NEW YORK INSTITUTE OF TECHNOLOGY

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Laboratory Report

Illuminating the Invisible: Electric Field Line Mapping

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ABSTRACT

This experiment aimed to visualize **electric field lines** and **equipotential surfaces** using a **conductive carbon paper** setup. By applying a potential difference of **12 volts** across **an 8 cm** distance, electric field patterns were drawn based on the measured equipotential points. Two configurations were tested: a **dipole arrangement** and a **capacitor-like configuration** with parallel plates. The **electric field strength** was estimated from the potential difference and the measured distance between electrodes, and the results were analyzed to understand the relationship between electric field lines and equipotential surfaces.

THEORETICAL BACKGROUND

Electric fields describe the influence that electric charges exert on one another, with the field's strength and direction represented by electric field lines. The **electric field** $\boldsymbol{E}$ at any point is defined as the force $\boldsymbol{F}$ experienced by a **positive test charge** $\boldsymbol{q}$**,** placed at that point, divided by the **magnitude** of the charge:

$$E = \frac{F}{q}$$

Electric field lines represent the **direction** of the **electric field** at any point in space, always pointing *away from positive charges and towards negative* charges, while **equipotential lines** *connect points with the same electric potential*, meaning they are **perpendicular** to the electric field lines at every point (Figure 1); essentially, you can think of equipotential lines as imaginary lines where no work would be done to move a charge along them, whereas electric field lines show the path a positive charge would take if released in the field.

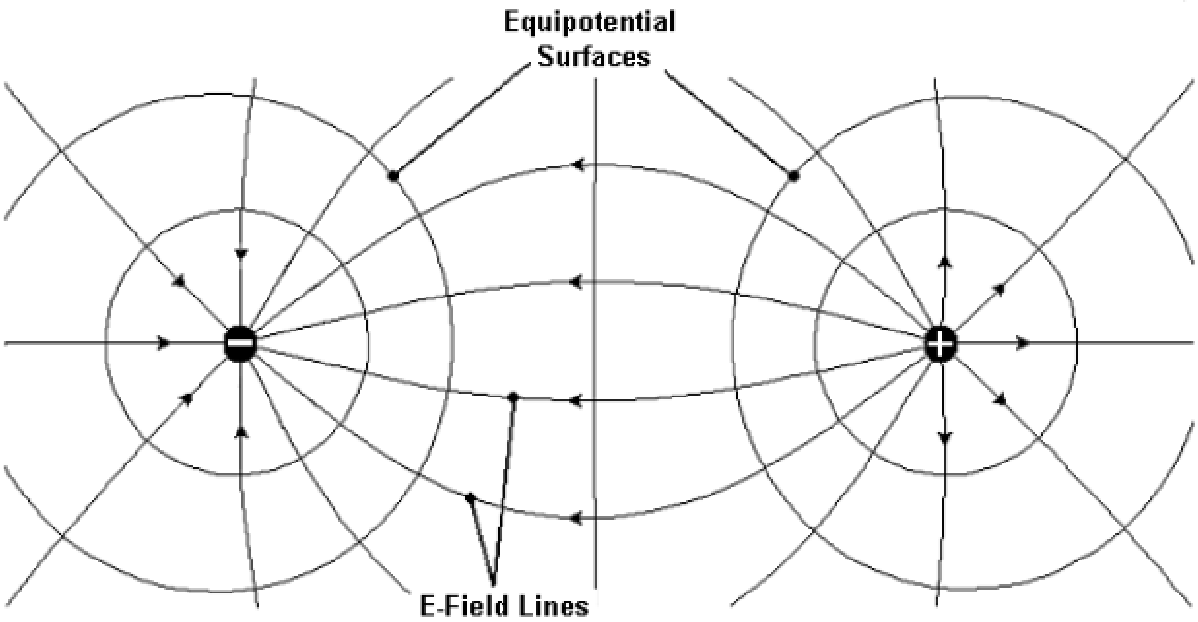

FIGURE 1. *Electric field lines (arrows) reveal the direction and strength of the electric field between two opposite charges, while the concentric equipotential surfaces(circles) highlight regions of constant electric potential.*

For a **uniform electric field**, such as that **between two parallel plates** (Figure 2) with a **potential difference V** separated by a **distance d**, the electric field strength is:

$$E = \frac{V}{d}$$

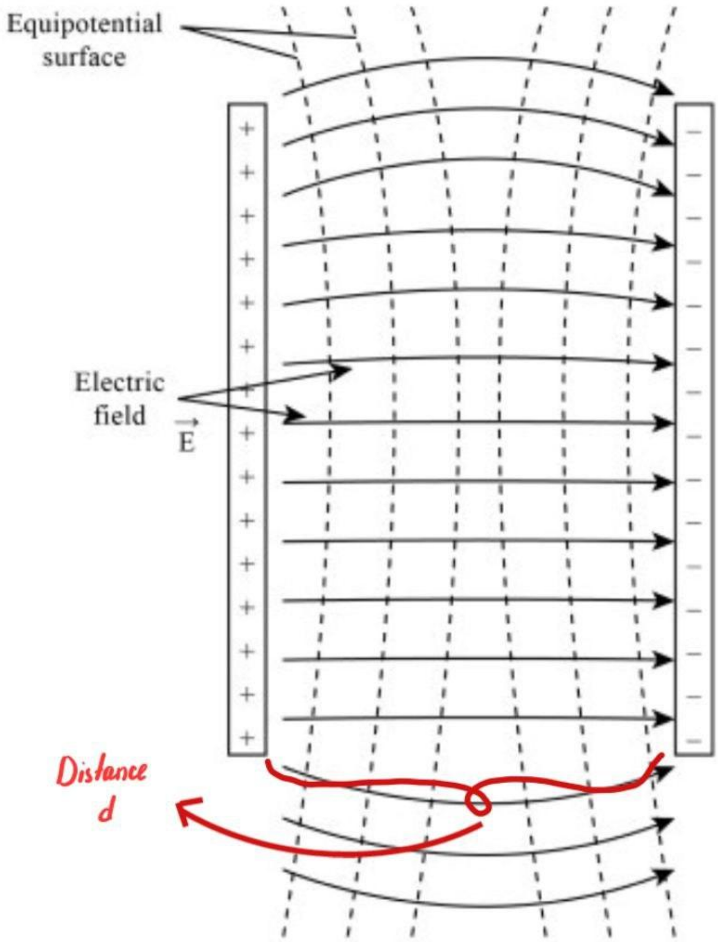

FIGURE 2. *This image depicts the electric field E between two parallel plates, with equipotential surfaces intersecting perpendicularly. The marked distance d highlights the spatial relationship affecting the field intensity.*

In a dipole configuration (Figure 1), consisting of two equal and opposite charges separated by a distance, the electric field lines emanate from the positive charge and terminate at the negative charge, while equipotential lines form closed loops around each charge, with higher density indicating stronger fields.

PROCEDURE

APPARATUS:

1. Conductive paper with electrodes for dipole and parallel plate configurations (Figure 3)
2. Power supply (Figure 4)
3. Digital multimeter or voltmeter (Figure 5)
4. Connecting wires (Figure 4)
5. Graph paper (Figure 6)
6. Probes (Figure 5)

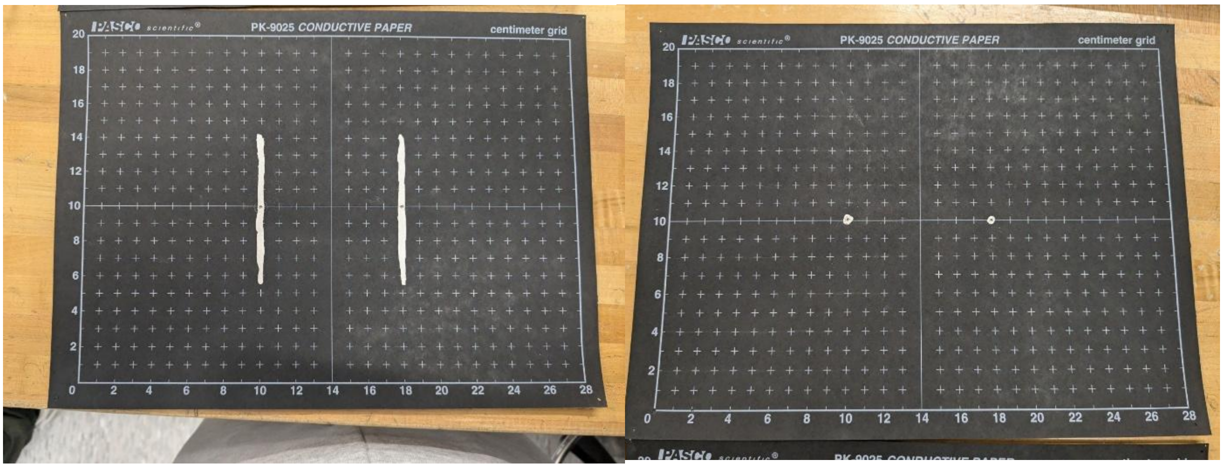

FIGURE 3. *Conductive paper featuring silver electrodes—**two vertical silver strips** for parallel plate configuration (left) and **two circular silver dots** for dipole configuration (right).*

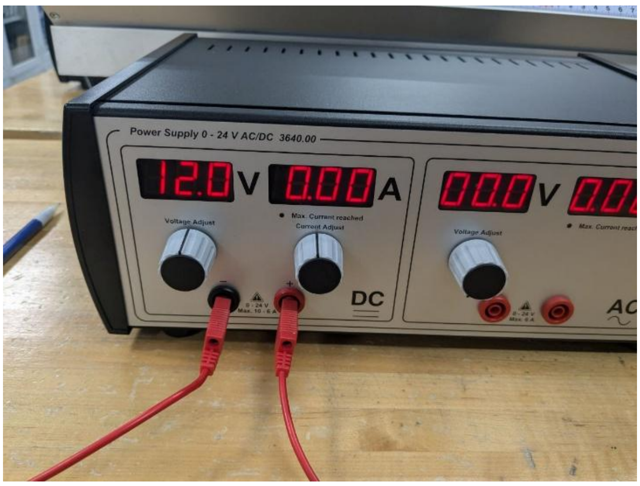

FIGURE 4. *Power supply set to 12 volts with 2 connecting wires attached.*

FIGURE 5. *Digital multimeter used to measure potential differences, with 2 probes attached.*

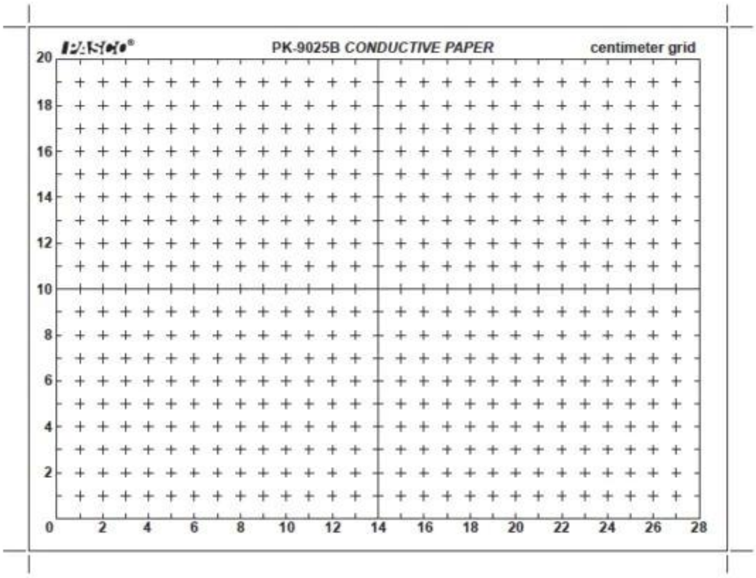

FIGURE 6. *Standard centimeter-grid graph paper used for documenting experimental results. Unlike the conductive carbon paper used for measurements, this paper serves as a visual aid for plotting equipotential lines and electric field patterns based on recorded voltage data.*

SETUP:

1. Place the conductive paper on a corkboard and attach the parallel electrode configuration (Figure 7).
2. Connect the electrodes to the power supply set to 12 V.

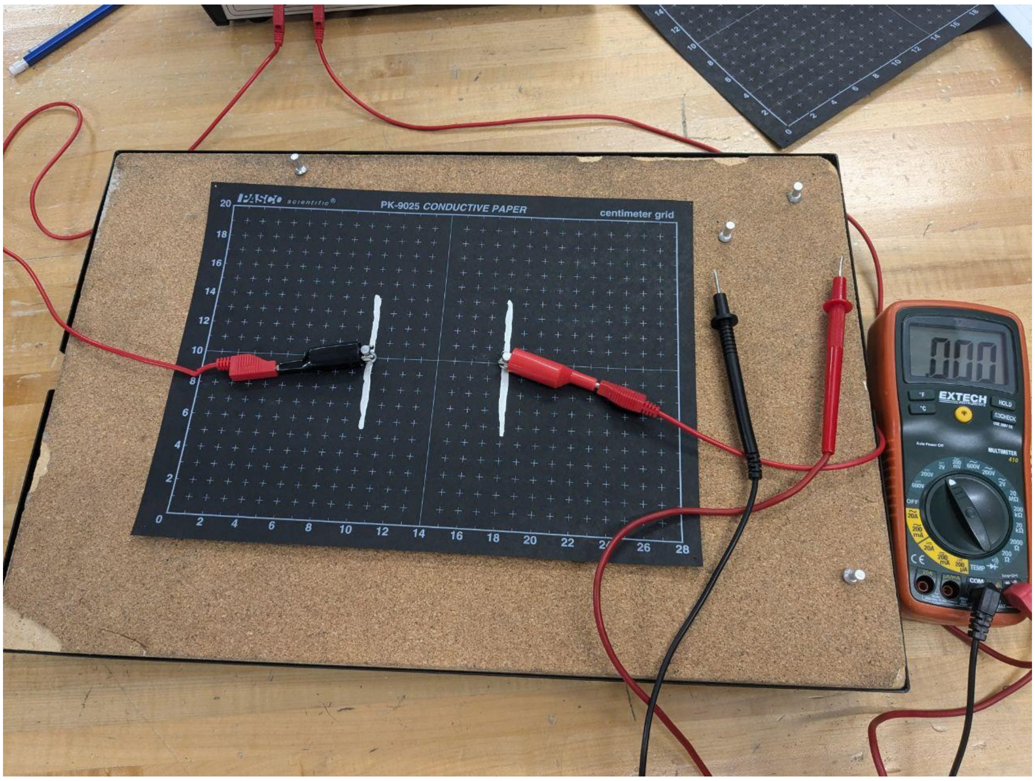

FIGURE 7. *Conductive paper with attached parallel plate electrodes secured on a corkboard. The chosen electrode configuration is connected to the power supply, set to 12 V, in preparation for mapping electric field lines and equipotential surfaces.*

EXPERIMENT:

3. Place the black probe (negative terminal) at a fixed position (e.g., x = 0 cm) and the red probe (positive terminal) along the y-axis (e.g., y = 2 cm).
4. Move the red probe along the grid until the multimeter reads 0.00 V, indicating an equipotential point. (Figure 8)

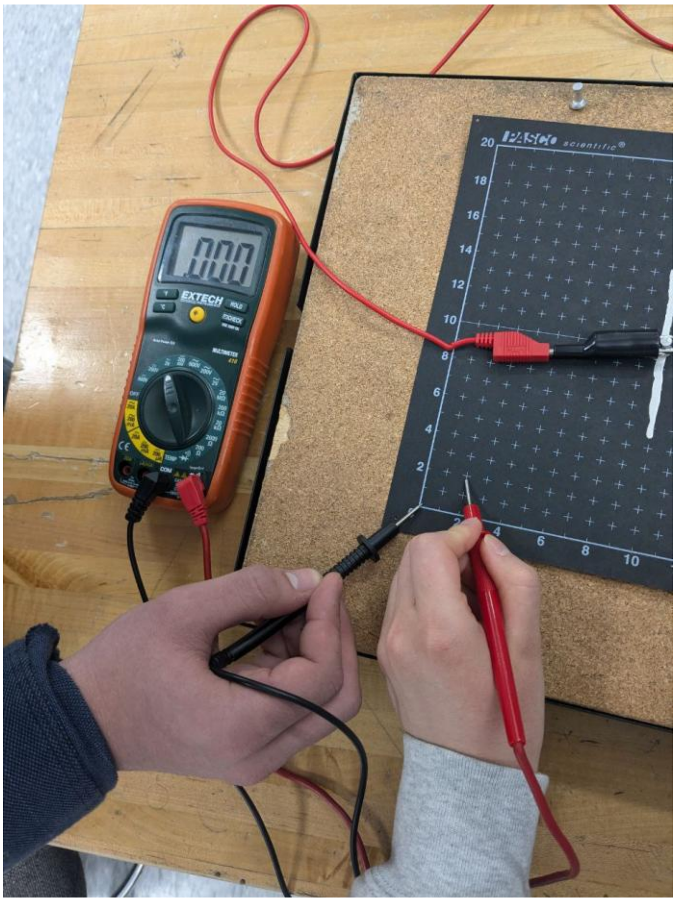

FIGURE 8. *Demonstration of the measurement process using the probes. The black probe (negative terminal) is fixed at x = 0 cm, while the red probe (positive terminal) is moved along the y-axis to identify equipotential points, as indicated by the multimeter reading 0.00 V.*

5. Record the point on the graph paper and repeat for other y-axis values (e.g., y = 2, 4, 6, 8....20 cm) by moving the re probe and keeping the black probe at x = 0.
6. Move the black probes fixed point (e.g., x = 2, 4, 6, 8 ... 14 cm) and repeat step 5 for every until x is the same us the x – axis of the midpoint between two electrodes (x = 14 in our case).
7. Reflect the data across the symmetry axis (x =14) to complete the electric field map.
8. Turn off the power supply and remove connecting wires from electrodes. Replace the parallel configuration to dipole configuration and repeat from step 2 till step 7.

DATA & ANALYSIS

The equipotential points for both configurations were plotted, revealing distinct electric field patterns:

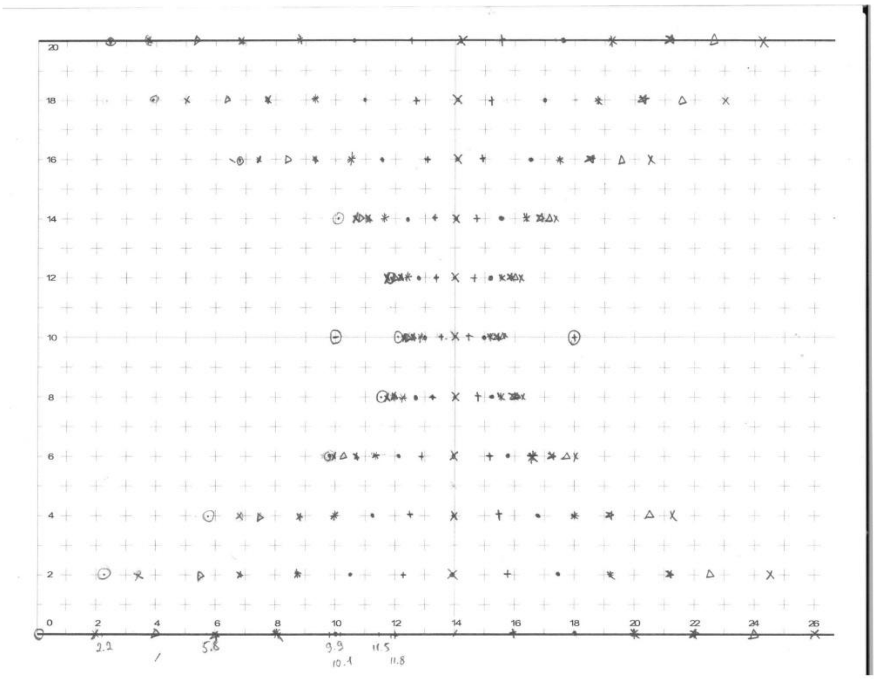

FIGURE 9. *Raw data representation of recorded equipotential points for the dipole configuration. The positions where the voltage readings were zero are marked for further analysis.*

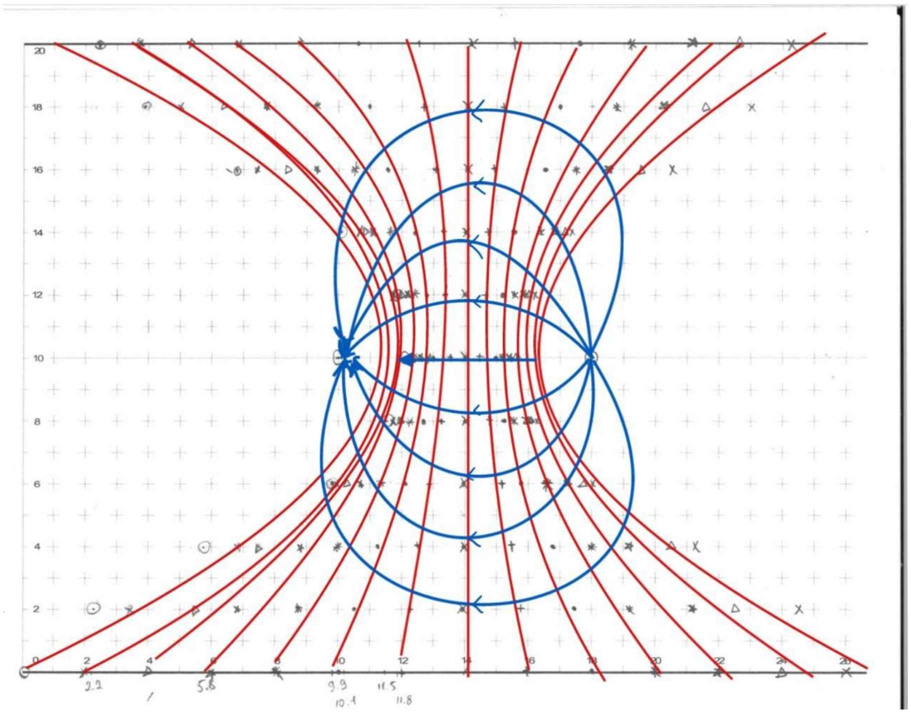

FIGURE 10. *Visualized electric field lines (blue) and equipotential surfaces (red) based on the recorded data. The arrows indicate the direction of the electric field, reinforcing the relationship between potential and field strength.*

Dipole Configuration: Equipotential surfaces appeared as closed loops around each charge, with electric field lines extending from the positive to the negative charge.

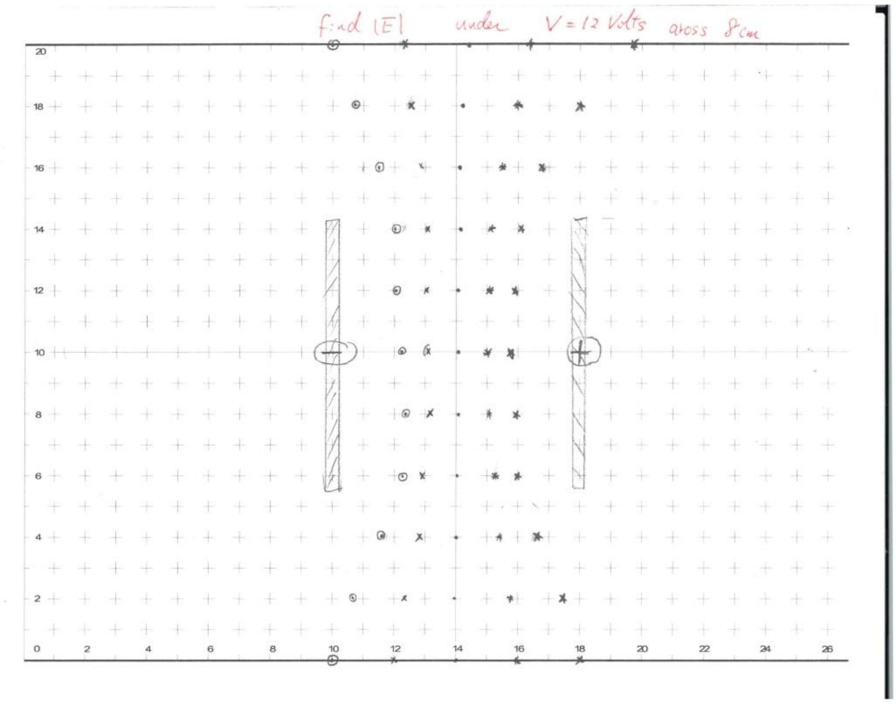

FIGURE 11. *Recorded equipotential points for the parallel plate configuration*.

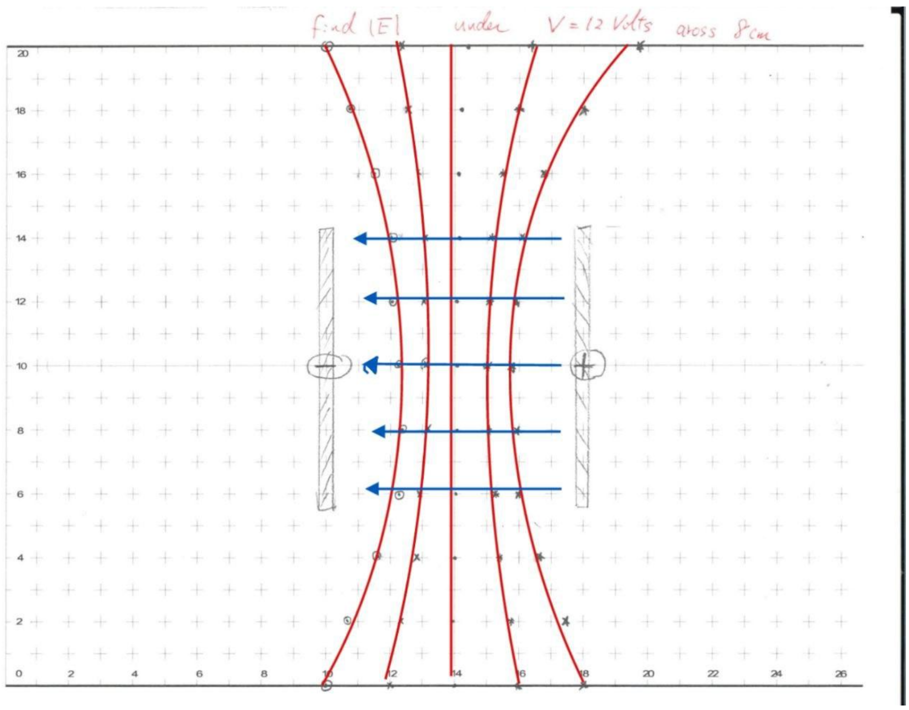

FIGURE 12. *Electric field visualization between parallel plates, with red lines indicating equipotential surfaces and blue arrows representing the uniform electric field direction*.

Parallel Plate Configuration: Equipotential surfaces were **parallel** and **evenly spaced** between the plates, indicating a **uniform** electric field. Electric field lines ran perpendicular to these equipotentials, from the positive to the negative plate.

The calculated electric field strength for both configurations, using $E = \frac{V}{d}$, was:

$$E = \frac{12\,V}{0.08\,m} = 150\,\frac{V}{m}$$

The experiment successfully visualized electric field lines and equipotential surfaces. In the dipole setup, the field lines **curved outward from the positive** electrode and **inward toward the negative** electrode, consistent with theoretical predictions. In the parallel plate setup, the field lines were **uniform** and **perpendicular** to the **plates**.

The calculated electric field strength (150 V/m) matched the expected value based on the applied voltage and plate separation. Minor discrepancies could result from probe placement inaccuracies and variations in conductive paper resistance.

CONCLUSION

This experiment successfully demonstrated the relationship between electric field lines and equipotential surfaces for different electrode configurations. The measured electric field strengths were consistent with theoretical calculations, enhancing understanding of electrostatic principles.

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Figure 2: Study.com. (n.d.). Electric field between two parallel plates [Image]. Retrieved from https://homework.study.com/cimages/multimages/16/5117881_b2698317308760274469.jpg

Figure 6: PASCO Scientific. (n.d.). PK-9025B Conductive Paper [Image]. Retrieved from https://manuals.plus/wp-content/uploads/2022/05/PASCO-PK-9025B-Conductive-Paper-550x420.png

Figures 3–12: Tuiachieva, Z. (2025). Experimental images of electric field mapping [Photographs]. Taken in the laboratory during the experiment.