electrode geometry A (point source with guard ring) on the conductive paper and make the connections as shown in Fig. 1. The guard ring should be between 12 and 16 cm in diameter and centered on the point source. Set up a sheet of graph paper to correspond to the electrode pattern chosen.

(b) Adjust the power supply output to give a voltage reading of about 10-12 V between the positive and negative electrodes. This voltage should be checked periodically for consistency during the measurements.

(c) With the negative probe of the voltmeter connected to the negative terminal of the power supply, use the positive probe to map 6-8 equipotential surfaces (lines). Read the coordinates of a point on the grid for a particular voltage and mark the corresponding point on the graph paper. The equipotential should be followed until it closes or reaches the edge of the paper; 5 to 10 points are usually sufficient to determine one equipotential. Great precision in locating the equipotential is not required. The goal is to establish a general pattern, not an exact shape. As the data points are added to the graph paper, connect them with a faint pencil line to give an idea of the shape of the equipotential. Locate an equipotential as closely as possible to each electrode and space the rest uniformly between the electrodes. As a new equipotential is started, write on the graph paper the voltage for that equipotential.

(d) To determine the electric field pattern, utilize the voltmeter leads as follows. Start by taping the two leads together so there tips are about 1 or 2 cm apart. Then place one tip on the conductive paper (not on an electrode), and then by pivoting on that tip, and placing the other tip at various points within reach, find the point which has the greatest potential difference. The direction between the two tips is the direction of the electric field at that point in space! Now move the first tip to the position of the second tip and repeat this procedure to map out an electric field line. Have one partner draw the electric field line at the corresponding points on the graph paper.

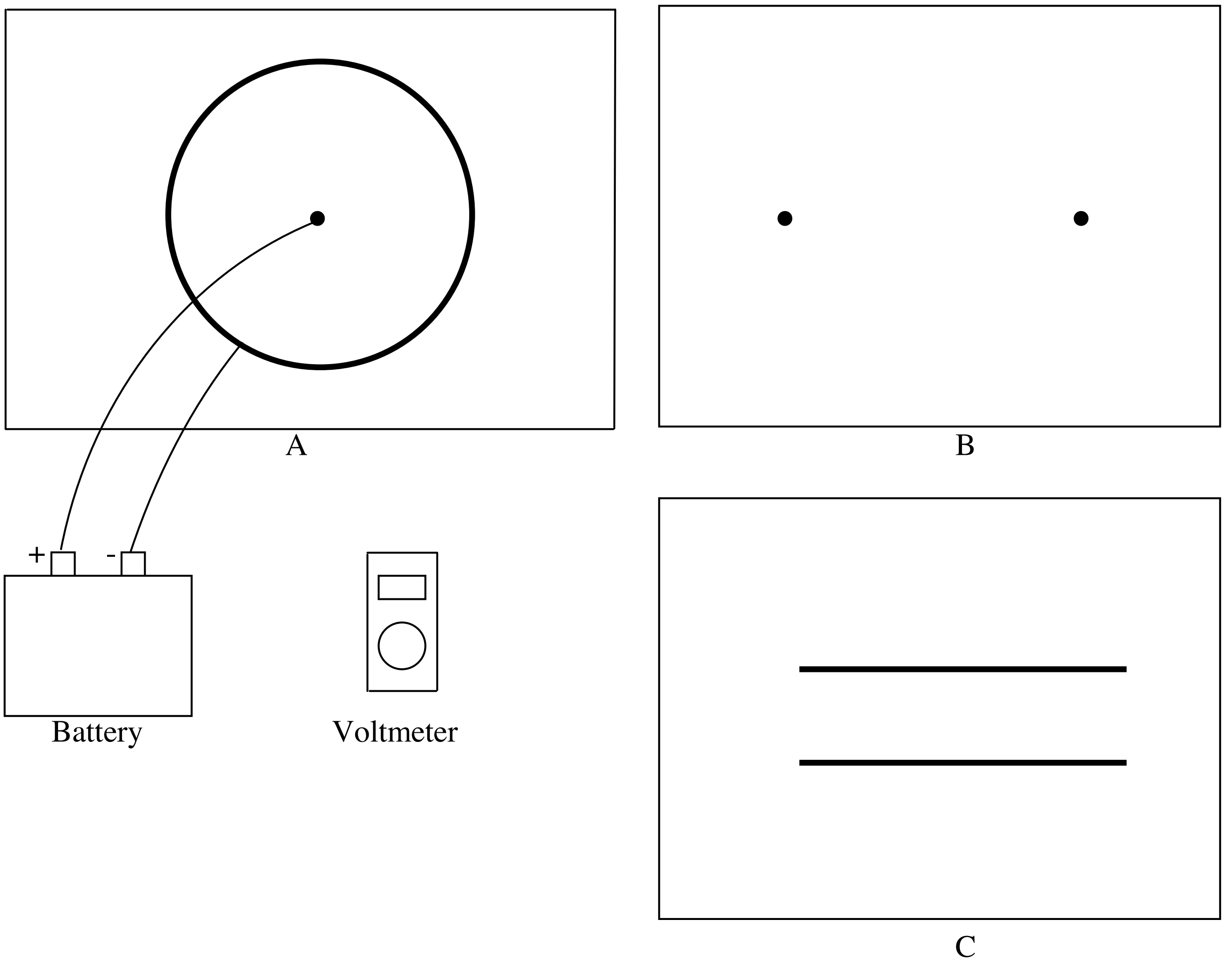
(e) Repeat steps (a) through (d) for the electrode geometry B (dipole), using a separate sheet of graph paper.

(f) Now repeat steps (a) through (d) for geometry C, (parallel plate capacitor). Again, record all data on a separate sheet of graph paper.

<u>Lab Report:</u>

(1) For each of the equipotential plots, outline the electrode shape in one color. Sketch the equipotential lines in a second color. Use a third color to show the electric field pattern by drawing well spaced lines of force that conform to the properties described in part I of the Principles' section. Recall also that the electric field is stronger where the equipotential lines come closer together, and thus the lines of force are also closer together.

(2) In the conclusion section include a discussion of the following items:
- comparison of your experimental equipotential patterns with theory;
- distribution of the surface charge density over extended electrodes;
- possible causes of discrepancies between the experiment and theory.



Name of Student: ____

Date Performed: ____

Instructor's Initial: ____

Questions

1) Cite some similarities between gravitational, magnetic, and electrical fields. State the law of force in each case.
2) What is an electric field line of the force?
3) What is an equipotential line or source?