E2a: Electric Fields

Introduction:

The main objective of this experiment is to examine the electric field lines that develop when electric charges are present. When two equal but opposite charges are some distance apart, a fixed potential difference, known as voltage, will exist between them. The space surrounding these charges will also develop potential differences ranging in value. All points in space have a certain potential difference, and in a three-dimensional space, the collection of points with the same voltage forms an equipotential surface. A two-dimensional sheet of paper will represent a slice of this surface in the form of a line. Since all points in this line are also at the same potential, they are called equipotential lines. Because of the weak electric field being used for this experiment, it is easier to map the electric field lines in an indirect way, by first measuring the voltages of these equipotential lines. The electric field lines are always perpendicular to the equipotential lines, so once several equipotential lines are obtained, it becomes possible to map the electric field.

Apparatus:

- Conductive paper
- Multimeter
- Power supply
- Metallic Rulers
- Plastic Ruler
- Graphing paper
- Metal pushpins

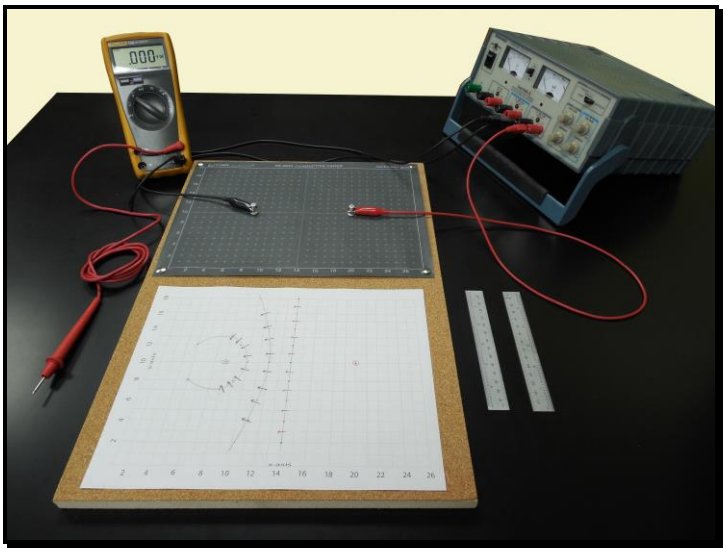


Figure 1

Discussion:

Before beginning this experiment, it is necessary to first read up on and understand the relationship between electric field lines and equipotential lines. *Please read the relevant material in your textbook for this experiment.*

The Electric Field	Cutnell & Johnson. **Physics**, *Chapter* **18** *section* **6, 7**
The Electric Potential Difference	Cutnell & Johnson. **Physics**, *Chapter* **19** *section* **2**
Equipotential Surfaces &…	Cutnell & Johnson. **Physics**, *Chapter* **19** *section* **4**

Do not begin this experiment without first checking with a lab instructor and reading any supplemental reading material that the lab instructor provides.

Procedures:

This experiment consists of two different parts. The first portion finds the electric potentials and the electric field lines for two point charges. The second part of the experiment finds the electric potentials between two bar charges and graphs the data to find the electric field.

Part I

1. Make sure the COM port on the digital multimeter (DMM) is connected to the negative terminal on the power supply.
2. Connect each cable on the power supply to the pushpins located in the conductive paper. Make sure these pins are located at the specified points: (x,y) where x=8 and y=10 for the first point (8,10) and x=20 and y=10 for the second point (20,10).
3. Turn on the power supply and set it to approximately 15V.
4. Using the positive (red) probe of the DMM measure the voltage at the points listed in table one. Mark these points on the graph provided in the lab handout. You will want to record these voltages so you can find points corresponding to these equipotential lines later.
5. Using the DMM find another point on the conductive paper at y=8 corresponding to the voltage you found at (10,10). Mark this point on your graph.
6. Repeat step five for y=6. If you can't find a point with a matching potential along the line y=6 then move up one line (to y=7) and check there.
7. Repeat step five for y=12 and y=14. If you can't find a point with a matching potential at y=14 move down one line and continue.
8. Now use the positive probe of the DMM to find another point on the conductive paper at y=8 corresponding to the voltage you found at (12,10) and mark it on the graph. Repeat this step, moving down the y-axis by two units each time (e.g. y=6, y=4, etc.) until you reach y=2.
9. After reaching y=2 repeat step 8 for y=12 to y=18. You should have nine points between y=2 and y=18 at the end of this step.
10. Repeat steps eight thru nine for the points you found in step four at (12,10), (14,10) and (16,10), Table 1.
11. Repeat steps five thru seven for the point you found at x=18. At the end of this step you should have five separate lines. Smoothly connect the dots in each of these lines using the French curve provided to form your equipotential lines.
12. Now it is possible to map the electric field lines. These lines always cross the equipotential lines at 90º, so by intercepting each equipotential line by another line perpendicular to it, the electric field can be sketched. Start with the center equipotential line and draw short vector field lines, each about 1 cm long, evenly spaced every 2 cm, always keeping them perpendicular to the equipotential line. There should be about eight electric field vector lines for this center line. Move to the next closest equipotential line and repeat, again keeping the vector filed lines each about 1 cm long and evenly spaced. Continue to repeat this for the other equipotential lines.

TABLE 1

x	y
10	10
12	10
14	10
16	10
18	10

Part II

1. Place the two metallic rulers on the conductive paper, 12cm apart, and parallel to each other. Use the pushpins provided to secure the ends of each of the rulers (see figure 2).

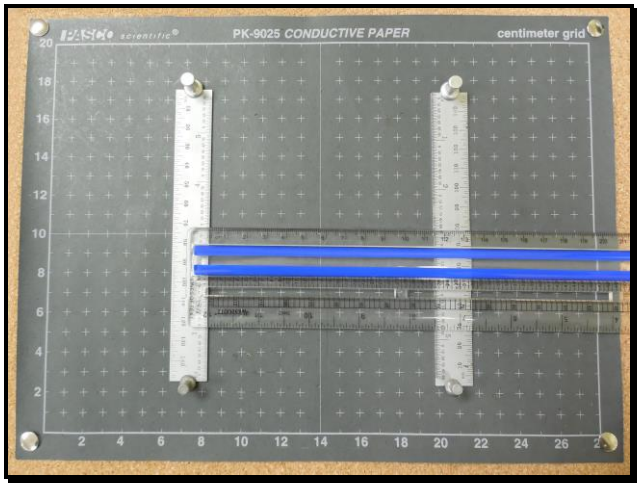


Figure 2

2. Make sure the COM port on the digital multimeter (DMM) is connected to the negative terminal on the power supply.
3. Attach the red (+) cable from the power supply to a pushpin, on one ruler, and the black (-) cable from the power supply to a pushpin on the other ruler. Turn on the power supply and set it to approximately 15 volts.
4. Touch the ruler connected to the red (+) cable anywhere with the positive (red) probe from the voltmeter; you should read on your voltmeter the maximum voltage (approximately 15V). Touch the conductive paper in the middle between the metallic bars with the positive (red) probe from the voltmeter. This time, you should read in your voltmeter a voltage lower than 15V.
5. Using the plastic ruler, place the positive (red) probe on the conductive paper along a line perpendicular to the metallic bars in the middle of the "capacitor" at 5 mm from the negative conducting bar**.** Record the reading on the voltmeter.
6. Move another 5mm along the line, so you are now 10mm from the negative conducting bar. Again, record the reading on the voltmeter.
7. Repeat this procedure and measure the voltage along the same line, increase the distance by exactly 5 mm each time. Stop your measurements when you reach the metallic bar connected to the positive terminal. Record your data in the **Table 2**.
8. Use Excel to plot a graph of the electrostatic potential (voltage you measured) as a function of the distance from the bar connected to the negative terminal. Use Excel to fit your data with a theoretical curve by choosing an appropriate trendline. Show your data and the graph with your fit to the lab instructor.

Experiment E2a: Electric Fields

Student Name_____

*Lab Partner Name*_____

*Lab Partner Name*_____

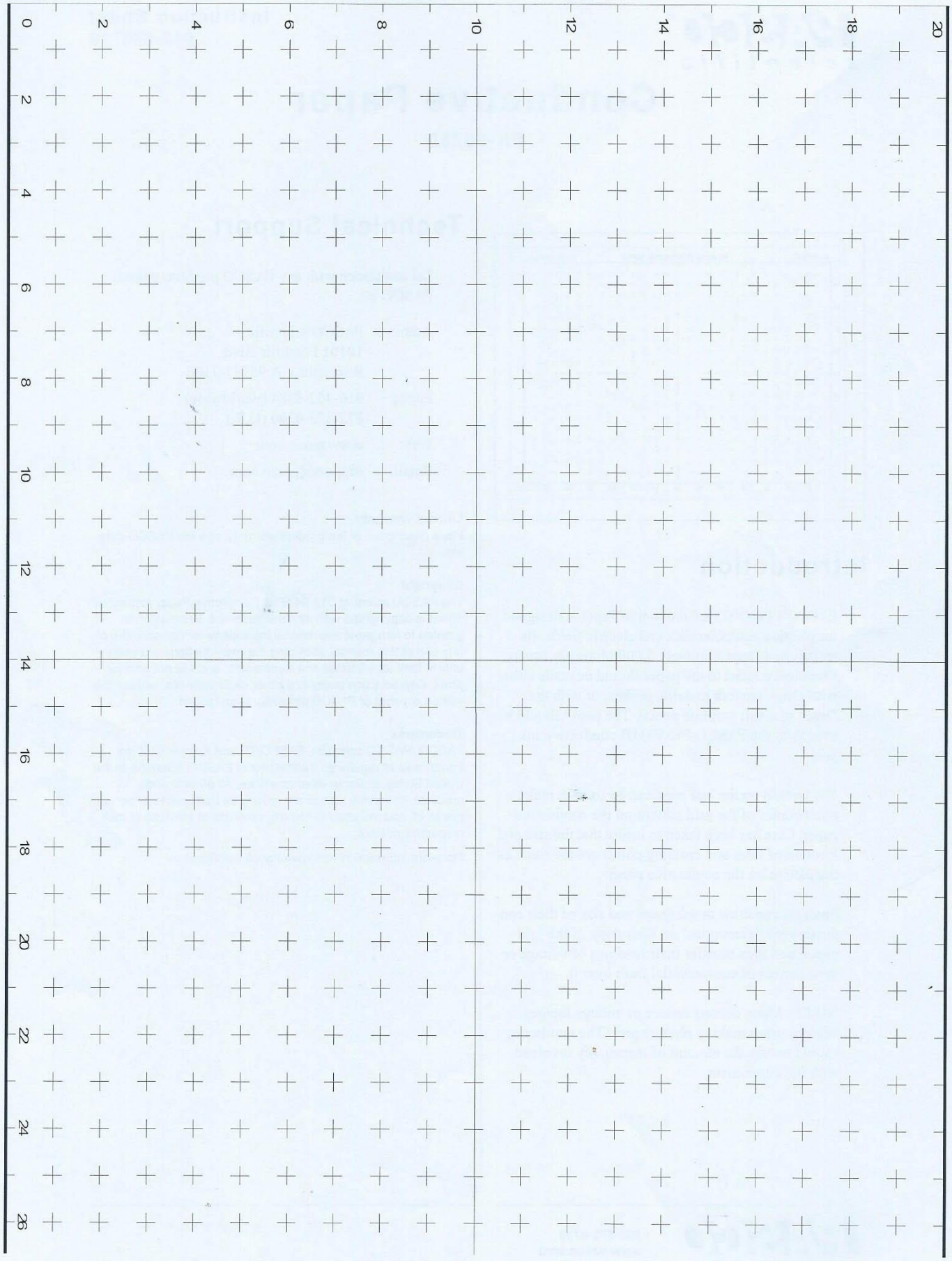
Physics Course_____

Physics Professor_____

Experiment Start Date_____

Lab Assistant Name	*Date*	*Time In*	*Time Out*

Experiment Stamped Completed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24
26

Data Sheets: E2a: Electrostatic Potential

NAME: _____ DATE: _____

TABLE 2

Dependence of Electrostatic Potential on Distance from Negative Bar of Parallel-Plate Capacitor

Distance from Negative Bar (mm)	Electrostatic Potential (Volts)

Electric Field (from graph)_____