

Potential Mapping

Experiment 13

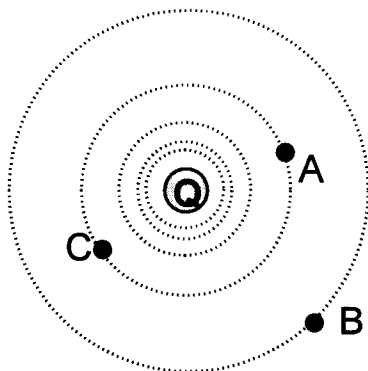
INTRODUCTION

Electric potential is a very important concept in electrostatics. It is usually easier to use because it is a scalar, whereas Coulomb forces and electric fields are vectors. In this experiment, we will measure the potential surrounding a charged body to create a two-dimensional representation of the potential and use our findings to obtain the electric field.

THEORY

The electric potential of point charge Q is given by $V = k\frac{Q}{r}$, where r is the distance measured from the position of the charge. As we move away from the charge, the electric potential decreases and reaches a value $V = 0$ at $r = \text{infinity}$. In Figure 1, the electric potential at point A is greater than at point B since it is closer to the charge Q . On the other hand, since points A and C are at the same distance from Q , $V_A = V_C$. If instead we have a system where there are 2 or more charges, the electric potential at any point in space is given by the *algebraic* (not vector) sum of the potential due to each individual charge.

An equipotential plot can help us visualize how the electric potential changes in space. These plots are 2 dimensional and consist of a set of lines equipotential lines. An equipotential line is form by simply connecting all points that share the same electric potential value. For example in Figure 1 equipotential lines will form concentric circles with Q in at the center.



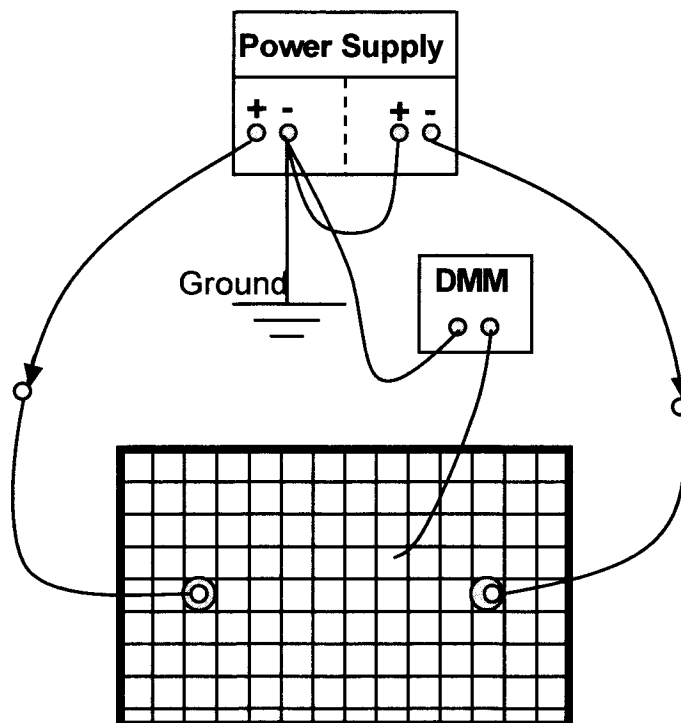
**Figure 13.1: Equipotential lines for a positive point charge Q .
The value of V decreases as we move away from the charge.**

The electric field is another important concept in electrostatics. It is easy to map the electric field lines using the equipotential lines. Unlike the electric potential, the electric field \mathbf{E} is a vector quantity; it has magnitude and direction. The electric field is given by the change of electric potential over a change in position. In one dimension, the electric field can be written as $E = -\frac{\Delta V}{\Delta x}$, where the negative sign simply gives the direction of the field. Therefore, the closer equipotential lines are spaced, the larger the magnitude of E in that region. Electric field lines point in the direction of decreasing electric potential, and they are always perpendicular to the equipotential lines. How would the field lines look for the situation in Figure 13.1?

In this experiment, we will apply a voltage to the electrodes in a slightly conductive piece of paper and measure the electric potential across its surface. Because the paper does have a finite resistance, a small current will propagate on its surface creating a potential difference. Since the current does not change with time the potential will not change either, and we can use a multimeter to measure V on the surface and create a two-dimensional map of the potential.

EXPERIMENT NO. 13

1. Connect the power supply to the electrodes on the paper as shown in the diagram below. Use push pins to fix the ring connector wires to the electrodes on one end and alligator clips (arrows in the diagram) on the other end to connect the power supply.



2. Connect one end of the digital multimeter to the ground input of the power supply. Ground is simply the reference voltage value against all measurements will be made; in this case, $V_{\text{ground}} = 0$ volts. The other end of the DMM at whatever point on the paper you want to measure V . To get the exact location, you must place this end vertically on the paper.
3. Turn ON the power supply each side should provide 5 V. To check that the push pins make good contact use the DMM to read the potential at each electrode. The potential on one electrode should read 5 V and -5 V on the other. Take reading at different points of the electrode to convince yourself that it is the same. The electrodes have been drawn with silver ink which has a much larger conductivity than the paper.
4. We now want to start creating the equipotential lines. Use the DMM to find a location where the potential is 3 volts and mark that position on paper provided to sketch the equipotential map. Continue to identify other locations with $V = 3$ V. To have a clear picture, these locations should not be more that 2 cm apart. Connect the dots with a soft curve to obtain the equipotential line for $V = 3$ V.
5. Similarly, sketch the equipotential lines for $V = 1$ V, 0 V, -1 V, -3 V.
6. Repeat the process for the other configurations of electrodes provided.
7. After you have finished drawing the equipotential lines, draw the electric field lines. Remember that these lines are perpendicular to the equipotential lines, and they point in the direction of decreasing V . Be sure to illustrate the direction of \mathbf{E} in your plot and to clearly label each set of lines
8. The configuration of two straight electrodes is similar to that of a parallel plate capacitor. Starting on one plate, take several measurements of V spaced by 1 cm until you reach the other plate. Take the measurements along the middle of the plates.

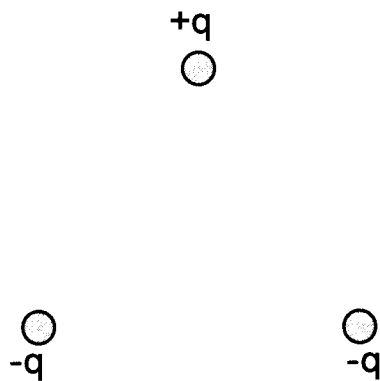
V (volts)	x (cm)

9. Plot your results in a V vs x graph and calculate the electric field between the plates.

QUESTIONS

1. Can two or more equipotential lines intersect each other? Explain.

2. Three point charges are placed an equal distances from each other as shown in the figure below. Draw the electric field and equipotential lines for the figure.



3. The graph show below can be divided into 5 different segments. a) Where do you have the largest electric field? b) Which segment(s) has the smallest electric field? Explain your answers. c) Calculate the electric field for each segment.

