Electric Fields and Potentials

Your Name ______________________________

Partners' Names ______________________________

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TA's signature allowing you to take the quiz or leave ______________

Obtained reasonable experimental results?	yes ☐
Answered questions?	yes ☐
Cleaned your table?	yes ☐

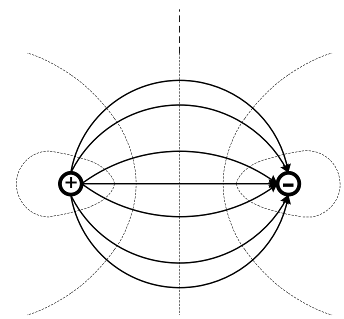
Please do not write on the conducting sheet, and do not use more than 5 volts from the power supply.

Introduction

The force between electric charges is intriguing. Why are unlike charges repelled and like charge attracted? How do we explain them? We can use more fundamental concepts, which are 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 a scalar quantity determined by the different location. 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 from the charges. The electric potential entices other physical quantity, 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 and 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. A point-charge shown as the figure creates the potential as follows:



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

where k is an electrostatic constant , 8.99×10^9 Nm^2/C^2, q is the charge, and the r is the distance between a point from the charge. If it is a different shape of charges, the geometry of the electric fields and potentials vary accordingly.

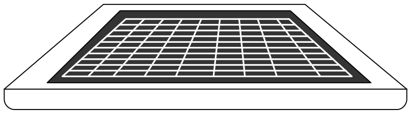
From the above equation, potential difference depends on the magnitude of the charge and a distance from the point. In space, we may find numerous different equal potential points. The equal potential points, which means zero potential difference between the points, can be found by two probes of a multimeter (voltmeter). The series of the equal potential points will be an equipotential line.

The electric field lines embody 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 expressed.

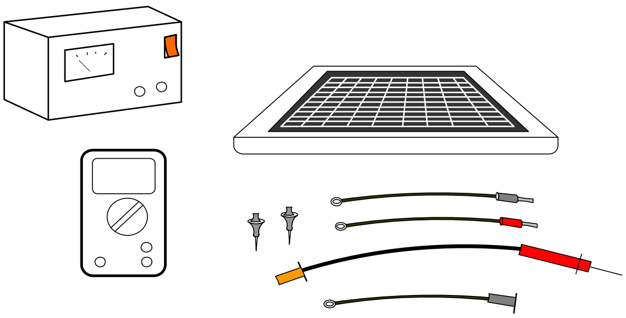
Objectives:

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

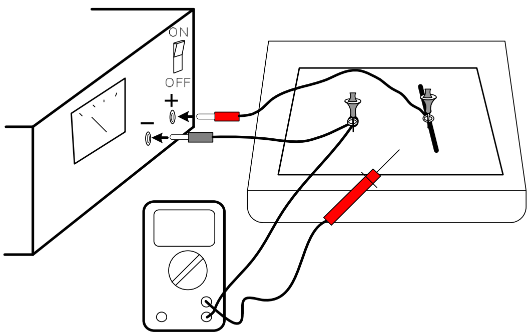
The procedure



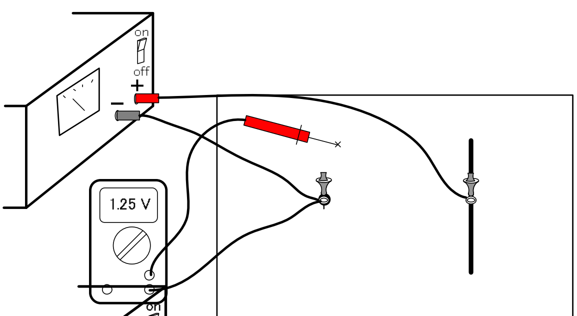
- **Select one of the sheets and put it on the cork board.**



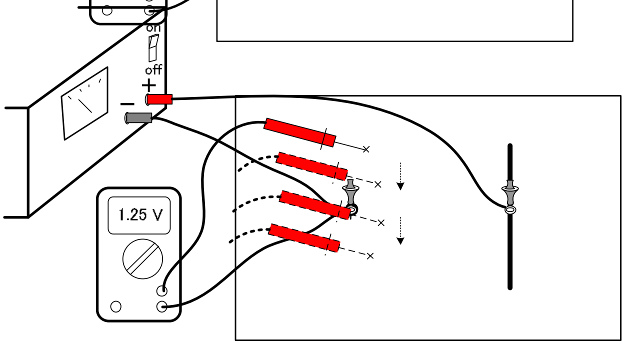
- **Make sure you have the other items, such as banana leads, two metallic pins, a multimeter, a power supply, etc. as shown in the picture.**



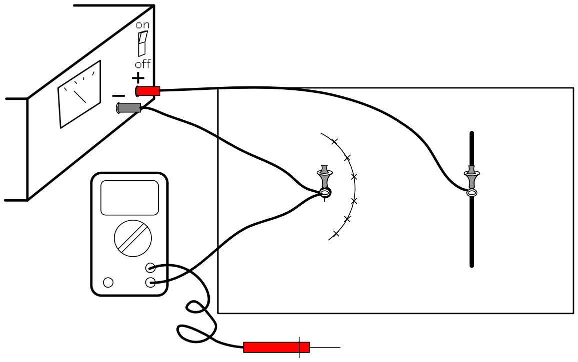
- **Connect each electrode on the sheet with positive and negative voltages respectively.**
  The figure is for a plate and point electrode. The negative voltage means ground. Follow the figure exactly. <u>Refer to Appendix, which is located in the last page of this manual, to know how to use the multimeter. Look at how to measure DC voltages.</u>



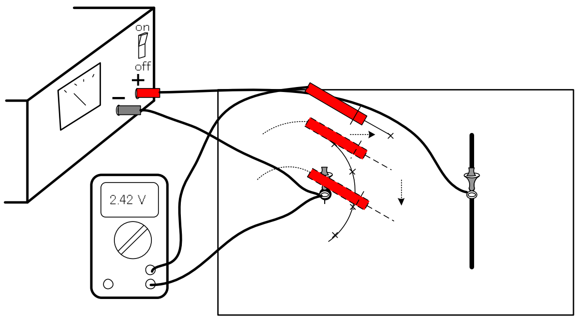
- **Find an equipotential line, by using the multimeter. The probe will be put on the sheet as shown. You will observe a potential difference. Write it down on the datasheet.**



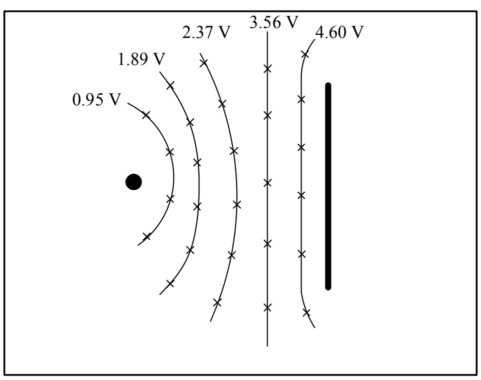
- **Move the probe by keeping the same voltage on the multimeter. Record each point on the datasheet.**



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

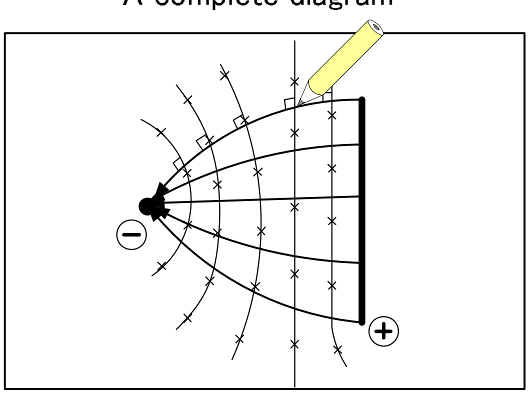


- **Find another equipotential line as shown.**



- **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.**

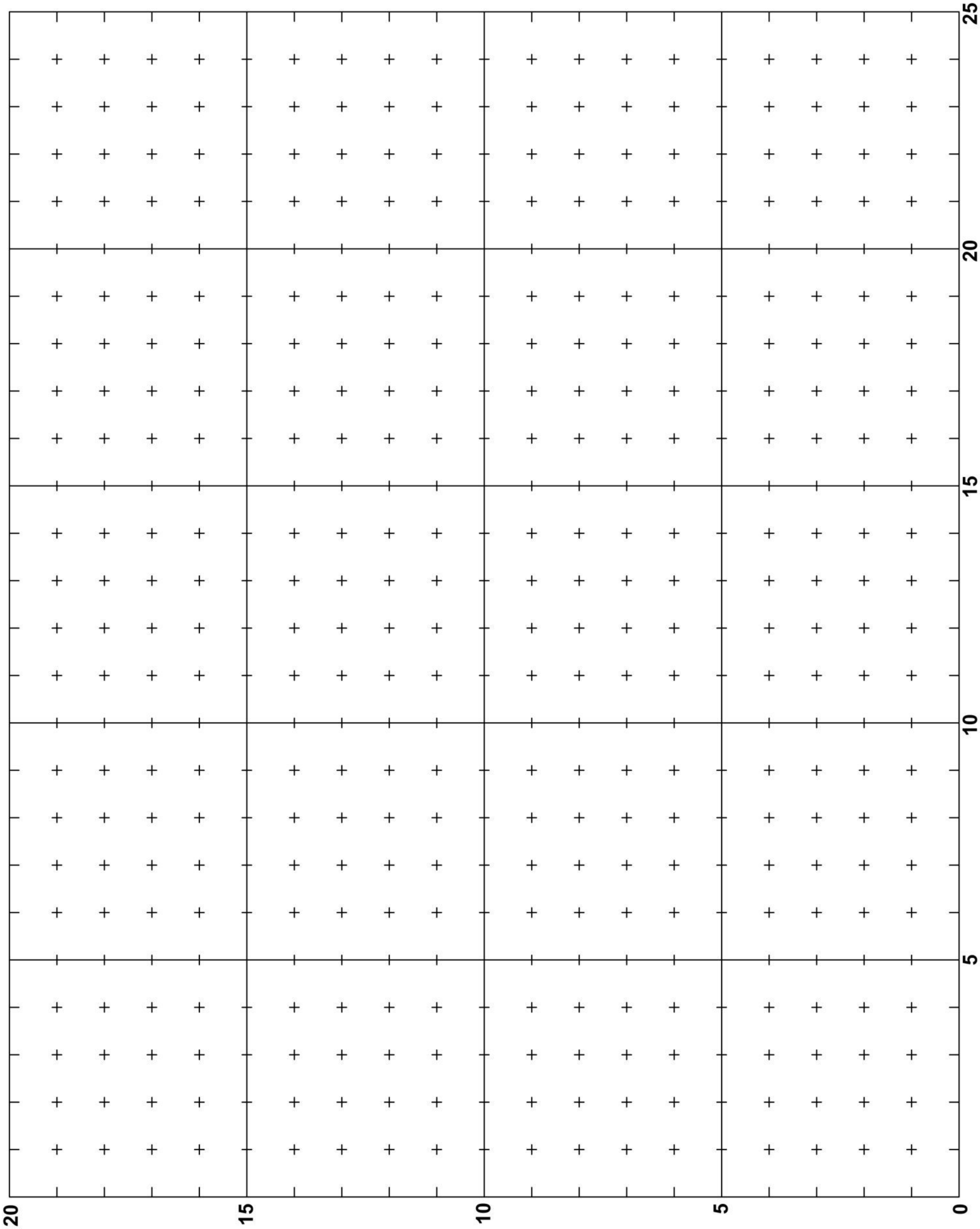
A complete diagram



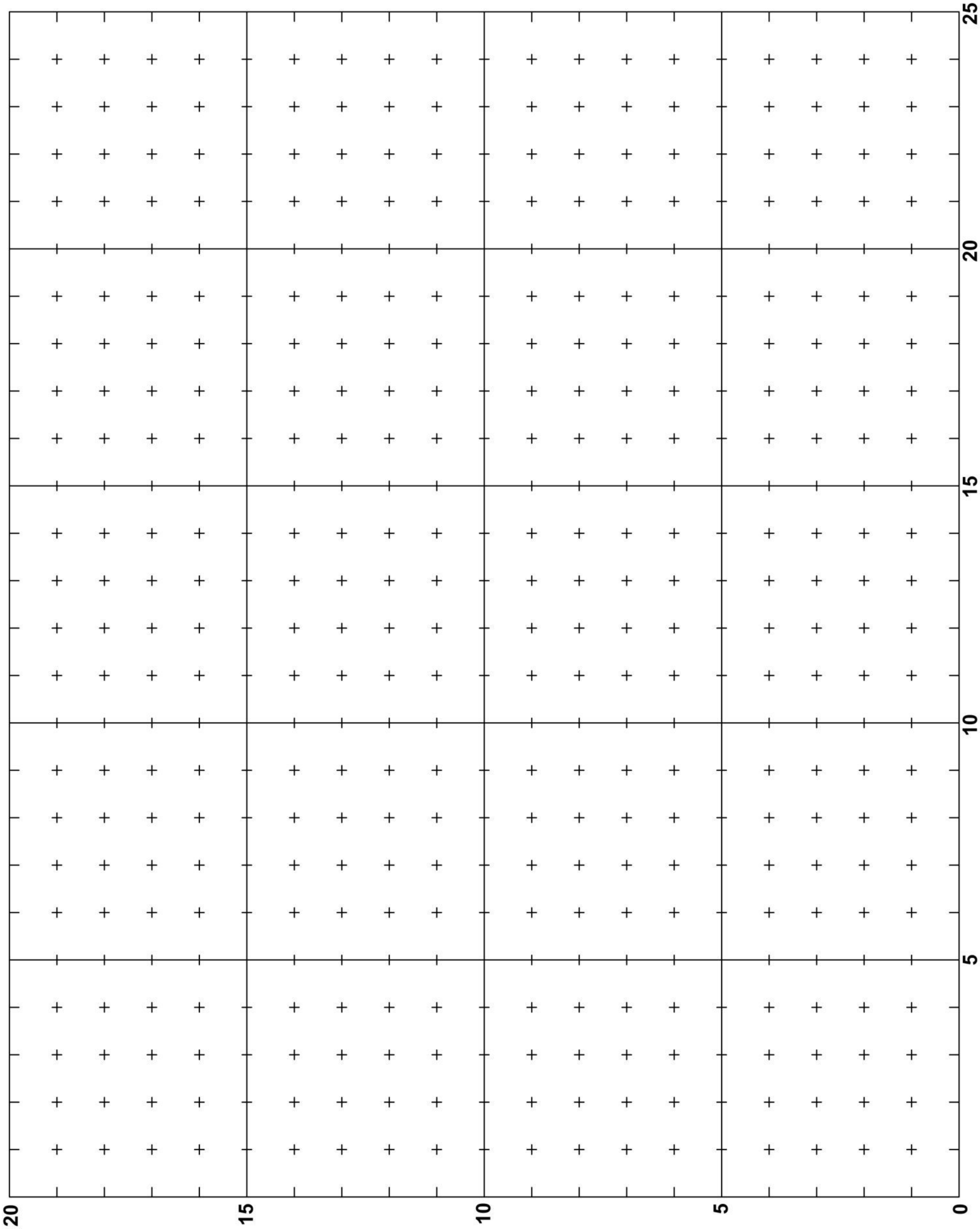
* This is to be drawn on the data sheet.

- **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.**



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.



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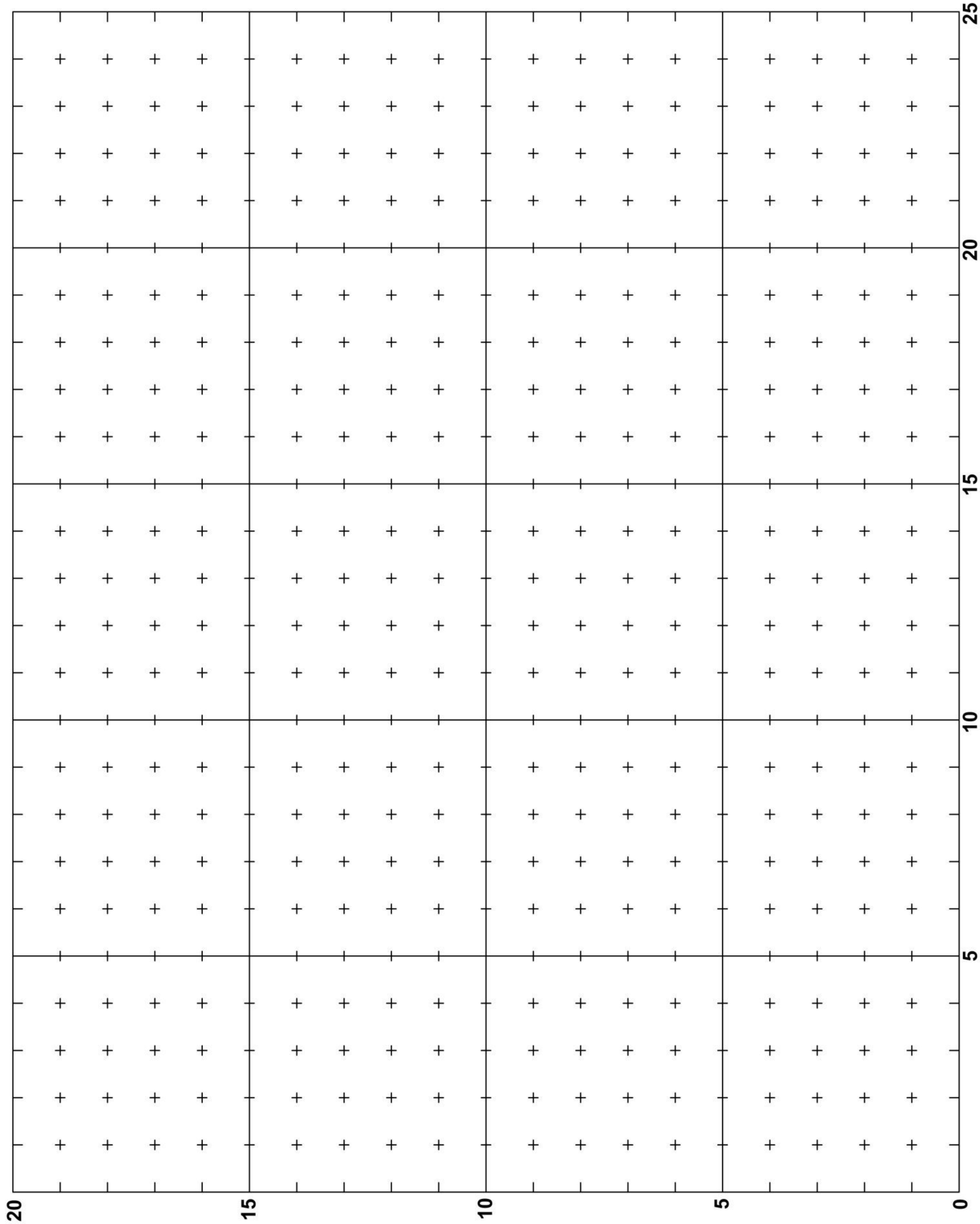

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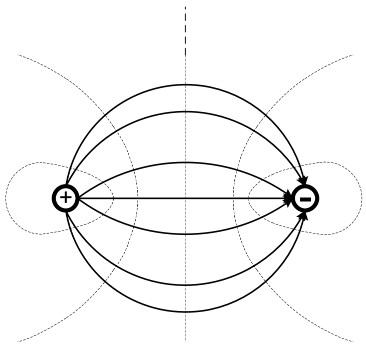
Discussions after the lab: (Discuss with your partners and the instructor.)

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

Two Point Charges



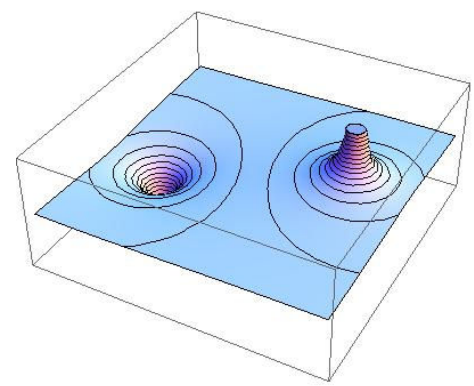
Electric Potential Lines - - - - - - -

Electric Field Lines ⟶

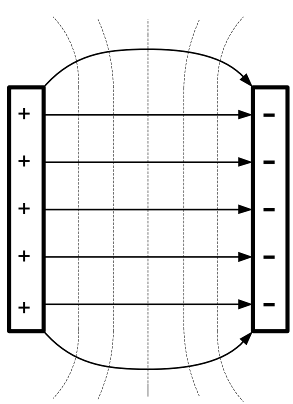
Question: From your results, which parts of the electric fields are close together? Does it make sense in terms of the strength of the field?

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?



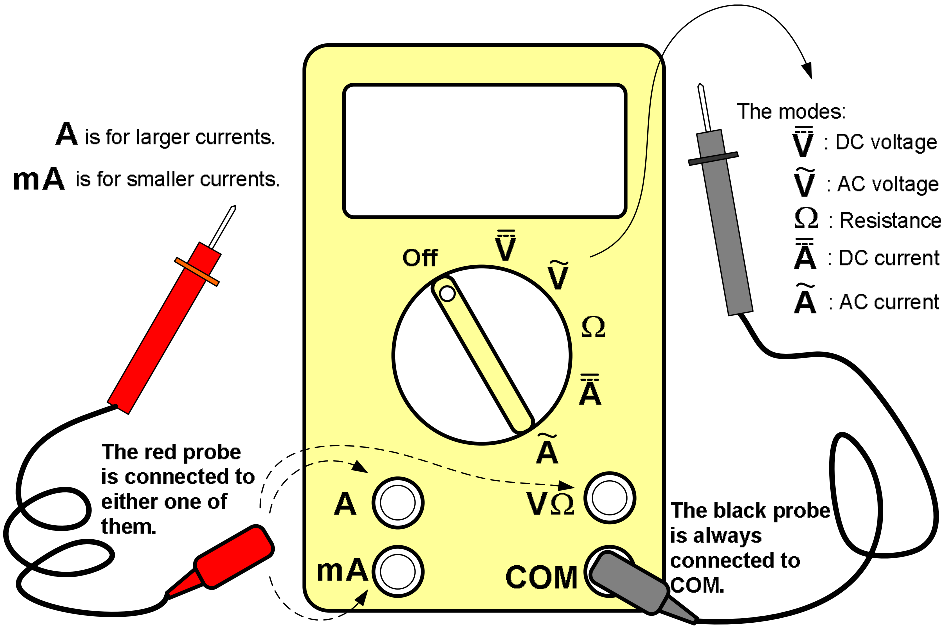
Two rectangular slabs

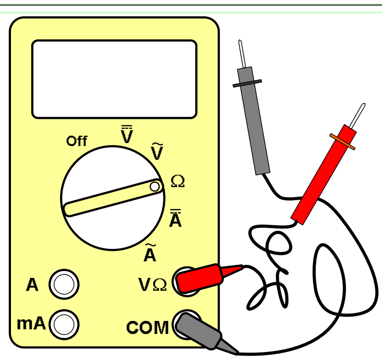
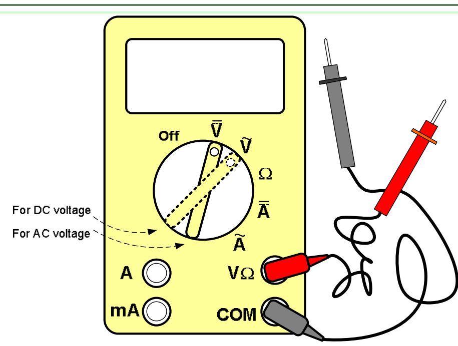
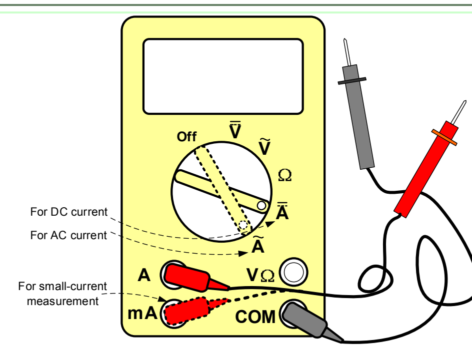
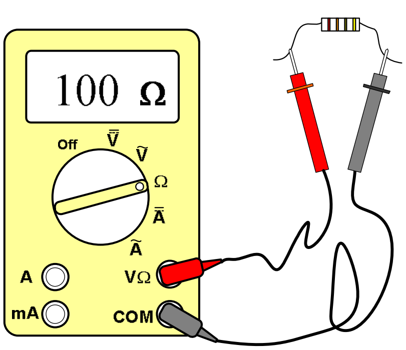
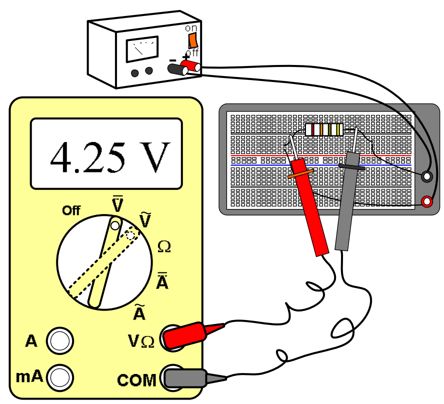
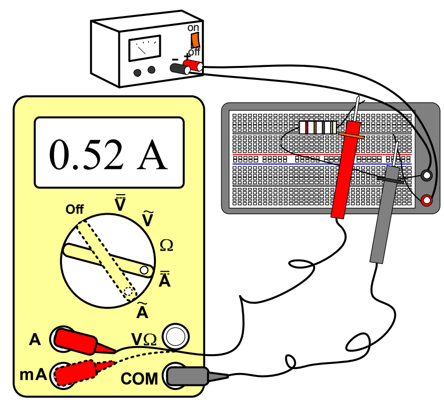


Question: What will be the three dimensional sketch for two rectangular slabs? [Refer to the above figure.]

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