

Electric Fields and Potentials

Your Name _____	TA's signature allowing you to take the quiz or leave _____
Partners' Names _____	Obtained reasonable experimental results? yes <input type="checkbox"/>
_____	Answered questions? yes <input type="checkbox"/>
_____	Cleaned your table? yes <input type="checkbox"/>

Please do not write on the conducting sheet, and do not use more than 5 volts from the power supply.

Introduction

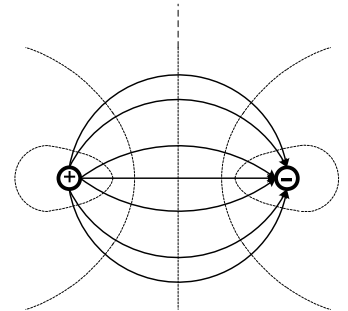
The force between electric charges is intriguing. Why are unlike charges repelled and like charge attracted? How do you explain them? The more fundamental idea is to use concepts of the electric fields and potentials. These can explain a series of electric phenomena. The electric potential is created by the distribution of charges, which is scalar determined by the different points. The difference of potential at two points is also known as voltage whose unit is volts (V). In general, potential is decreased when the point measured goes farther away. The electric potential entices other physical quantity that is the electric field. The electric field and potential are related as:

$$V = Ed$$

where V is the electric potential difference, E is the electric field, and the d is the distance between two points. One of the units of electric fields is V/m. The potential is scalar, but the field is vector. They are geometrically perpendicular each other as shown in the figure. (Solid and dotted lines are electric field and potential, respectively.) The basic example is a point charge. A point-charge creates the potential:

$$V = \frac{kq}{r}$$

where k is an electrostatic constant, $8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$, q is the charge, and the r is the distance between a point from the charge. With a different shape of electrodes, the geometry of the electric fields and potentials vary accordingly.



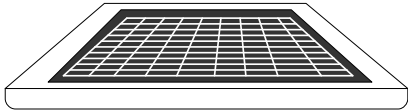
From the equation, potential difference depends on the magnitude of the charge and a distance from the point. If we consider two-dimensional space, we may find equal potential at numerous different points. The series of equal potential points can be found by measurement and this is known as equipotential lines. (In fact, the potential lines in the above figure are to be found by this procedure.)

The electric field lines express the magnitudes and directions of the field in space. There are important rules for the field lines: The electric field line must start on positive charges and end on negative charges. The field lines never cross. The magnitude can be found by how densely the lines are together. The closer the lines are, the stronger the electric field is.

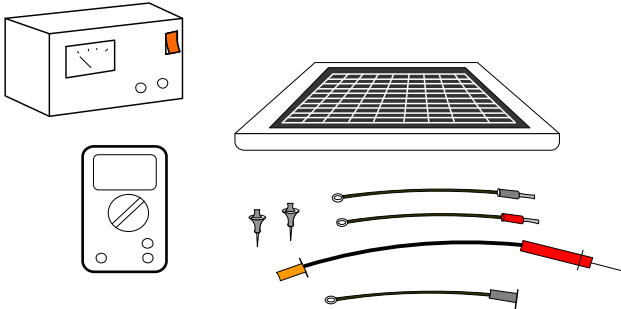
Objectives:

- To visualize electric potentials and fields
- To find the electric potential and field for different shapes of electrodes

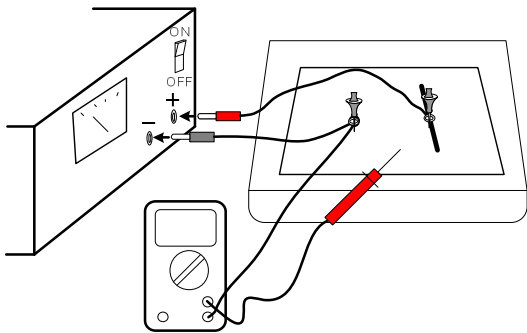
The procedure



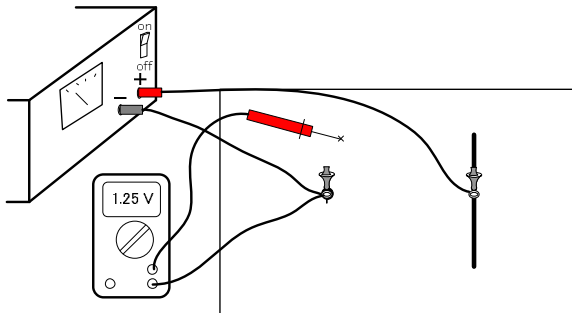
- Select one of the sheets and put it on the cork board.



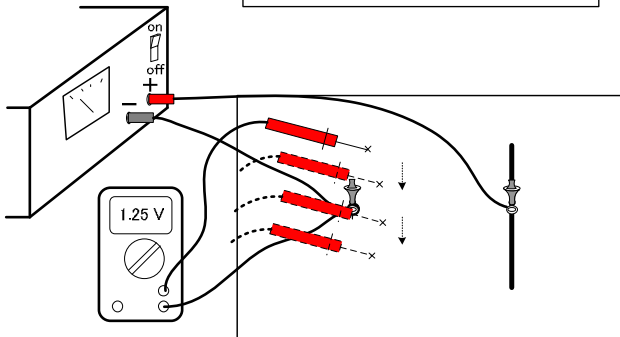
- Make sure you have the other items, such as banana leads, two metallic pins, a multimeter, a power supply, etc. as shown in the picture.



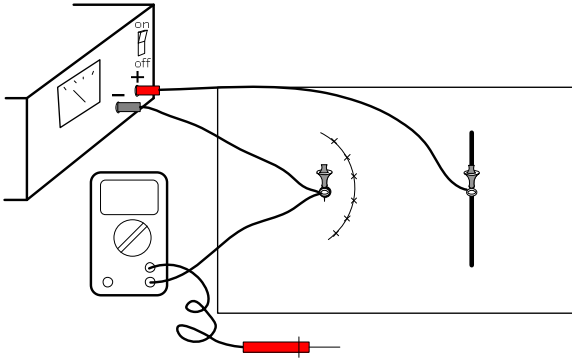
- Connect each electrode on the sheet with positive and negative voltages respectively. The figure is for a plate and point electrode. The negative voltage means ground. Follow the figure exactly. Refer to Appendix which is located in the last page of this manual.



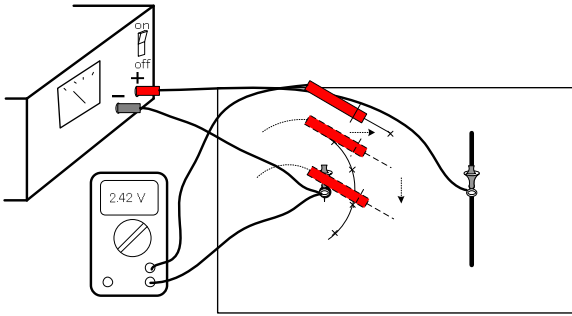
- Find an equipotential line, by using the multimeter. The probe will be put on the sheet as shown. You will observe a potential difference. Write it down on the datasheet.



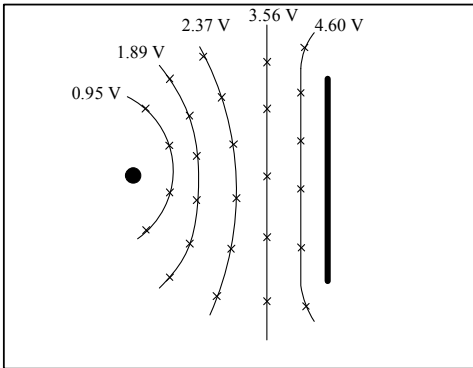
- Move the probe by keeping the same voltage on the multimeter. Record each point on the datasheet.



- Find at least 6 points to draw an equipotential line.

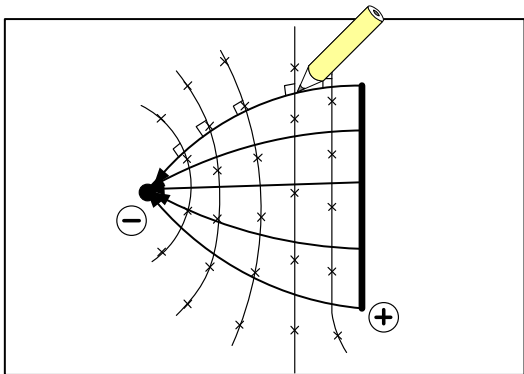


- Find another equipotential line as shown.



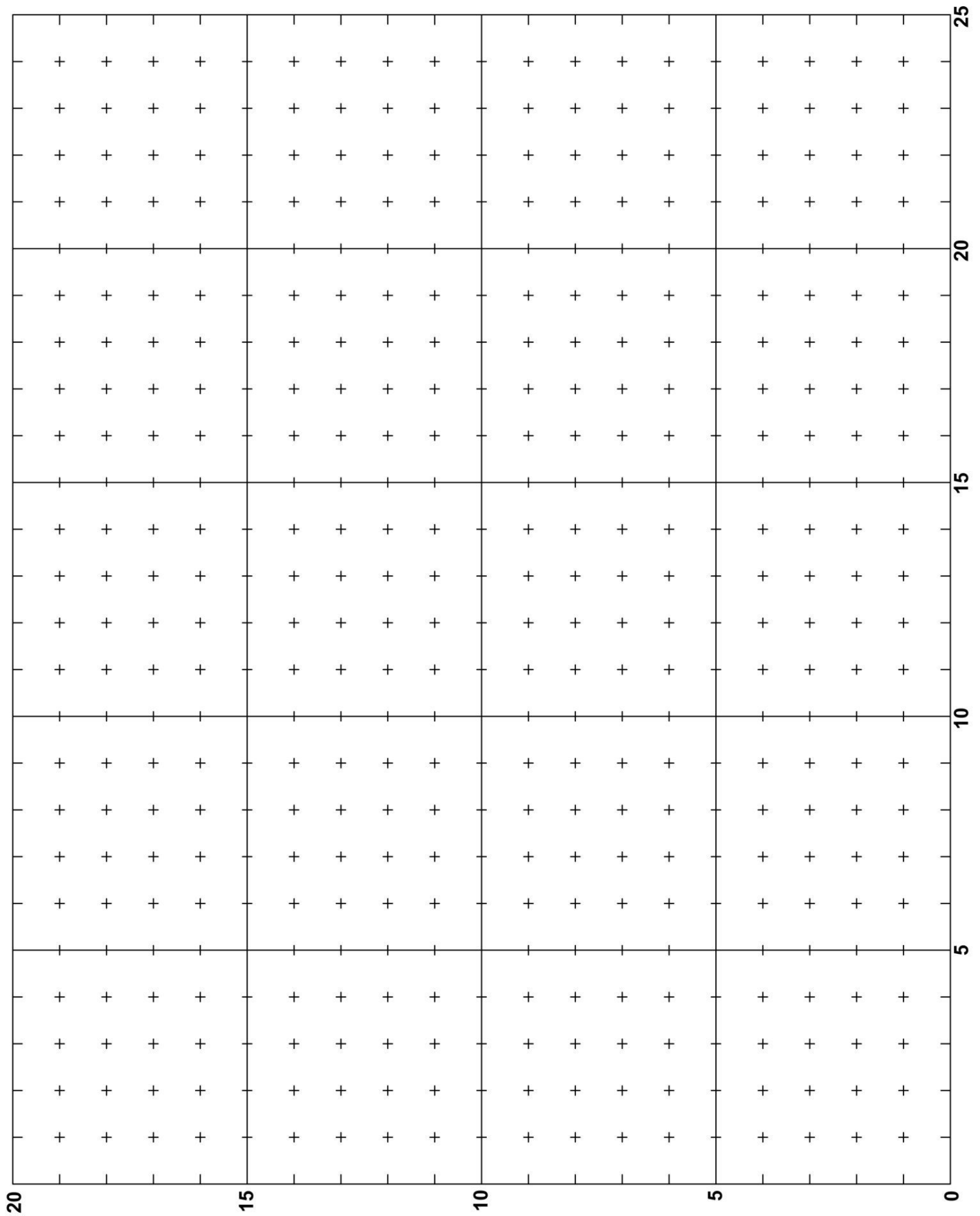
- This is a complete measurement for one set of the electrode. Take proper points so you can draw the series of lines. The points and lines should be symmetric.

A complete diagram

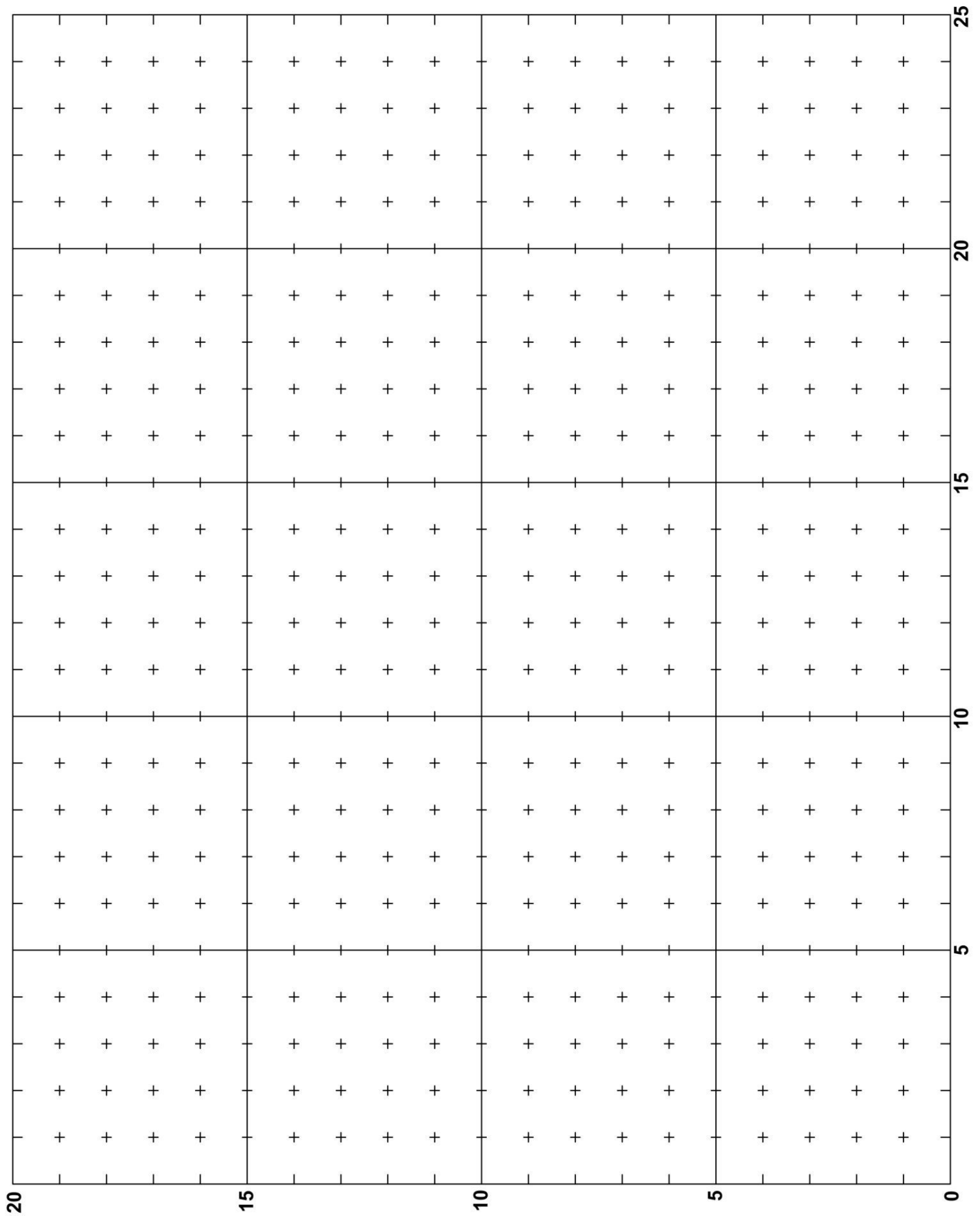


- After you get the proper number of equipotential lines, draw the electric field lines, which are perpendicular to the potential lines.
- Electric fields are from positive to negative electrodes. Indicate the directions with arrows.

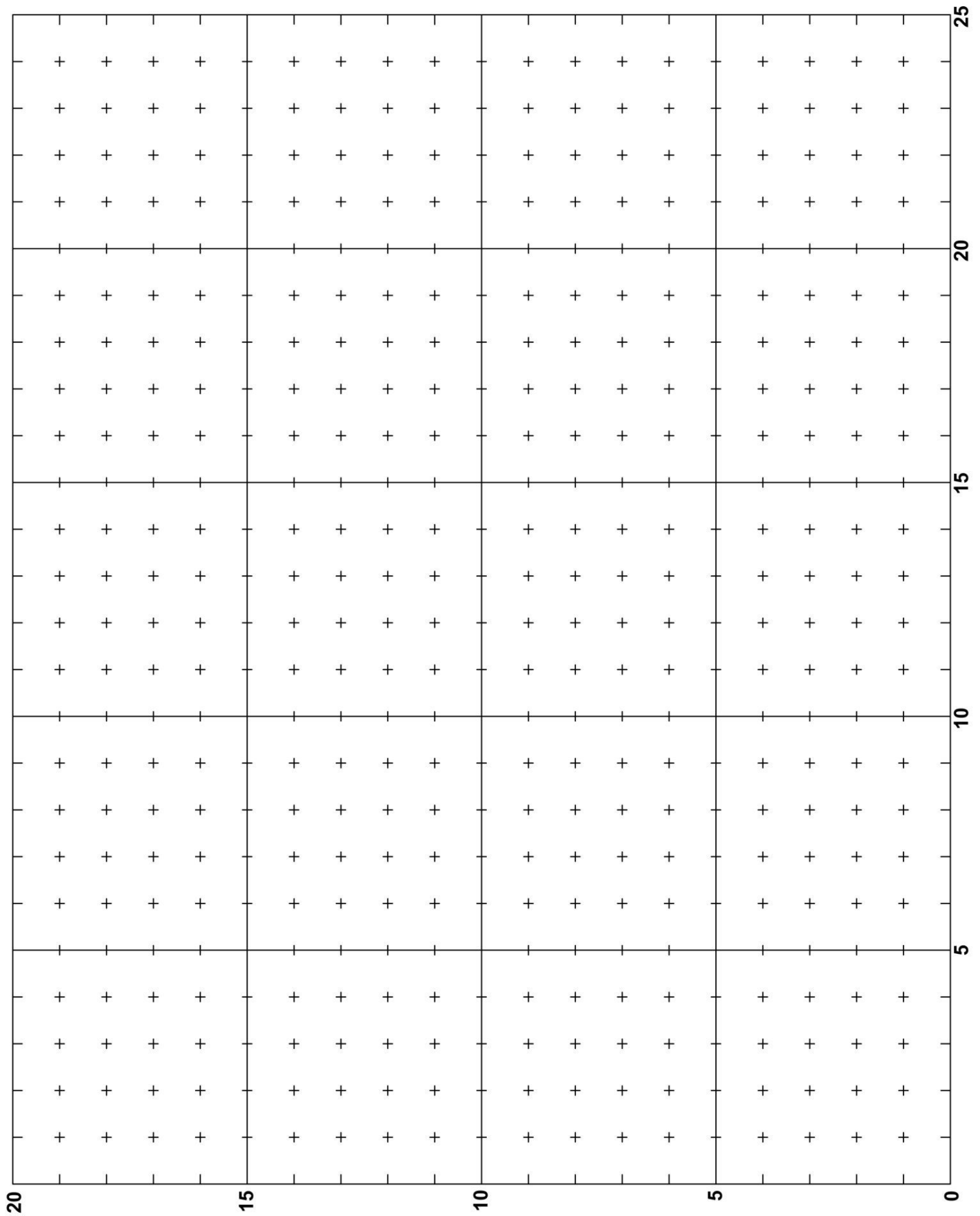
* This is to be drawn on the data sheet.



Question: Make sure that the voltage difference between + and - point charges is the same as displayed in the voltage source. Then measure the difference between one of the charges and the center potential lines. Is it just half of the above difference? Make sure with your instructor.



Question: Make sure that the voltage difference between + and - point charges is the same as displayed in the voltage source. Then measure the difference between one of the charges and the center potential lines. Is it just half of the above difference? Make sure with your instructor.

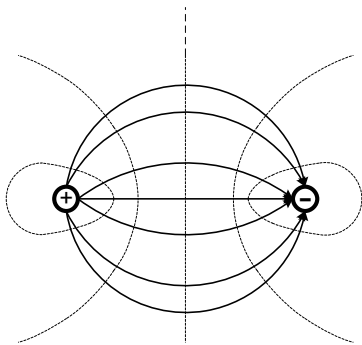


Question: Make sure that the voltage difference between + and - point charges is the same as displayed in the voltage source. Then measure the difference between one of the charges and the center potential lines. Is it just half of the above difference? Make sure with your instructor.

Discussions after the lab: (Discuss with your partners and the instructor.)

Note: Do not copy these onto the lab sheet. You must obtain the equipotential points to draw the lines experimentally.

Two Point Charges



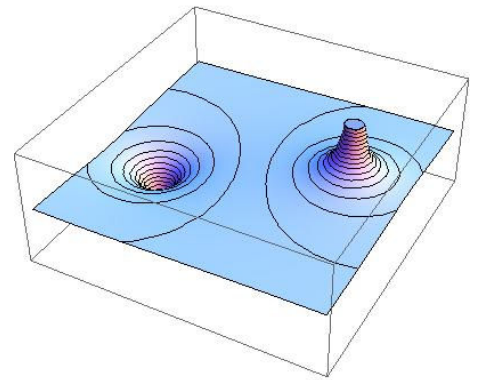
Electric Potential Lines - - - - -

Electric Field Lines →

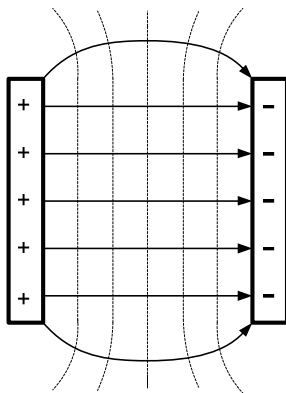
Question: From your results, which parts of the electric fields are close together? Does it make sense in terms of the strength of the field?

Question: If you plot the potential of two-point charges three dimensionally, the picture will be as follows: (The figure is from “Electric Dipole Potential” in the Wolfram Demonstrations Project)

Suppose you place a test charge exactly middle of the potential created two-point charges. What happens with the test charge?



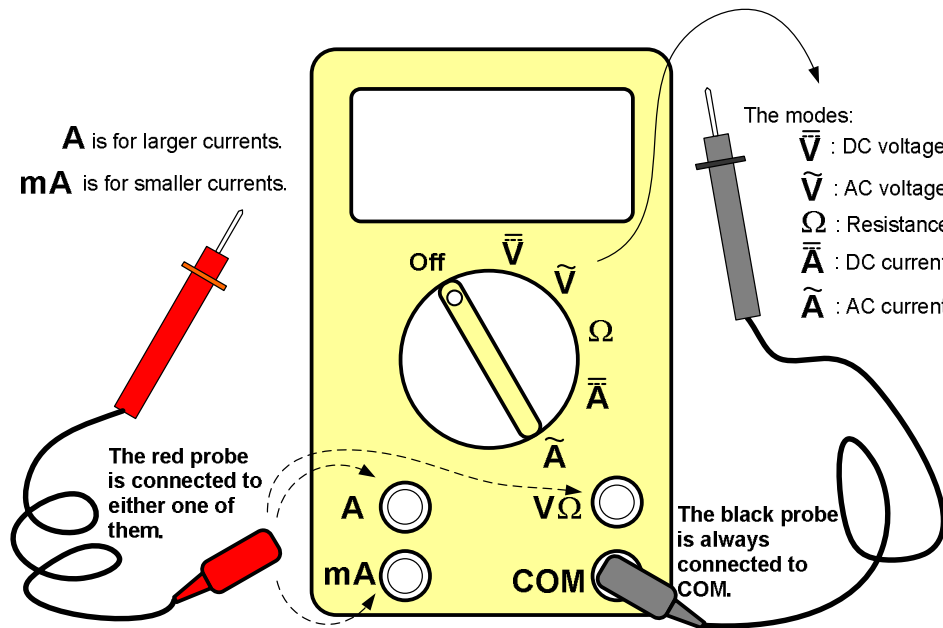
Two rectangular slabs



Question: What will be the three dimensional sketch for two rectangular slabs? [Refer to the above figure.]

Question: Pick out any one of equipotential mappings. Specify only two equipotential lines in the graph. What is the correlation between the displacement of two points on the two lines and the potential difference? If it is farther apart, will the potential difference become more/less?

Appendix: Instruction of How to Use a Multimeter



Resistance Measurement

Voltage Measurement

Current Measurement

	<p>For DC voltage For AC voltage</p>	<p>For DC current For AC current For small-current measurement</p>
<p>When you measure resistance, connect the probes to the indicated places and select the mode, Ω.</p> <p>The resistance of a resistor is measured as above without power supply.</p>	<p>When you measure voltage, connect the probes to the indicated places and select either V for DC or AC.</p> <p>The voltage is measured as above. The probes contact the circuit element as parallel.</p>	<p>When you measure current, connect the probes to the indicated places and select either A for DC or AC.</p> <p>The current is measured as above. The probes contact the circuit element as series.</p>