Electric field and electric potential

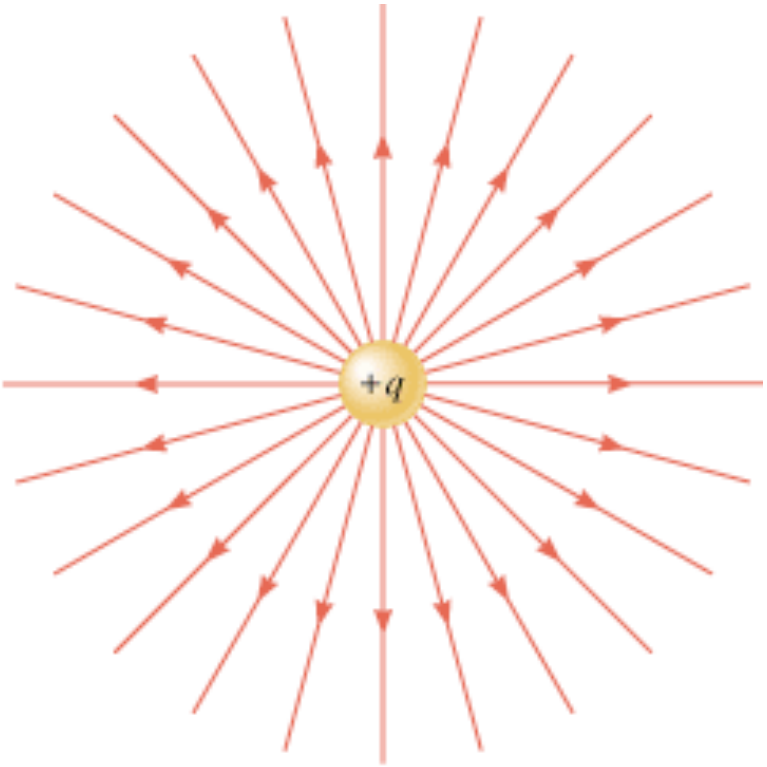
Introduction: Electric fields

Electric field $\vec{E}$ is a **vector**, with the units *newtons per coulombs* (N/C), defined by the electric force $\vec{F}$ acting on an electric charge q_0, defined as

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

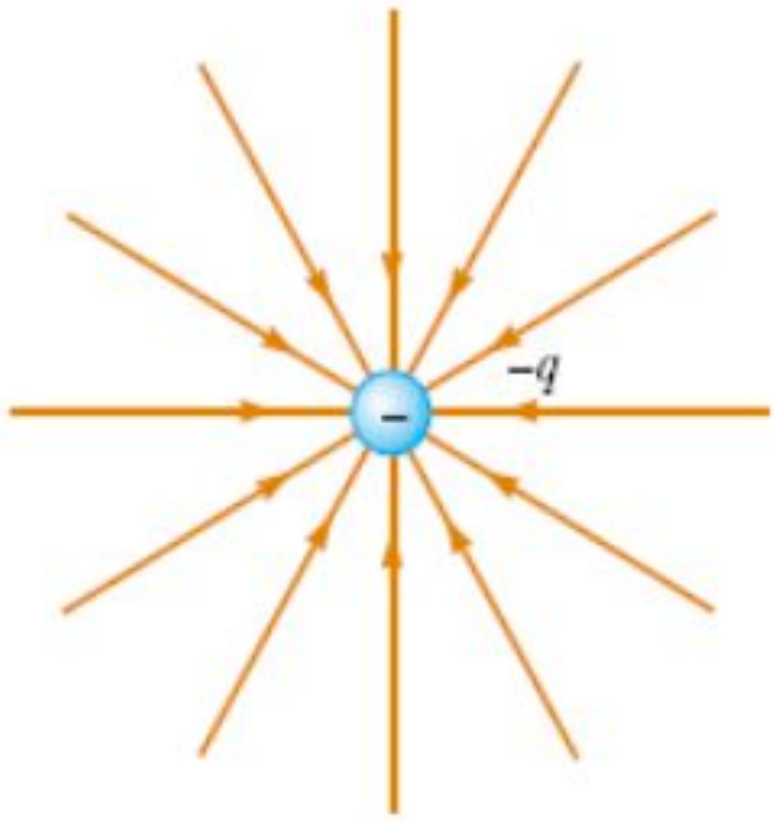
Electric field points away from a positive charge and towards a negative charge. Electric field lines are used to visualize electric fields and show the electric field around charges or configurations of charges.

Introduction



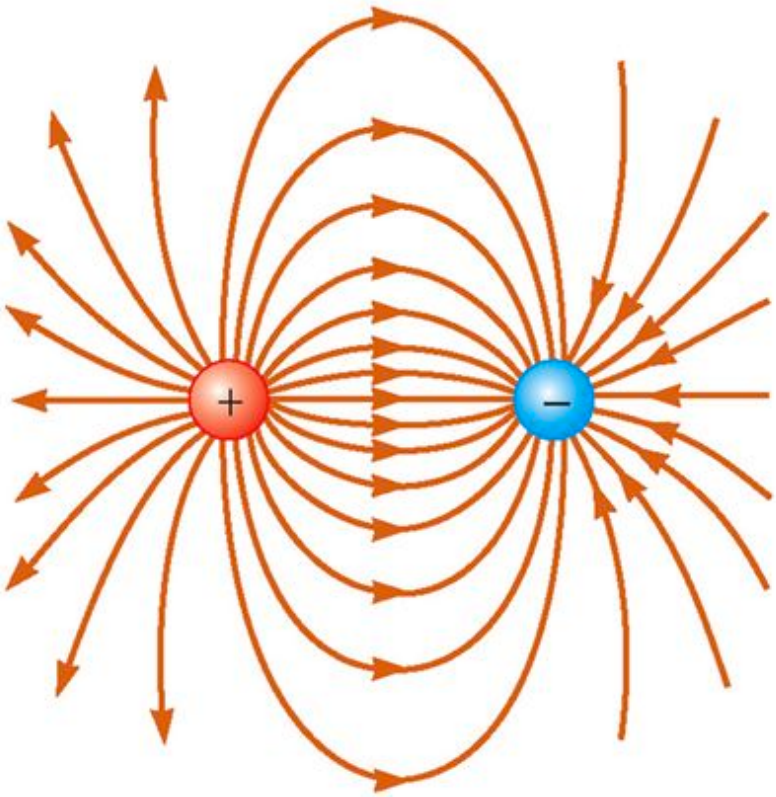
Charge q is positive, and the electric field radiates outward as indicated by the arrows.

Introduction



Charge q is negative, and the electric field radiates inward as indicated by the arrows.

Introduction



If a positive and negative charge are brought together, 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 a **scalar** quantity denoted by V, with unit $volts\ (V)$, defined as the amount of potential energy per unit charge.

$$V = \frac{U}{q_0}$$

Electric field and electric potential are related by the expression:

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

where E_r is the electric field in the r direction. This shows that the electric field points in the direction of decreasing electric potential. So, if we map the direction of decreasing V, we can show the direction of the electric field.

Part II: Introduction Equipotential lines

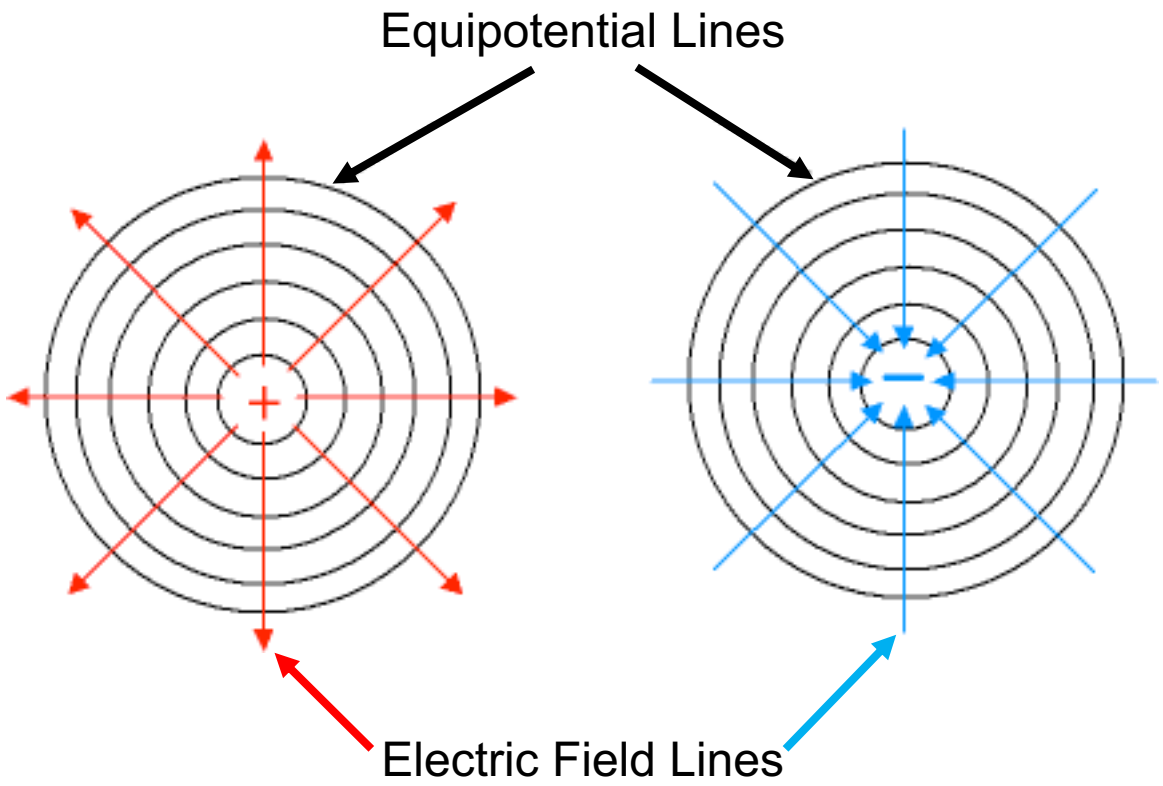
Equipotential lines are lines along which the electric potential is constant.

By tracing equipotential lines, you can use these lines to determine the shape of the electric field around some electric charge.

Equipotential lines are always perpendicular to electric field lines.

Some examples are shown on the following slides.

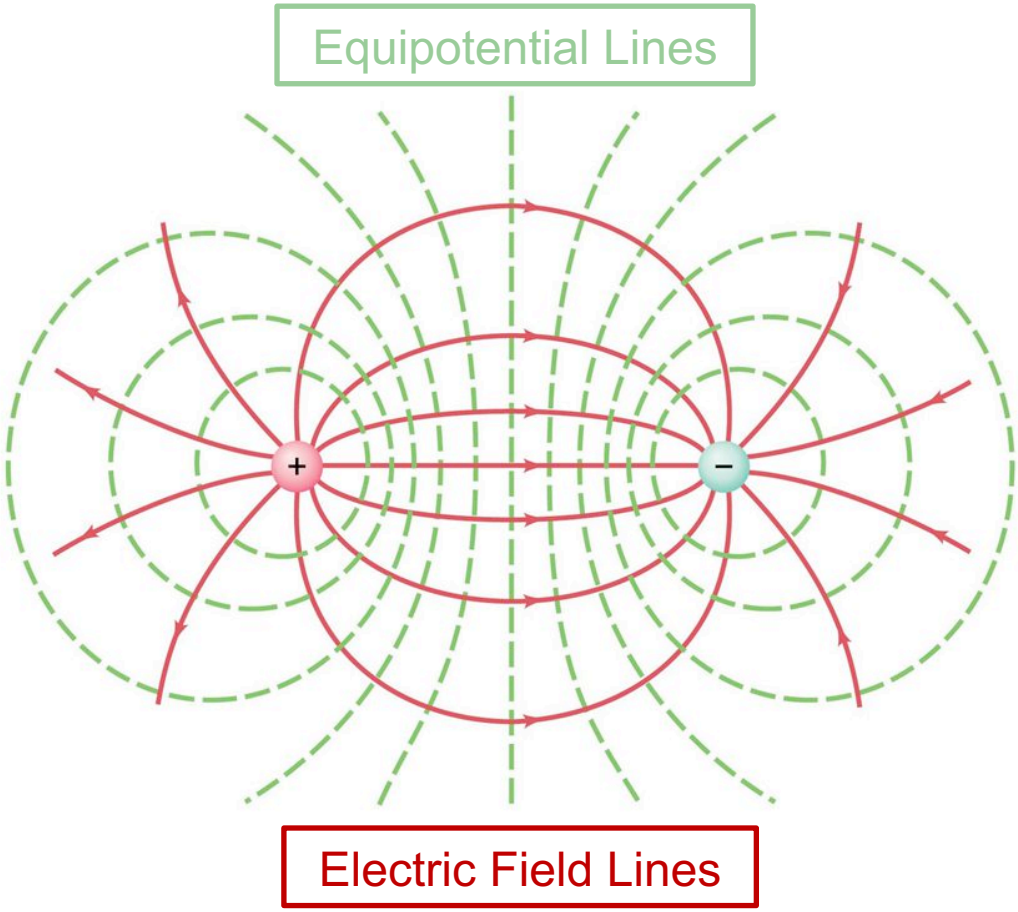
Part II: Introduction



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



When two charges are in close proximity to each other, their fields begin to interfere with one another.

This is referred to as a *dipole*.

Equipotential lines are in green and electric field lines are in red.

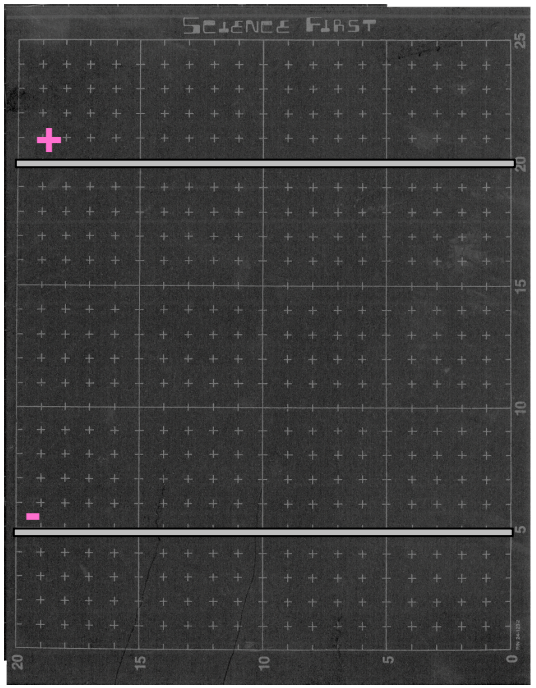
Objectives

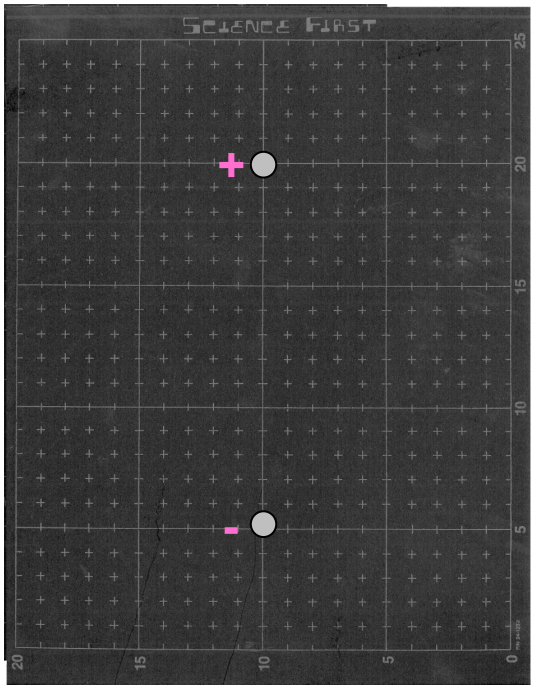
In this experiment, you will measure electric potential and use those measurements to plot both equipotential lines and electric field lines for two configurations of charges.

This process will allow us to better visualize the electric field and electric potential when presented with problems with electric charges.

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

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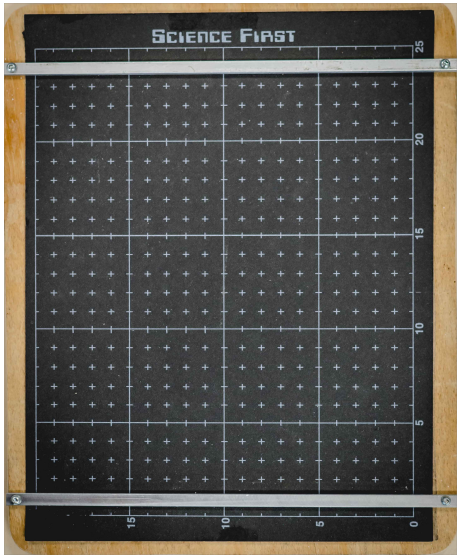
Question 1: For the two line pattern, draw the placement of your electrodes in the space provided. Indicate the positive and negative electrodes.



LW

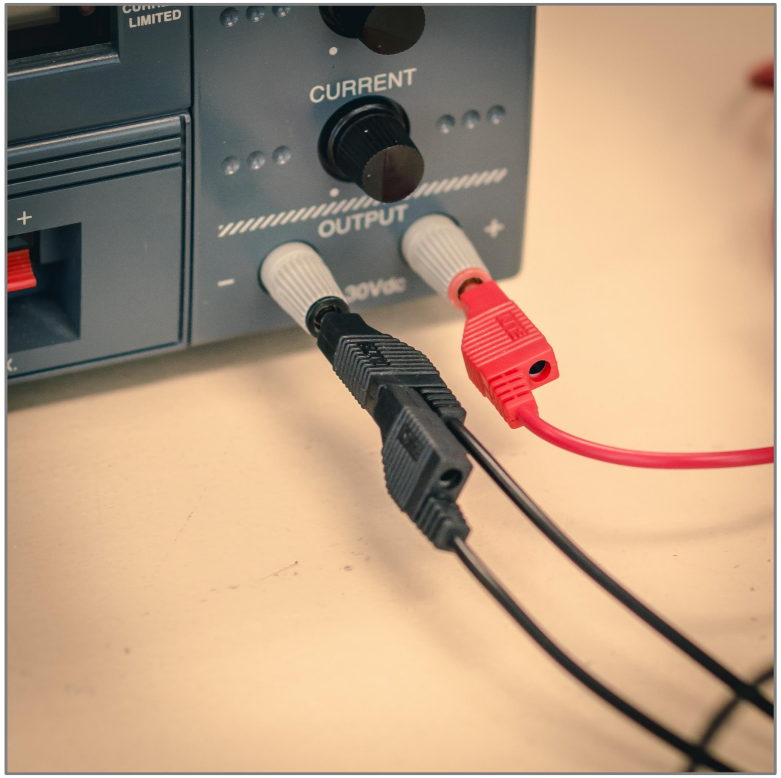
Draw what you expect for the electric field and electric potential lines on this pattern.

Apparatus and setup

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

Apparatus and setup

Using two more leads, connect one into the back of the **negative** lead on the power supply, and the other into the **positive** terminal of the power supply.



Apparatus and setup

Using two alligator clips, attach these to ends of the leads and connect them to the both of the electrodes on your conductive paper.

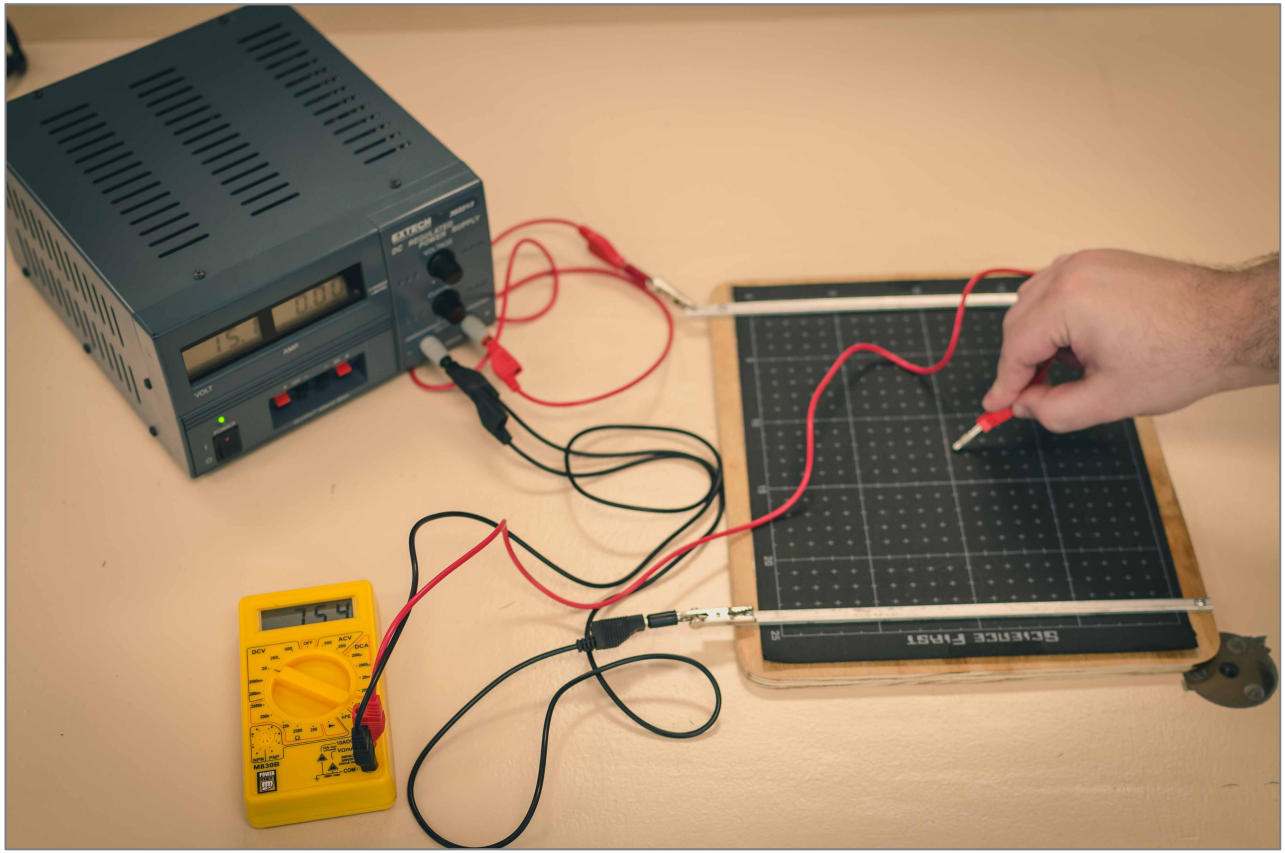
Apparatus and setup

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

Leave the remaining end free (it will be the **probe**).

Apparatus and setup

The completed setup:



Apparatus and setup

- Turn on the power supply. Adjust the current and voltage controls until the voltage display on the power supply reads about $15\ V$.
- Turn on your multimeter by moving the switch to $20\ DCV$.

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.

Measurements: Finding the first equipotential

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

LW **Mark this location** in the corresponding position in your workbook and label it with it's value.

Do not mark on the black conductive paper!

LW **Move the probe a few cm** and find a nearby place where the potential is also roughly $7.5\ V$. Mark this in your workbook 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 spots are spread approximately equally across the whole width of the paper.

Measurements: Finding the remaining equipotential lines

- 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.**

LW
- Continue this process and approximate at least **3 more equipotential lines** (of 5 labelled points) **on either side** of your $7.5\ V$ equipotential line. The suggested voltage values can be $2.0\ V, 4.0\ V, 6.0\ V, 7.5\ V, 9.0\ V, 11.0\ V, 13.0\ V$.

LW
- Once you have drawn all 7 equipotential lines, **draw electric field lines** to illustrate the electric field for this charge configuration.

Analysis:
Drawing the equipotential lines

Question 2: Comment on your agreement between your sketch in Question 1 and the plot you just created.

Exchange your electrode pattern with the other pattern.

Question 3: For this pattern, sketch the placement of your electrodes in the space provided and label the electrodes + and -.

Draw a rough sketch of what you expect for the equipotential and electric field lines on this pattern.

Measurements:
Repeat finding equipotential lines

LW

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

LW

- Find at least 3 more equipotential lines (of 5 labelled points) **on either side** of your $7.5\ V$ equipotential line. The suggested voltage values can be $2.0\ V, 4.0\ V, 6.0\ V, 7.5\ V, 9.0\ V, 11.0\ V, 13.0\ V$.

LW

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

Analysis

Question 4: Comment on your agreement between your sketch in Question 3 and the plot you just created.

Question 5: Comment on how your electric field varies and the location where electric field is stronger, weaker, or constant:

a) for pattern 1.

b) for pattern 2.

Analysis

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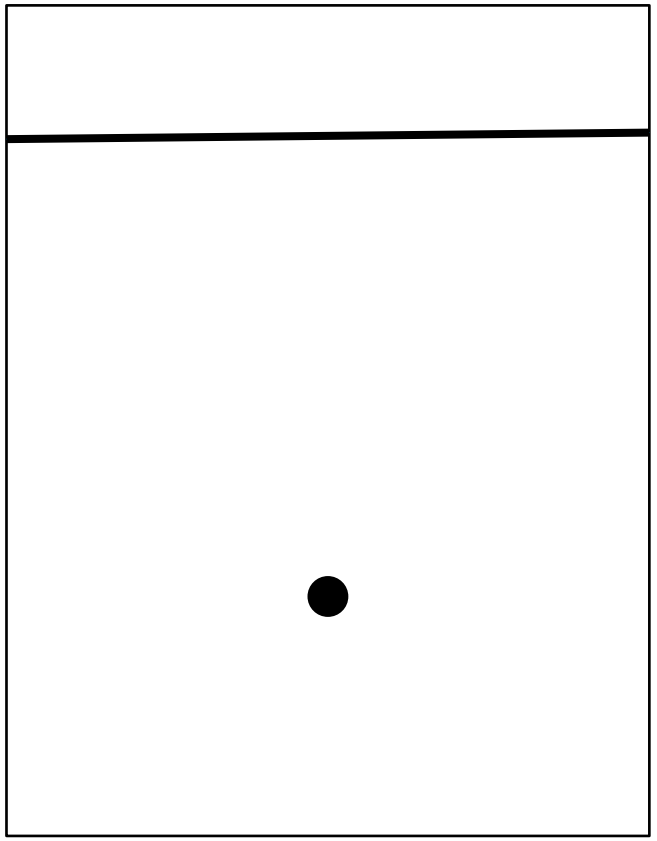
Question 6:

Indicate the positive and negative electrodes.

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



Conclusions

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Question 7: Give two sources of uncertainty and classify them as random or systematic.

- **Staple your prelab to the appropriate page.**
- **Disassemble setup and return lab equipment bin and unplug the power supply.**
- **Don't forget to log out of the computer and sign out.**