Introduction

The purpose of this lab was to investigate electrical fields, by measuring the electric potential through point and bar magnets.

Theory/Pre-Lab

Question 1

$$V_{(total)} = \frac{K_e Q_1}{r_1} + \frac{K_e Q_2}{r_2}$$

$$V_{(total)} = \frac{K_e Q_1}{r} + \frac{K_e Q_2}{d - r}$$

Question 2

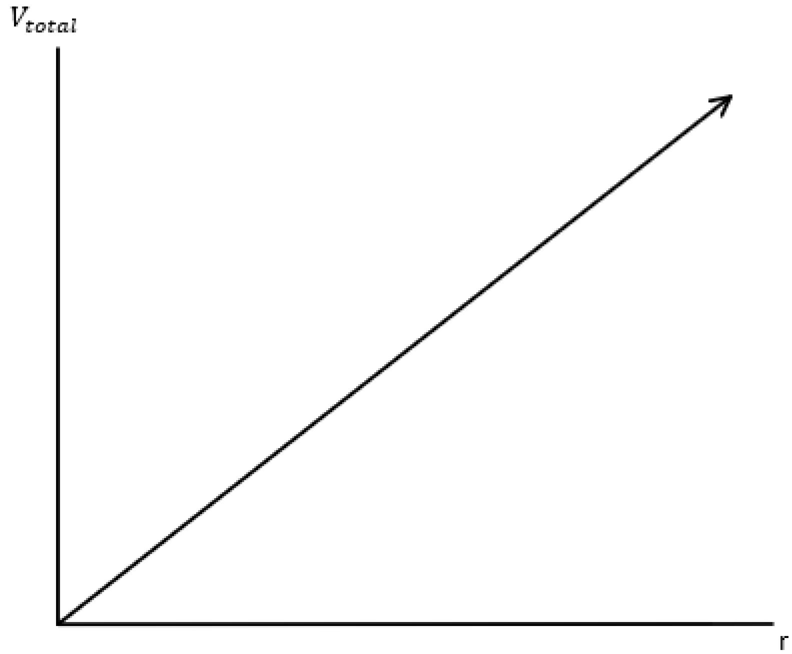
$$V_{(total)} = 2 * K * Q * ln(\frac{r_o}{r}) - 2 * K * Q * ln(\frac{r_o}{d - r})$$

Question 3

$$V_{(total)} = 2 * K * Q * ln(\frac{r_o}{r} \div \frac{r_o}{d - r})$$

$$V_{(total)} = 2 * K * Q * ln(\frac{r_o}{d - r})$$

Question 4



- The slope of the graph would be the change in total voltage with respect to the change in radius.

- The slope of the graph would be linear.

Question 5

a)
- $\Delta U = q * \Delta V = 1C * 0V = 0J$

b)
- $\Delta V = V_f - V_i = 10V - 10V = 0J$

- The electric potential change is 0J because point A and point B are on the same 10V equipotential line

c)
- $\Delta U = q * \Delta V = 2C * 0V = 0J$

- $\Delta V = V_f - V_i = 10V - 10V = 0J$

- The electric potential change would still be 0J because point A and point B are on the same 10V equipotential line

<u>Question 6</u>

a)

- $\triangle V = V_f - V_i = 20V - 10V = 10\,V$

b)

- $\triangle U = q * \triangle V = 3C * 10V = 30\,J$

c)

- The change in electric potential, $\triangle V$ = 10V, would remain the same because the charge would still move from a point on a 10V equipotential line to the other point on a 20V equipotential line

- $\triangle U = q * \triangle V = 2C * 10V = 20\,J$

Procedure:

The Loggerpro program was used with a differential voltage probe to read voltage difference values. Small and bar magnets represented point and plate charges. A sheet of conductor paper with a printed coordinate system was used to identify voltage locations.

Part 1:

1. Place the two smaller magnets on the same horizontal line, at least 20 cm away.
2. Connect the positive terminal of the power supply to the magnet on the right, and negative terminal to the magnet on the left.
3. Supply the circuit with a voltage within the range 2.8-3.5 V
4. Connect the black probe of the to the negative magnet, and the red probe to the positive magnet. The voltage measured should be the same value as the voltage chosen in step 3.
5. Touch the red probe to the negative magnet and record the observation.
6. Download an excel spreadsheet named PCS125LabPotential.xlsx to record data on.
7. Secure the black probe onto the negative magnet, and continuously touch the red probe below the negative electrode. Record the voltage observed and coordinates of the location. Repeat until 5 points are obtained
8. Repeat steps 7 and 8 with a different starting point, and a voltage that differs from the first one at least 0.2 V. Continue this process until at least 3 equipotential lines exist.
9. To record v(x) along the center of the point electrodes, move the magnets onto the same y value, record the voltage of several points along the y value line, at least 1-2 cm away from each other.

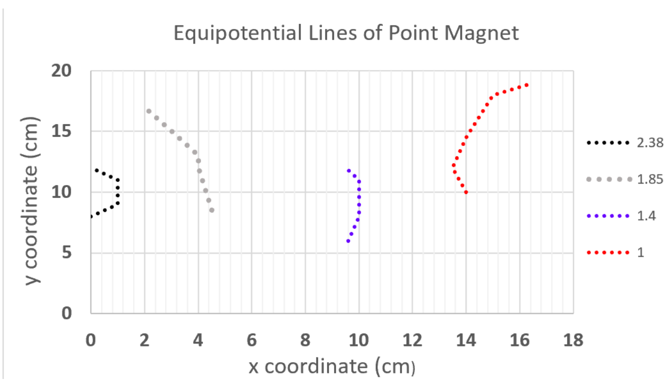
Part 2:

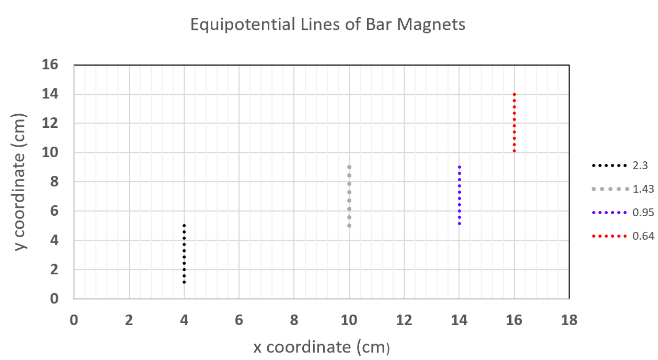
1. Place the long metal magnets vertically and flat on the paper, the same distance apart as the point magnets and with centers on the same y value line.
2. Connect the positive terminal of the power supply to the right magnet, and the negative to the left magnet.
3. Touch the red probe of the voltage difference reader to the positive magnet. This value should match the power supply voltage.
4. Touch the red probe to the negative magnet without touching the black probe. Record your observation
5. Make a copy of the PCS125LabPotential.xlsx document to record data on. Repeat steps 7-9 from part 1 using the long magnets.
6. To measure v(x) for the bar electrodes, repeat the steps for measuring v(x) in part 1.

Results and Calculations:

Data obtained in **Part 1**:

Voltage(V) ->		2.38		1.85		1.0
Coordinates	x (cm)	y (cm)	x (cm)	y (cm)	x (cm)	y (cm)
1	0.0	8.0	4.5	8.5	9.6	10.0
2	1.0	9.0	4.0	12.0	10.0	12.0
3	1.0	10.2	4.0	13.0	10.0	14.5
4	1.0	11.0	3.0	15.0	10.0	18.0
5	0.0	12.0	2.0	17.0	9.5	19.0
6	1.0	11.5	0.0	20.0	10.0	20.0

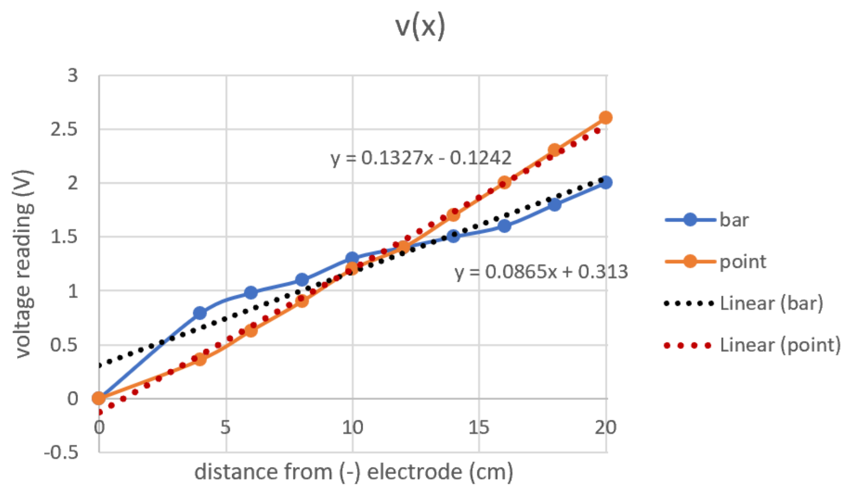




Data obtained in **Part 2**:

Voltage(V)		2.3		1.43		0.95		0.64
Coordinate	x (cm)	y (cm)	x (cm)	y (cm)	x (cm)	y (cm)	x (cm)	y (cm)
1	4.0	6.0	10.0	10.0	14.0	10.0	16.0	15.0
2	4.0	5.0	10.0	9.0	14.0	9.0	16.0	14.0
3	4.0	4.0	10.0	8.0	14.0	8.0	16.0	13.0
4	4.0	3.0	10.0	7.0	14.0	7.0	16.0	12.0
5	4.0	2.0	10.0	6.0	14.0	6.0	16.0	11.0
6	4.0	1.0	10.0	5.0	14.0	5.0	16.0	10.0

Analysis:



4. V(t)=2KQln(r1/d-r1), where m=2KQ and ln(r1/d-r1) is the x value.

$m = 2KQ$

$0.1327 = 2KQ$

$\frac{0.1327}{2K} = Q$

$Q = \frac{0.1327}{2(9 \times 10^9)}$

$Q = 7.3722 \times 10^{-12}$

5. Since the electric field is the change of voltage over the change of time, the electric field is simply the slope of the graph. According to the linear best fit equation, the value is ~0.0865.

$E = \frac{KQ}{r^2}$

$= \frac{KQ}{(20cm)^2}$

$= \frac{KQ}{(0.2m)^2}$

$E = 1.08125$ N/C

$Q = \frac{m}{2K}$

$= \frac{0.0865}{2K}$

$Q = 4.8 \times 10^{-12}$

$K = 9 \times 10^9$

Discussion and Conclusion:

1. Equipotential lines are unable to cross because that would require a location to contain two different voltages at once, which is impossible.

2. When comparing the voltage vs distance graphs for point and bar electrodes, the point electrode graph was completely linear. This contradicts equation (5) and (6) because the ‘infinite’ plate equation consists of a constant and a variable only making it a perfectly linear equation, compared to the point equation which contains a ln function, which theoretically would add a slight curve to the graph.

3. If the bars were twice as long, the length of the relatively straight section of the equipotential lines would increase. If the bars were infinitely long, the equipotential lines would be straight and parallel to the plates for infinity, since the magnitude of forces on each side would cancel each other to create the perfect line between the plates.

4. The observation of the electric potential at various points inside the ring remained constant to the behaviours of electric potential in the second part of the experiment. Similar to part two of the experiment, the electric potential at various points in the ring remained constant if you moved vertically. For instance, we observed that at positions (x = 12cm, y = 10cm) and (x = 12cm, y = 12cm), the electric potential were both 1.2V. A possible reason for this outcome could be because the properties of the electric potential for bar electrodes remain consistent with or without the conductive ring.