Physics 215 - Experiment 8

Electric Fields and Potentials

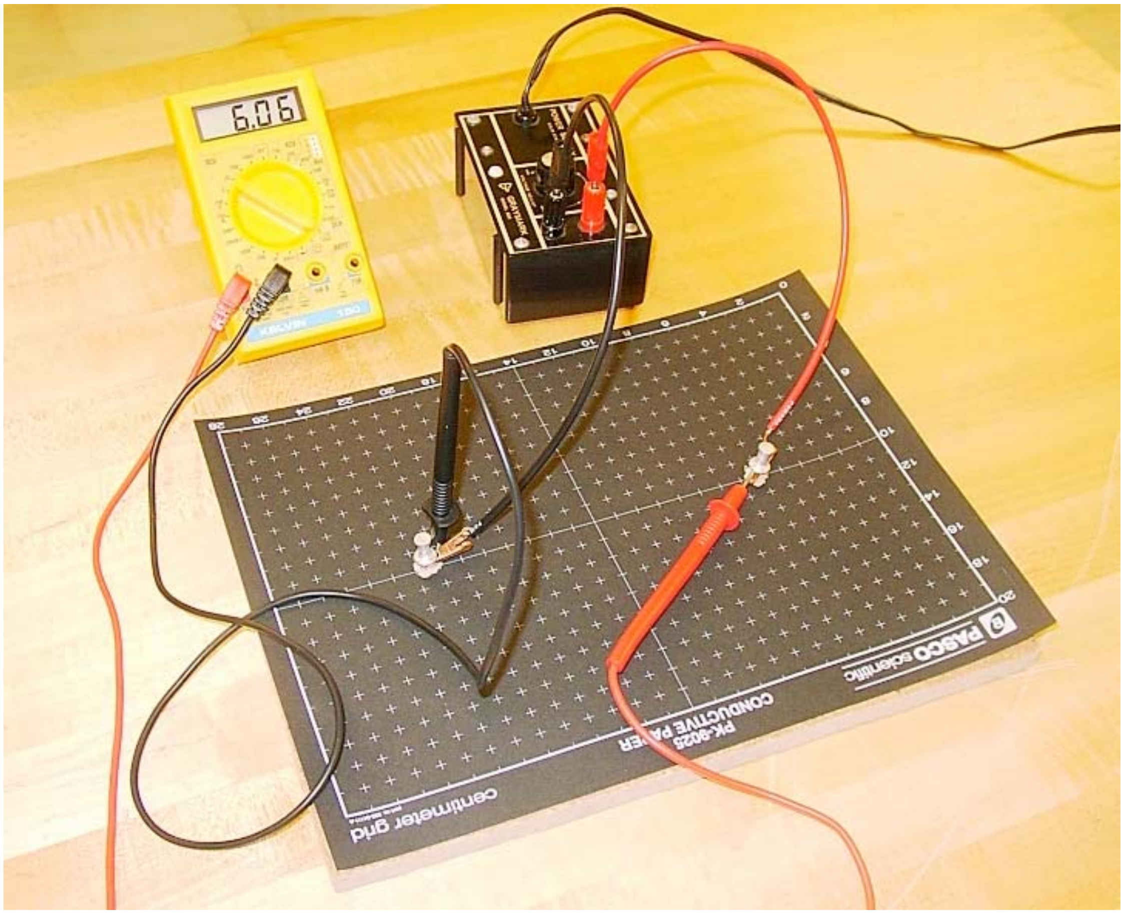

Fig. 8-1 Electric Fields and Potentials - Point Charge Arrangement

Equipment:

Conductive Paper with
Conductive Patterns (2)
Cork Board
Digital Multi-Meter (DMM)
Plastic Tip Holder
Power Supply
Grease Pencil
Field Program (Computer)
Conductive Thumb Tacks
Wire Leads

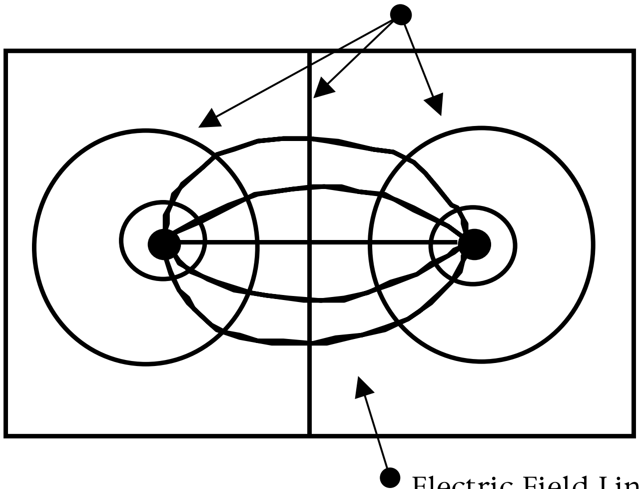

Fig. 8-2

Equipotential Surfaces

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Advance Reading

Urone, Chapter 17, sections 17-4 through 17-6; Chapter 18, Sections 18.1 through 18-4. Appendix C: Equipment DMM.

Objective: The objective of this lab is to map equipotential lines and field lines of point charges and parallel plates.

Theory: An **electric field, E,** at a point is defined as the force per unit charge at the point:

$$\mathbf{E} = \mathbf{F}/q \qquad \text{(Eq. 8-1)}$$

The electric field is represented by lines of force drawn to follow the direction of the field.

The **electric potential** is defined as the potential energy per unit charge, however, we can only measure the difference in potential energy between two points. This change in potential energy per unit charge (the voltage, V_{ba}) is equal to the work done by the electric force to move a charge from one point to another:

$$V_{ba} = V_b - V_a = W/q \quad \text{(Eq. 8-2)}$$

Electric field lines point in the direction of maximum decrease in potential.

An **equipotential surface** is defined as a surface where all points on the surface have the same electric potential. To move a charge around on such a surface requires no work. In two-dimensions the equipotential surfaces are equipotential lines. How close the lines are to each other is an indication of the field strength. Electric field lines are always perpendicular to equipotential lines.

The two conductive patterns, point charges and parallel plates, are on conductive/resistive paper. Perfectly conducting paper would have zero potential difference between two points. The paper tends to concentrate the electric field into the plane of the paper.

Procedure

Set Up and Connections

1. Place the point charge pattern (two dots) on the corkboard. Push a pin into the center of each point charge.
2. Unplug and turn off the power supply. Refer to Fig. 8-1 and 8-3: connect the power supply to the point charges.

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Fig.8-3 Banana-Alligator Wire Lead
Use the banana connector on the power supply, alligator connector on the pins.

3. Refer to Fig. 8-1 and Fig. C-9: connect the ground lead (black) from the DMM to the negative point charge (black wire). Connect the positive lead (red) of the DMM from the "VΩ" jack of the DMM to the positive point charge (red wire).
4. Turn the DMM on; turn the dial to *20* on the *DCV* (voltage) scale. This means the DMM (voltmeter) is configured to measure voltage up to 20V. Plug in the power supply; increase the power until the voltmeter reads 6.0V. Label the point charges with the grease pencil (i.e., the ground from the power supply is at 0.0V and the positive lead from the power supply is at 6.0V).

Equipotential Lines: Point Charges

5. Hold the DMM ground lead on the 0.0V point charge. Watch the voltmeter as you move the positive lead across the conductive sheet.
6. Keeping the ground lead at the 0.0V point charge, find at least four equally spaced points where the voltmeter reads 1.0V. As you locate each point, press the tip of the lead into the sheet to leave an indentation. After finding the four points, "connect the dots" using the grease pencil. Label the equipotential line as 1.0V.
7. Repeat Step 6 for 3.0V , 4.0V & 5.0V. Each lab partner should draw one set of equipotential lines.
8. Place the DMM leads into the plastic tip holder and measure the potential difference across the 3.0V equipotential line. Calculate the field strength at this location in V/m.
9. Use the grease pencil to mark the position where you measured the field strength, then record the value on the conductive paper.

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Electric Field Lines - Point Charges

10. Place the DMM leads in the plastic tip holder. Place the ground lead as close to the 0.0V point charge as possible, just off- center of a line that would connect the two point charges. As you pivot the positive lead around the ground lead, watch the values on the voltmeter. When you have located the position of maximum value, press an indentation into the paper with the red lead. Now "walk" the leads across the paper by placing the ground lead into the indentation you made with the positive lead. When you reach the 6.0V point charge, "connect the dots" with the grease pencil.
11. Your partner will repeat Step 10, beginning from a different position around the 0.0V point charge. Are your field lines perpendicular to the equipotential lines?

Measuring Electric Field Strength - Parallel Plates

12. Refer to Figure 18.10 in your textbook. If you repeated Steps 6-11 for the parallel plate configuration, it would be similar to this illustration. Refer to Steps 1-4: Connect the power supply and DMM to the parallel plate pattern. Set the potential difference to 6.0V.
13. Refer to Step 8 and Step 9. Measure the field strength at the geometric center of the parallel plate.

Equipotential Lines

14. Locate the 2.0V equipotential line near the edge of the plate configuration (refer to Step 6). Find three more points outside the end of the parallel plate that are at 2.0V potential. Connect the dots.
15. Your partner repeats for 4.0V.

Questions

1. Use dimensional analysis to show that the electric field unit of N/C equals V/m. *(Urone, Section. 18.1.)*
2. How does Figure 18.8 in your text compare to the point charge sheet you produced?