ILLINOIS INSTITUTE OF TECHNOLOGY - PHYS 221 L03

Lab Report - Lab 03: Electric Fields and Electric Potential

October 4, 2020

Daniel Ayabe

Daniel Ayabe
Phys 221-L03
Lab 03
TA: Alex Brueske

Lab 03 - Electric Fields and Electric Potential

Introduction

In this lab we interacted with electric fields and electric potential. By measuring the voltage between two conductors connected to a power supply, we were able to draw equipotential lines and therefore draw the electric field lines and analyze how the field changes with different configurations of conductors.

Equations:

1. $V = \int_{P_0}^{P} E\cos(\theta)ds + V_0$
2. $\overline{E} = (\frac{\partial V}{\partial x}\widehat{i} + \frac{\partial V}{\partial y}\widehat{j} + \frac{\partial V}{\partial z}\widehat{k})$
3. $|E| = |\frac{\Delta V}{\Delta d}|$

Experimental Methods

1. Pin the conductive paper to the slab of cork using the conductive thumbtacks. Connect the power supply to the two thumbtacks using banana to alligator wires.
2. Connect one wire from the multimeter to the circuit. Turn on the power supply and set the voltage to 10.0V.
3. Using the probe from the multimeter, find points on the conductive paper where V = 2V. Record those points on the white grid paper. Repeat for 4V, 6V, and 8V.
4. Repeat steps 1-3 using another charge configuration for the conductive paper (used the parallel plate configuration shown in Figure 1).

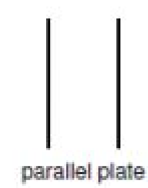
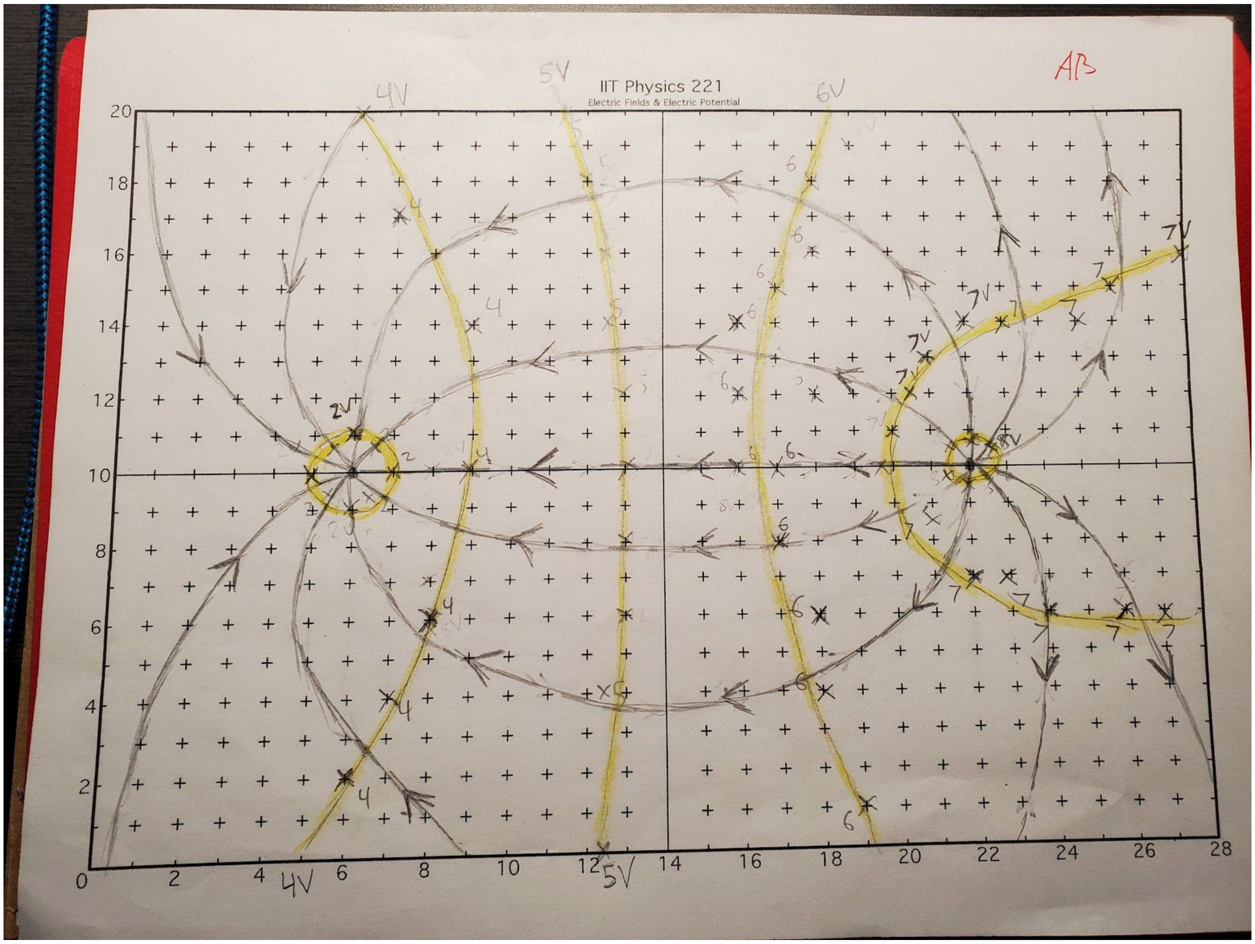


Figure 1: Configuration for parallel

Results and Discussion

For the point charge configuration, the data observed and drawn is shown below in Figure 2.

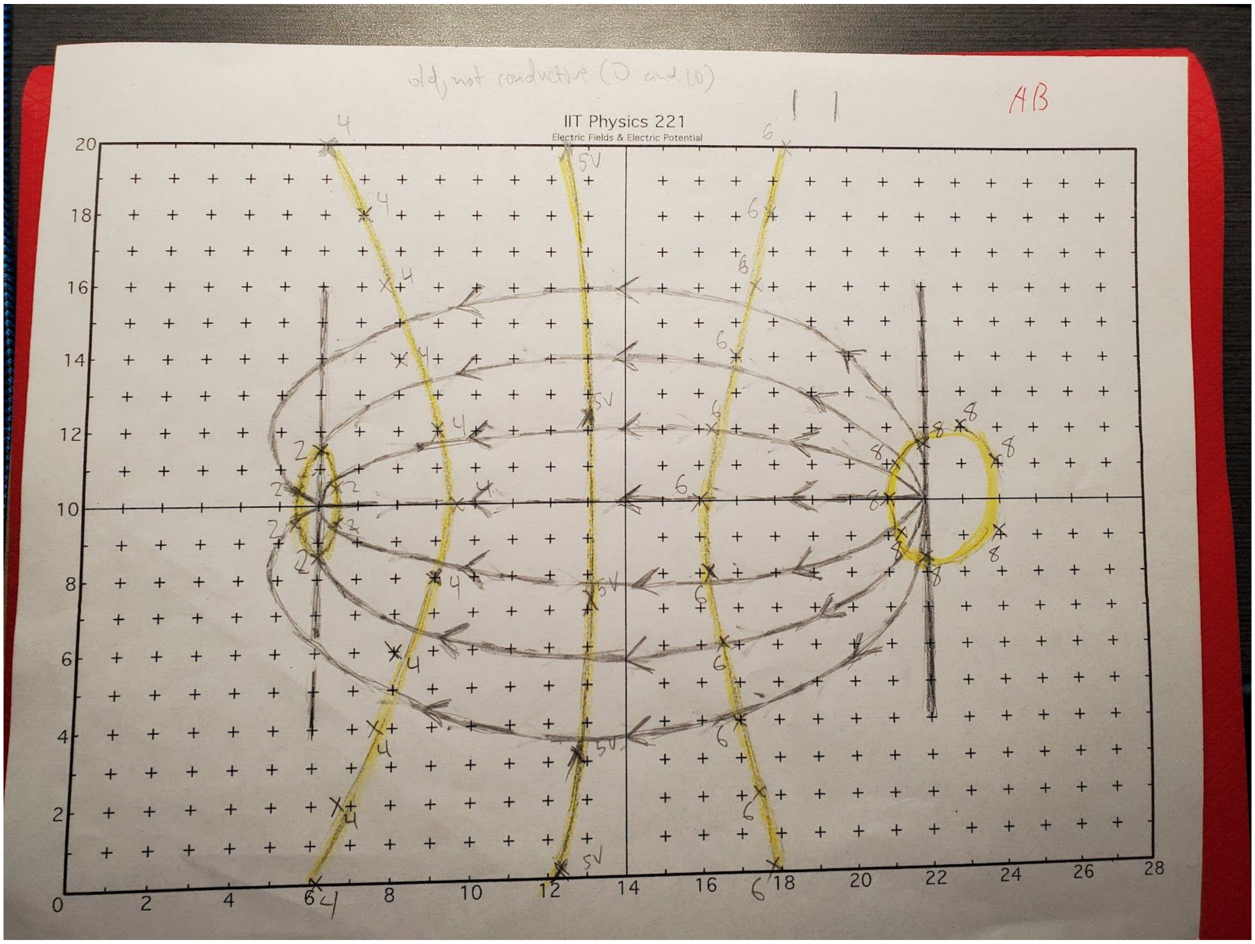
Figure 2:



Since the conductive paper was old, data points at 10V could not be taken, so I didn't have enough equipotential lines to determine the electric field. To accommodate this, I took data points at 5V and 7V to get 2 more equipotential lines to then be able to draw the equipotential lines. After drawing the equipotential lines, I then drew the electric field lines by drawing them perpendicular to the equipotential lines. It was interesting to see how the electric field lines point from positive to negative. The field was strongest nearest to the point charges.

In this second configuration, there were 2 conductive parallel lines resembling parallel plates. The data recorded is shown below in Figure 3.

Figure 3:



Since the conductive lines were drawn a long time ago, they did not conduct well. This was shown in Figure 3 as the voltage on the parallel lines should have been 0V or 10V on the left and right line, respectively. However, the lines did show some difference to the normal charge as the equipotential lines were more elongated and vertically stretched. The more circular rings for the equipotential lines fit more of an oval shape. The field lines were then more closely together than in the first configuration. Similarly to the first configuration, the field lines pointed from positive to negative, and the fields were strongest when nearest to the parallel lines.

<u>Analysis Questions:</u>

1. Which way do the field lines point? That is, where do they start and end?
    a. They point from positive to negative.
2. If the power supply voltage was doubled, how would the equipotential lines and electric field strength change?
    a. The positive charge producing the electric field would double while the negative charge would stay the same, which makes the field double.

3. How does the arrangement/shape of the conductors (electrodes) alter the E?
    a. The superposition of electric fields from each point charge changes, causing the electric field to change.
4. Where is the field the strongest? Where is it the weakest?
    a. The electric field is strongest when close to the source charge and weakest when further away from the source charge.

Questions

1. How does the potential vary with distance on your plots?
    a. Electric potential increases as it moves further away from a point charge. The electric potential lines that are closer to the point charges form a circle-ish shape around the point charge.
2. Calculate the electric field strength at a few places with different characteristics using Eq. 2. Do your results agree with the idea that electric field line density is proportional electric field strength? Sketch neatly and clearly an appropriate amount of lines on your grid paper. You may want to use a different color.
    a. The equipotential lines are highlighted in yellow, and each line is labeled with the measured voltage. The electric field lines are shown by the arrows in which direction it is pointed towards.
    b. Using Figure 2, we take several points and use equation 2 to calculate the electric field.
        i. Place 1 (between (6,10) and (7,10)): E = (2-0)V/(1 x 10^{-2}m) = 200 V/m
        ii. Place 2 (between (7,10) and (9,10)): E = (4-2)V/(2 x 10^{-2}m) = 100 V/m
        iii. Place 3 (between (9,10) and (13,10)): E = (5-4)V/(5 x 10^{-2}m) = 20 V/m
    c. With places 1-3 having decreasing electric field line densities respectively, with place 1 having the greatest density and place 3 having the smallest density, we see that greater density corresponds to greater electric field strength, showing that it is indeed proportional.
3. Consider the following situation: An object with charge qo = 1.5μ C and mass 0.7 g starts from rest at the +6V equipotential line. Calculate its change in potential energy and speed when it reaches the +2V line.

3. $q_0 = 1.5\times10^{-6}$ C , $m = 0.0007$ kg

$U_0 = \frac{1}{2}QV = 4.5\times10^{-6}$ $\Delta U = U_f - U_0 = \boxed{-3\times10^{-6}\,J}$

$U_f = \frac{1}{2}QV = 1.5\times10^{-6}$

$3\times10^{-6} = \frac{1}{2}mv^2$

$3\times10^{-6} = \frac{1}{2}(0.0007)v^2$ $\boxed{v = 0.0926\ m/s}$

Conclusion

Overall, the data recorded had some issues due to old conductivity paper, but it was possible to draw accurate conclusions due to explaining the anomalies. By using conductivity paper and different configurations, we were able to see how electric potentials and electric fields interact with each other and how electric field strength is proportional to electric field density.