LAB 4 - ELECTRIC FIELDS AND POTENTIALS(TPL2)

Goals :

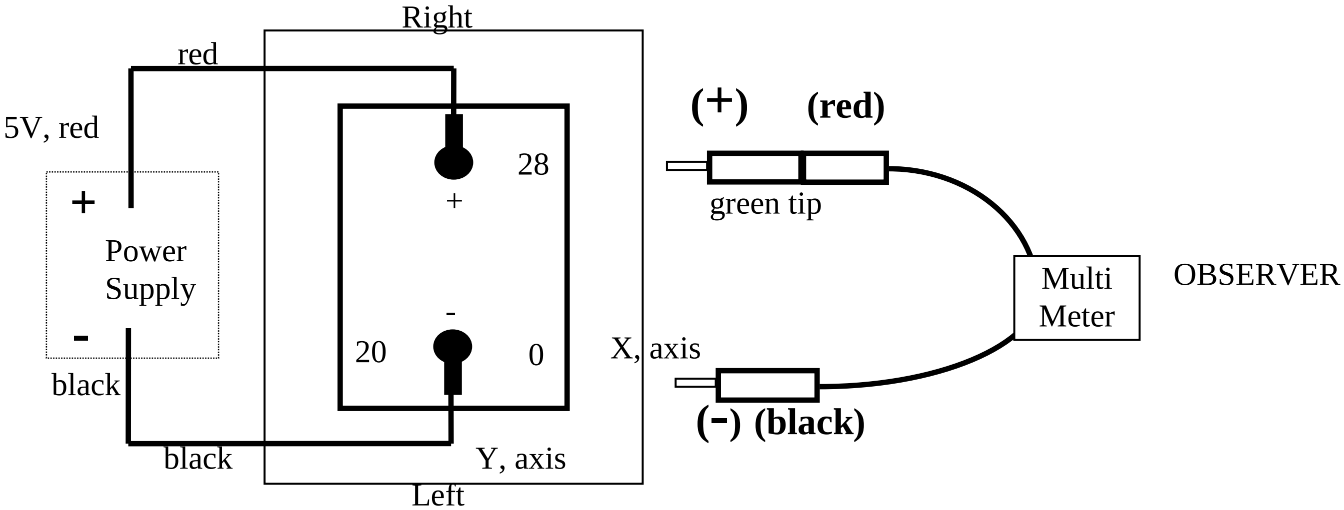
- **Map equipotential lines for certain electrode configurations**
- **Draw corresponding lines of force**

Part 1 - Circuit Setup

It would also be very helpful to look at the online help page for this lab.

1. Measuring voltages. We will use a multimeter to read the voltage values during this lab. We want to set up an electric field pattern using the conduction sheet. The 5 volt power supply will provide the voltage across the two "point charges" (two dots of silver ink on the conducting paper).

2. Circuit connections. We will be using the terminals on the left side of the power supply. Connect a red lead to the red terminal of the 5V power supply and the other end to the terminal on the mapping board. Place the "point charge" sheet between the terminals. Connect a black lead from the black terminal of the power supply, to the sheet as shown. Orient the charge sheet so that the (-) terminal is near the left axis (0-20), as shown below and you stand as the OBSERVER.



Initial equipment configuration for equipotential field mapping

We will be measuring the voltage of various points on the conducting sheet (we will look for equipotential lines -- lines of equal voltage -- and then be able to draw the electric field lines.)

3. Multimeter connections. Use the check list below to prepare multimeter.
   - ☐ The power supply has a direct current output, so turn the multimeter dial to direct current voltage.
   - ☐ Connect a red lead to the V terminal
   - ☐ Connect a green tip plug to the other end of the red lead
   - ☐ Connect a black lead to the COM terminal on the multimeter

4. Test the system. Test your system by touching the positive lead to the

negative lead - you should get a zero reading. Now try touching the positive lead to the (+) terminal of the mapping board, you should get the reading of the power supply voltage (something close to 5 volts). If you don't get these readings, test all the connections in the circuit. [Later, you can "double check" that the circuit is still good by finding those minimum and maximum voltages. Keep checking periodically to make sure you have 5 volts across the system. If not, that is an indication that a connection might be loose!]

Part 2 - Equipotential Lines

The "point charge" sheet is supposed to represent a plus charge and a minus charge as shown. There will be an electric field pattern "flowing" out from these charges, and there will be an equipotential pattern "around" these charges. The probe that we have will measure a potential difference. We will be searching for points along the sheet that have the **same** electrical potential -- therefore, if both multimeter leads are touched on the same equipotential line, they will give a zero reading for the voltage. If they are on different equipotentials, they will give a non-zero reading.

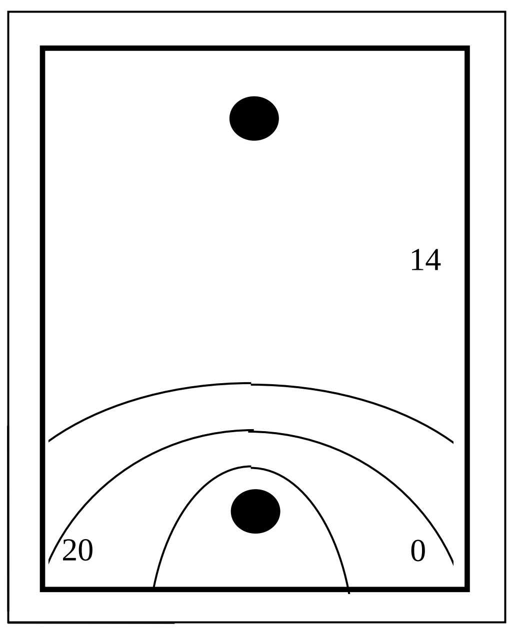
> **NOTE**: The contact with the sheet is crucial. If you touch down with a probe, and the reading doesn't seem normal, make sure that you are making a good connection. (The paint dots on the sheet can interfere with the connection. Also, if there are scrapes on the paper, they can interfere with the connection.) Also, make sure that the clips on the board make a good contact with the paper. If your readings start to vary during the lab, make sure that you are getting the full 5 volts across the circuit - you can test that by putting the multimeter leads on the two "charges" on the sheet.)

1. Finding the equipotentials. Start near the point (14,0) and record the voltage in the chart on the Data/Question sheet. Now, move the probe roughly 1 cm away from that point, until you find another point of the same voltage. (DON'T SCRAPE THE PROBE ALONG THE PAPER, TRY TO "LIFT AND TOUCH DOWN, LIFT AND TOUCH DOWN") On the paper containing the grid points, draw a line connecting the equal potential points (an "equipotential" line) and label the voltage of that line. Keep looking for more points of that same voltage to trace out the equipotential line. Continue this until you reach the middle of the sheet (you should have created an "arc" half way across the sheet). Then move to the next point in the chart, and find that potential line, and the next, etc. See an example below. Record these values on the Data/Question sheet.

We are only mapping 1/4 of the whole sheet, since the charge configuration is symmetrical. The chart can be "filled-in" for the other three quarters by "mirroring" the lines that you have drawn in the first quarter.

To ensure that this "mirroring" will be valid, we will make measurements on one line on the other side of the page. **Continue the line started at (23,0) across the page.** If this line matches the (5,0), (in shape, not values) then it is reasonable to extend the rest of the lines to fill in the graph.

For the final report, draw the lines into the other 3/4 of the sheet and turn in that mapping sheet.



Equipotential voltage lines

Figure 2 shows several lines completed for the lower part of the sheet, below (14,0). These will be mapped on the upper half, above (14,0) by symmetry. (The lines near the middle of the sheet will be nearly flat.)

Part 3 - Potential difference between two lines

Let's test to see how accurate our mapping is. If we pick two of the equipotentials, we should be able to find the potential difference between them directly - then we can compare that with what the difference should be (each line has a potential relative to the negative terminal).

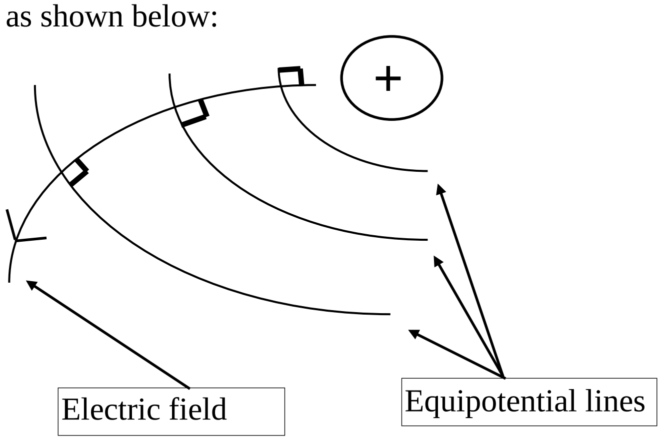
1. Measuring voltage across a pair of equipotentials. Disconnect the negative lead of the multimeter from the negative side of the board, and attach the other green plug to the lead. From your drawing, locate one point on one equipotential, and another point on a different equipotential. Now find the potential difference between those points directly (remember to keep the red probe closer to the positive charge side of the board). Record in the table on the Data/Question sheet.

2. Another set of lines. Repeat for another pair of lines (the lines don't have to be "adjacent"). Record the values on the Data/Question sheet.

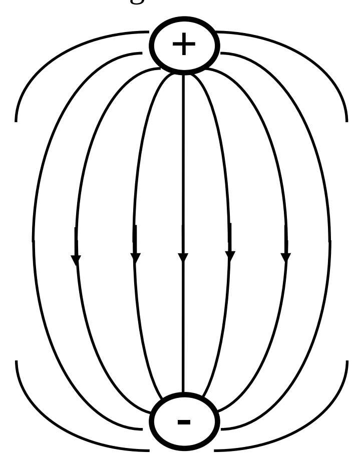
Question Answer on the Data/Question sheet.
How does that value match with the difference between the equipotential voltages (the "actual" values)?

Part 4 - Electric field lines on our Equipotential drawing

When the topic of charges comes up in the lecture course, we usually draw the electric field lines from the charges. In this case, the lines would radiate out from the positive charge and be drawn into the negative charge, as shown below:



Conceptual diagram showing electric field lines are perpendicular to the Equipotentials



Electric field map for two point charges

1. Draw the electric field lines. Use the completed drawing from Part 2, and draw electric field lines (spaced about a centimeter apart). Start on one of the equipotentials lines that is closest to the positive 'charge'. Draw a curve that is perpendicular to that line, and aims toward the next equipotential. After intersecting that equipotential perpendicularly, continue to the next one, until you fill in the whole picture. All the equipotential lines should be perpendicular to the electric field lines (lines of force). An example is shown above.

Data/Question Sheet for Lab 4 Electric Fields and Potentials

Use separate grid sheet on webpage!

Part 2 - Equipotential Lines

1. Finding the equipotentials.

Start point	(14,0)	(12,0)	(10,0)	(8,0)	(6,0)	(2,0)	(0,2)	(0,4)	(0,6)
Voltage (V)									

Chart of Voltages measured from Equipotential lines

Part 3 - Potential difference between two lines

1. Measuring voltage across a pair of equipotentials. Pick a pair of lines, for example, the ones starting at (12,0) and (8,0), and record the voltage difference between the two lines by following the directions in **Part 3** item 1 above. Record in the table below as ΔV_m. The ΔV_a is found from the chart below where V_{low} is the voltage for the line starting at (8,0), from above, and V_{high} is the voltage for the line starting at (12,0), from above.

2. Another set of lines. Repeat for another pair of lines (the lines don't have to be "adjacent"). Record the values below: (All values for V_{low}, V_{high}, ΔV_a, and ΔV_m are in volts.)

	V_{high} (actual) (above chart)	V_{low} (actual) (above chart)	ΔV_a (actual) (V_{high}-V_{low})	ΔV_m (measured)	% diff
First pair					
Second pair					

Equipotential voltage chart

Question How does the value, ΔV_m, match with the difference between the equipotential voltages, ΔV_a?

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Calculate the % diff for each pair using $x_1 = \Delta V_a$ and $x_2 = \Delta V_m$. and the usual %diff formula.

Pair one: % diff = ___________ Pair two: % diff = _____________

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