Electric Field and Electric Potential

Prelab

LR Write experiment title, your name and student number at top of the page.

LR **Prelab 1:** Write the objective of this experiment.

LR **Prelab 2:** Write the relevant theory of this experiment.

LR **Prelab 3:** List the apparatus and sketch the setup.

! Have these ready to be checked by lab staff at the door on the day of your lab.

Introduction

In this experiment, you will measure electric potential and use those measurements to plot both equipotential lines and draw the corresponding electric field lines for two configurations.

This process will allow us to better visualize the relationship between electric field and electric potential when presented with problems on these topics.

There are many analogies that can be drawn from this analysis to resistive elements in circuits, but more importantly, to static charges and charge distributions.

Introduction: Electric fields

Electric field $\vec{E}$ is defined by the electric force $\vec{F}$ acting on an electric charge q_0, defined as

$$\vec{E} = \frac{\vec{F}}{q_0} .$$

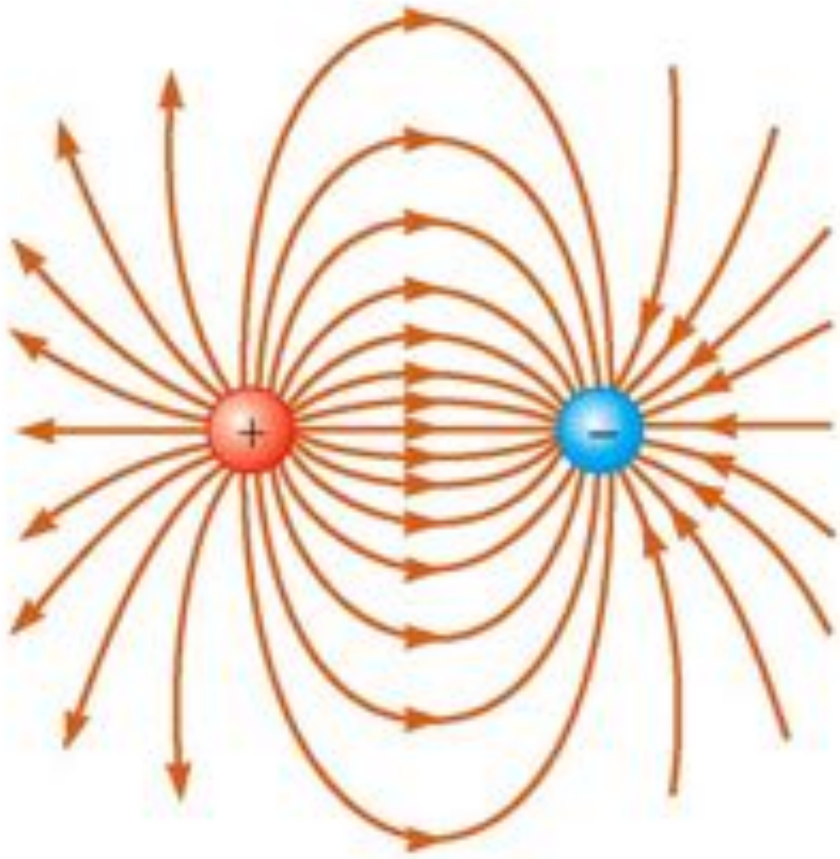
Electric field radiates away from a positive charge and towards a negative charge. Electric field lines are used to visualize the electric field around charges or configurations of charges.

In this experiment, the setup of two terminals are very analogous to configurations of static charges.

Introduction

If a positive and negative terminal are in close proximity, the electric field around them is altered as shown in the diagram. This is referred to as a dipole.

The number of field lines leaving or entering each charge also indicate the relative magnitude of the charge. i.e. The greater the charge, the greater number of lines.



Introduction: Electric potential

Electric potential V is defined by energy per unit charge.

$$Potential = \frac{joules\ (J)}{coulomb\ (C)} = volts\ (V)$$

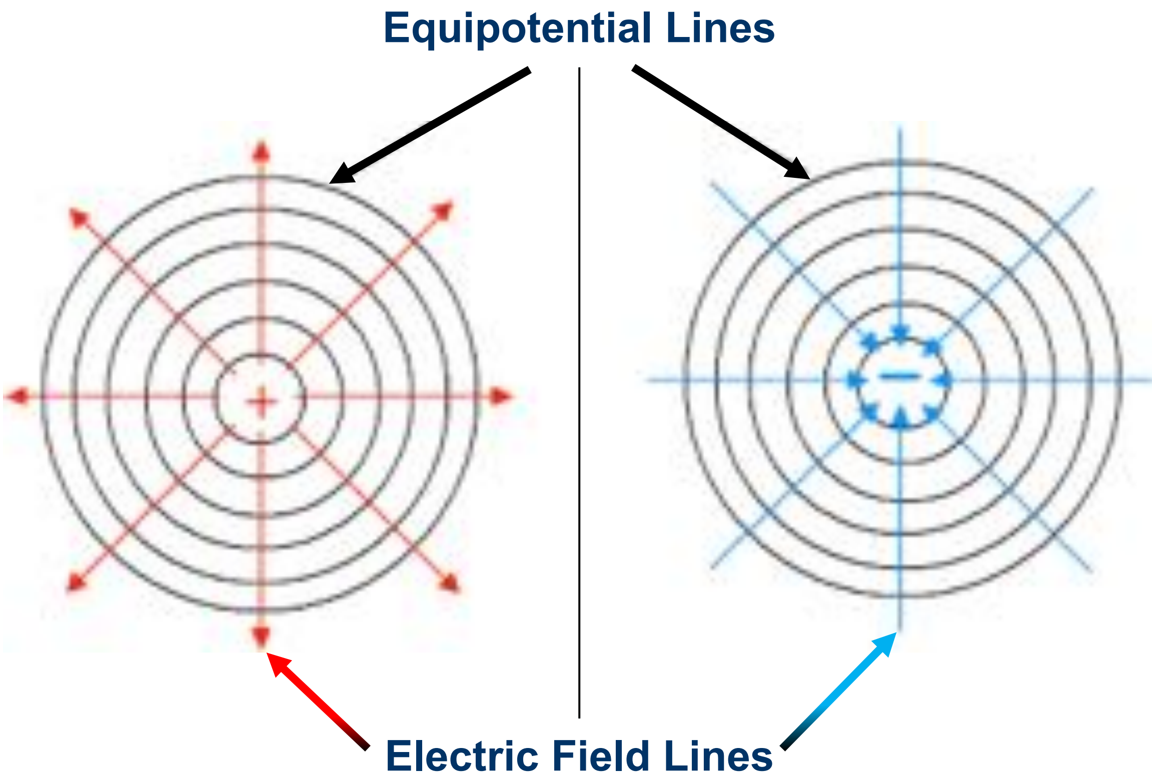
Specifically, it relates the amount of work required to move a unit of charge within and electric field. Electric field and electric potential are related by the expression:

$$E_r = -\frac{\partial V}{\partial r} \approx -\frac{\Delta V}{\Delta r}$$

where E_r is the electric field in the r-direction.

Equipotential lines are lines along which the electric potential is constant and are always perpendicular to electric field lines.

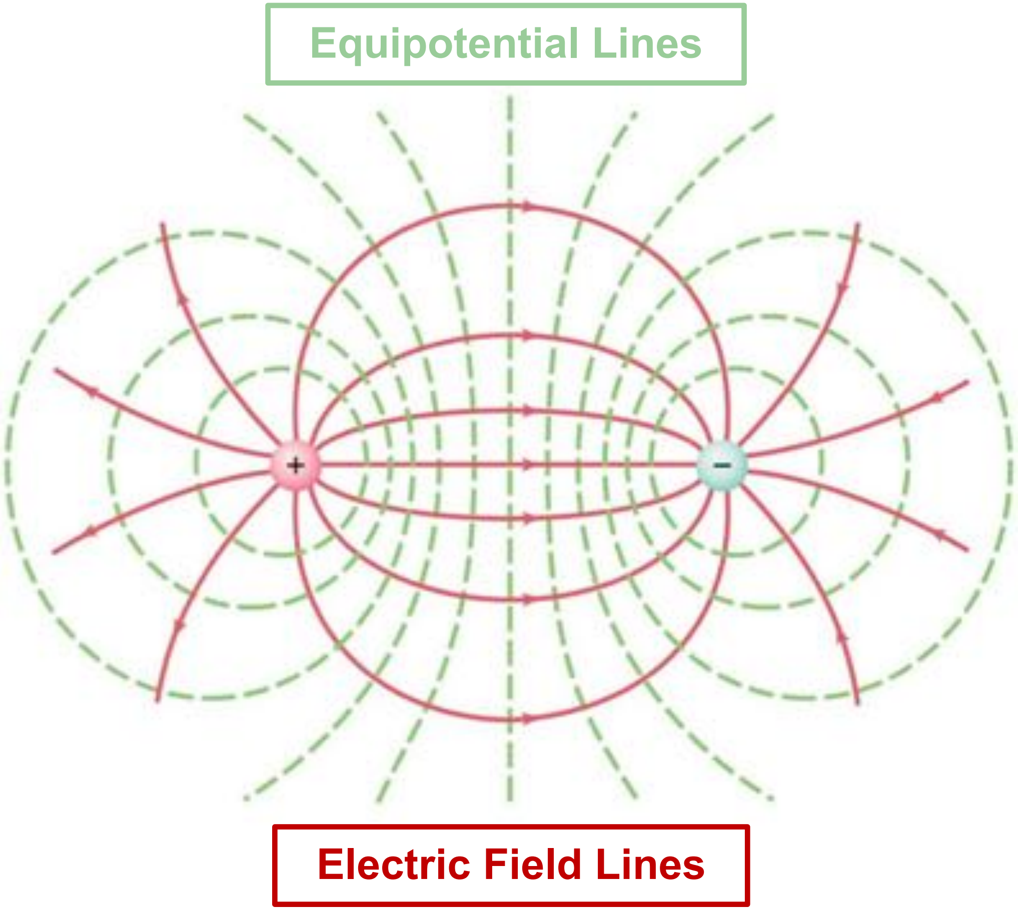
Introduction



Equipotential lines (black) and electric field lines (coloured) for positive and negative point charges are described as shown.

In this case, it is assumed that these charges would be far away from each other, with their fields not interfering with one another.

Introduction



Equipotential lines are always perpendicular to electric field lines, even in more complicated scenarios.

In charge configurations, the number of field lines leaving or entering each charge also indicate the relative magnitude of the charge. i.e. The greater the charge, the greater number of lines.

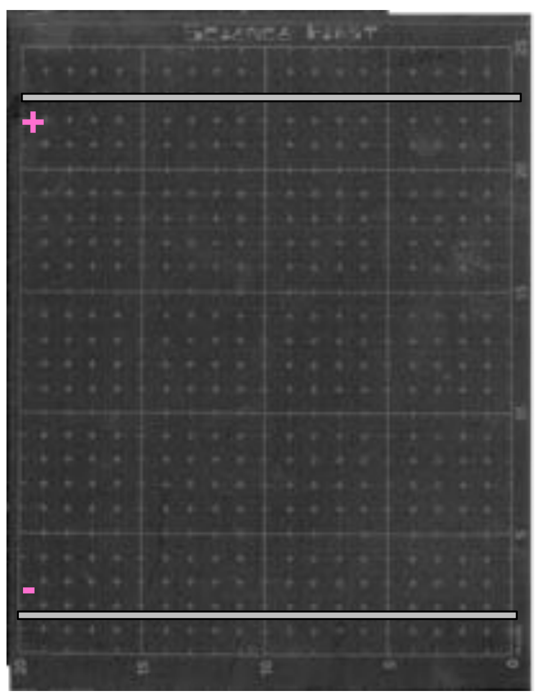
Apparatus and setup

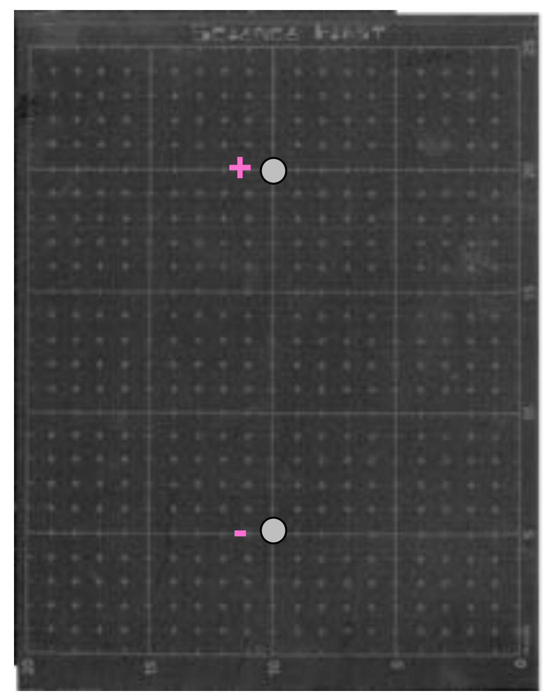
You have been provided with the following equipment:

- conductive paper boards
- multimeter
- power supply
- 4 electrical leads
- 2 alligator clips
- graph paper

Apparatus and setup

Your conductive paper has one of the following patterns. The metal components attached are referred to as **electrodes**. We'll connect our power supply leads to these electrodes to supply voltage.





Expected Field and Potential

Starting with the **bar-bar configuration** as shown here.

Lab Report 1: In your lab report, make a small sketch of what you expect for the electric field and electric potential lines for this electrode pattern.

Lab Report 2: On the graph paper provided, draw the placement of your electrodes.

Apparatus and Setup

Connect a lead from the COM port of the multimeter to the negative terminal of the power supply:

Apparatus and Setup

Use another lead and connect it into the **VΩmA** port of the multimeter.

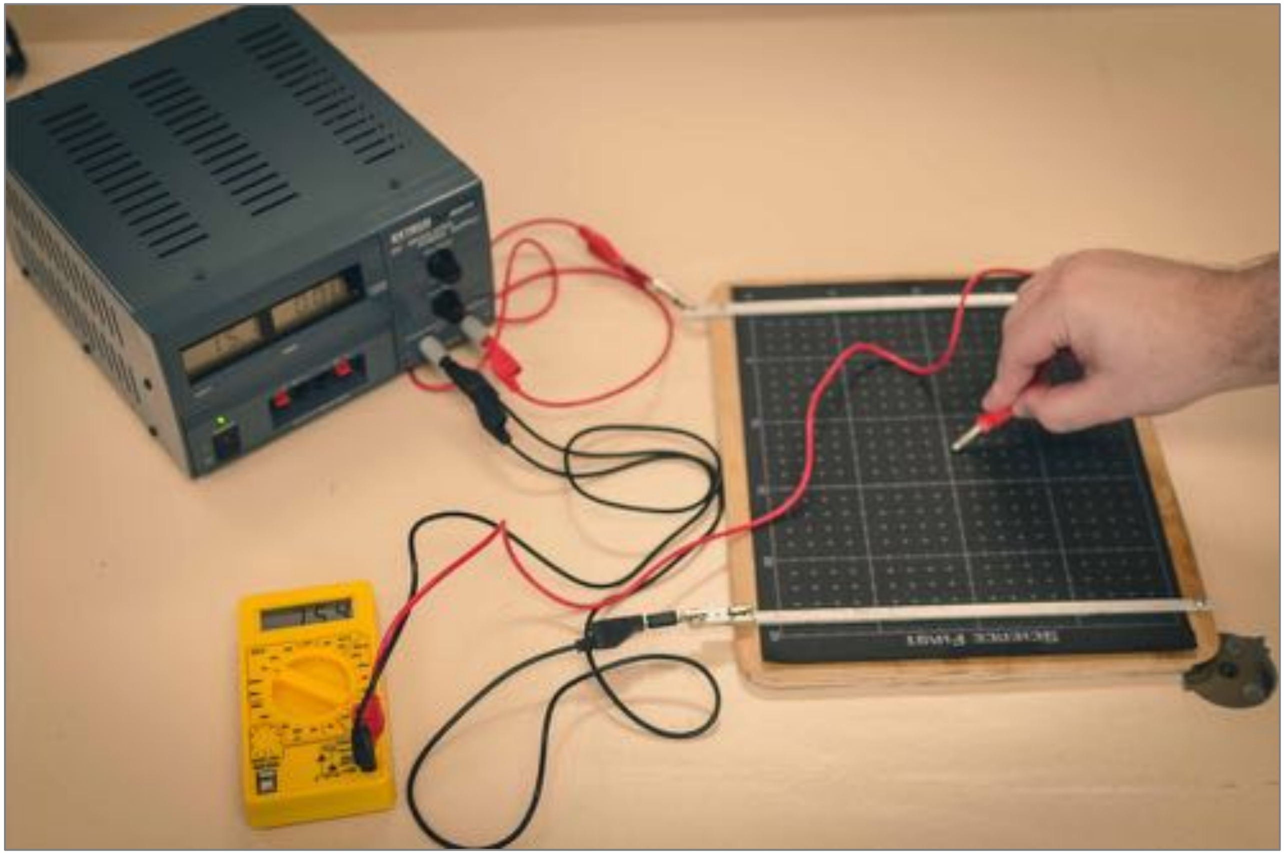
Leave the remaining end free to be used as a probe.

Apparatus and Setup

Using two more leads and the alligator clips, connect the power supply to the electrodes of the conductive paper.

Apparatus and Setup

The completed setup:



Apparatus and Setup

LR

- Switch your multimeter to 20 DCV to measure voltage.
- Turn on the power supply. Adjust the current and voltage controls until the voltage display on the power supply reads about 15 V.
- **Label your electrodes** on your graph paper as ‘+’ or ‘–’.

Test the setup:

Touch the probe end of the lead to the conductive paper, you should see a voltage reading on the multimeter.

If you do not see a reading, consult a member of the lab staff.

Data Collection

Use the probe to find a place where the voltage reads approximately 7.5 V, roughly in the center of your paper.

LR

Mark this location in the corresponding position on a piece of graph paper and label it with it's voltage value.

!

Do not mark on the black conductive paper!

LR

Move the probe a few cm and find a nearby place where the potential is also roughly 7.5 V. Mark this on your graph paper and label it.

Continue to move the probe and **locate at least three more points** where the potential is roughly 7.5 V. There should be 5 points total.

!

For best results, make sure your voltage measurements are spread approximately equally across the whole width of the paper.

Data Collection

LR Based on your labelled points, draw a line to approximate your equipotential line.

CP **Have an instructor check your work and initial your lab report.**

LR Continue this process and approximate at least **2 more equipotential lines** (of 5 labelled points) on **either side of your 7.5 V** equipotential line. You can choose at what voltage values you wish to use.

LR Once you have drawn all **5 equipotential lines**, **draw electric field lines** to illustrate the electric field for this charge configuration.

LR **Lab Report 3:** Comment on your agreement between your initial sketch and the graph paper plot you just created.

Analysis

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Consider the **dot-dot configuration**, as opposed to the bar-bar configuration. For the next part, we'll analyze the the dot-dot and determine the equipotentials and electric field for this configuration.

LR

Lab Report 4: For the dot-dot configuration, draw a rough sketch in your lab report of what you expect for the equipotential and electric field for this configuration.

Exchange your conductive paper for the **dot-dot configuration** as shown here.

Data Collection and Analysis

Repeat the process as before, drawing your electrode locations and beginning with roughly 7.5 V. Label 5 points and sketch your equipotential line.

LR Find and record at least 2 more equipotentials (of 5 labelled points) on either side of your 7.5 V equipotential line. You should have 5 equipotentials total.

LR Use your equipotential lines and draw your resultant electric field lines for this pattern.

LR **Lab Report 5:** Comment on your agreement between your initial sketch and the voltage plot for the dot-dot configuration you just created.

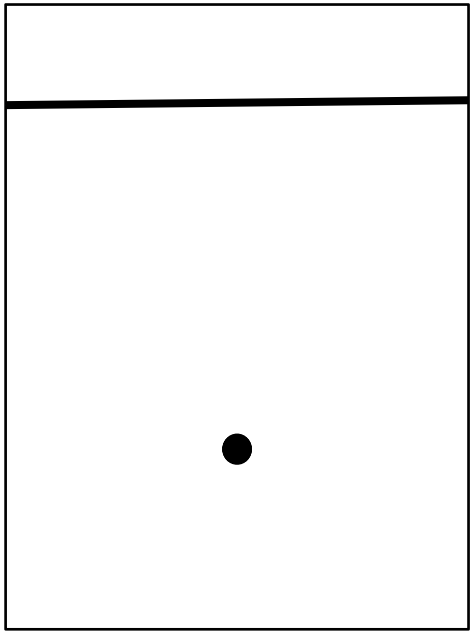
Analysis

LR

Lab Report 6:

Sketch what you would expect the electric field lines and equipotentials to look like for the pattern drawn here.

Indicate the direction of your electric field and label positive and negative electrodes.



Summary & Conclusion

LR **Lab Report 7**: Briefly summarize your experiment, in a paragraph or two, and include any experimental results.

LR **Lab Report 8**: List any sources of experimental uncertainty and classify them as random or systematic.

! **Include your prelab, voltage plots, and all analysis.**