# Lab 5: E-field Mapping

Graded

**Student**

Fady Youssef

**Total Points**

**77 / 97 pts**

**Question 1**

## Parallel bars

**10** / 15 pts

✔ **– 0 pts** Correct

**– 5 pts** Point adjustment

1 No E-field lines shown. -5

**Question 2**

## Contour plot

**20** / 27 pts

✔ **– 0 pts** Correct

**– 7 pts** Point adjustment

2 You were supposed to sketch the E-field lines. -7

**Question 3**

## Questions

**18** / 20 pts

**– 0 pts** Correct

**– 2 pts** Point adjustment

3 What about for your data? (-2)

4 the e-field is largest along the axis that connects the two conductors. The line connecting them is where they are closest to one another, which indicates the largest field

**Question 4**

## Error discussion

**10** / 10 pts

✔ **– 0 pts** Correct

**Question 5**

## Challenge

19 / 25 pts

**– 0 pts** Correct

**– 6 pts** Point adjustment

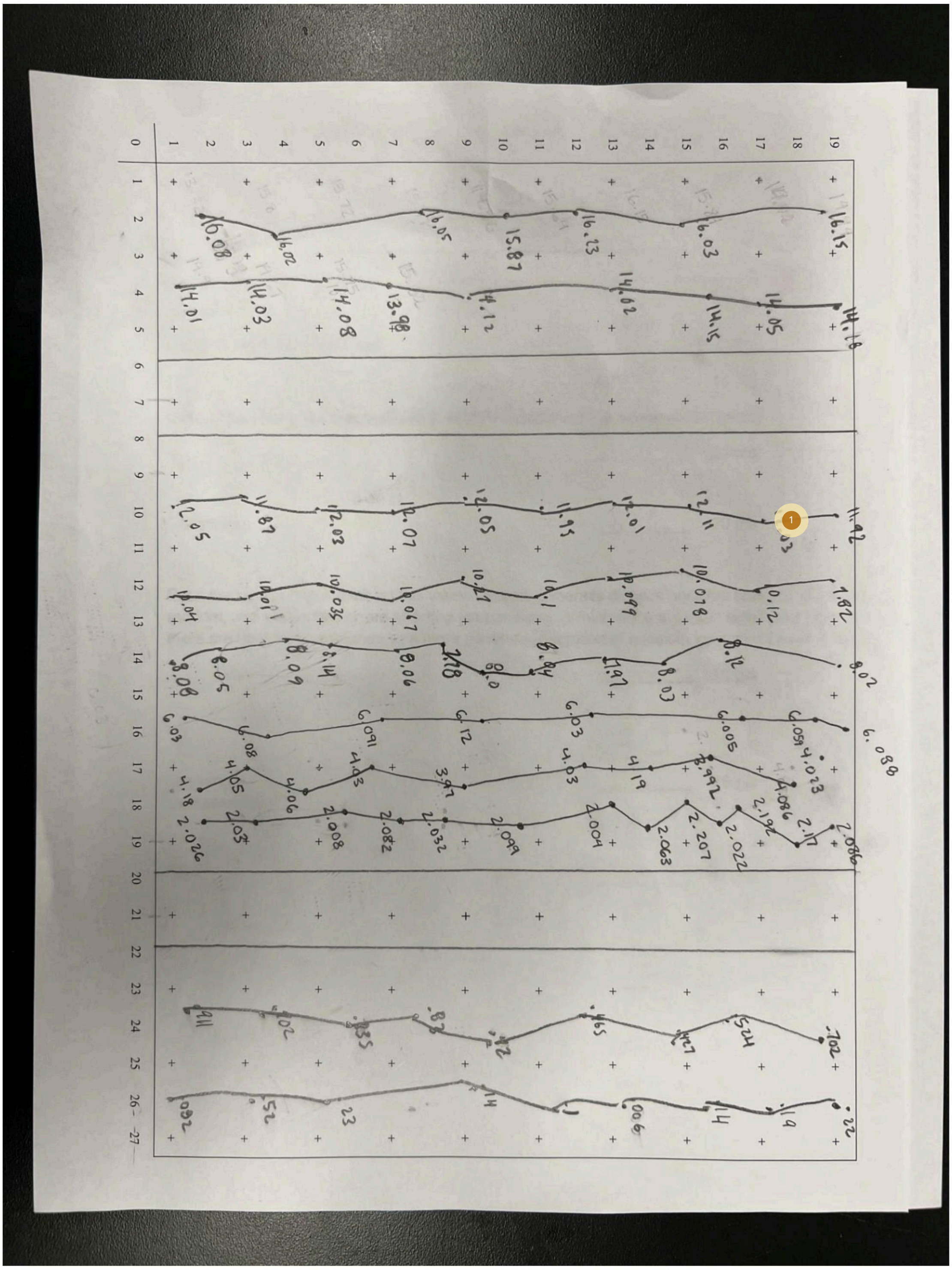
5 Good explanation overall.

6 10 + 9/15 = 19/25

7 Right, the E-field is most nearly constant along the line connecting the midpoint of the bar and the washer.

Question assigned to the following page: 1

Parallel bars E-Field Drawing:



Questions assigned to the following page: 3 and 4

Questions:

1. An electric field line must leave a conductor at right angles because the surface of a conductor is at the same potential everywhere. If the field had any part going along the surface, charges would move, but in electrostatic equilibrium, charges don’t move. Since the conductor cancels any sideways field, the electric field can only point straight out, making it perpendicular to the surface.

2. Yes, the electric field lines should leave the conducting regions perpendicularly. This happens because the surface of a conductor has the same voltage everywhere. If the field was not at a right angle, there would be a force along the surface, causing charges to move. But since the system is in electrostatic equilibrium, charges don’t move, so the field must be perpendicular to the surface.

3. The conducting areas on the paper heat up because current is flowing through them, and resistance causes some electrical energy to turn into heat. This is called Joule heating. As the experiment runs, energy keeps getting lost as heat, which builds up over time and warms the material.

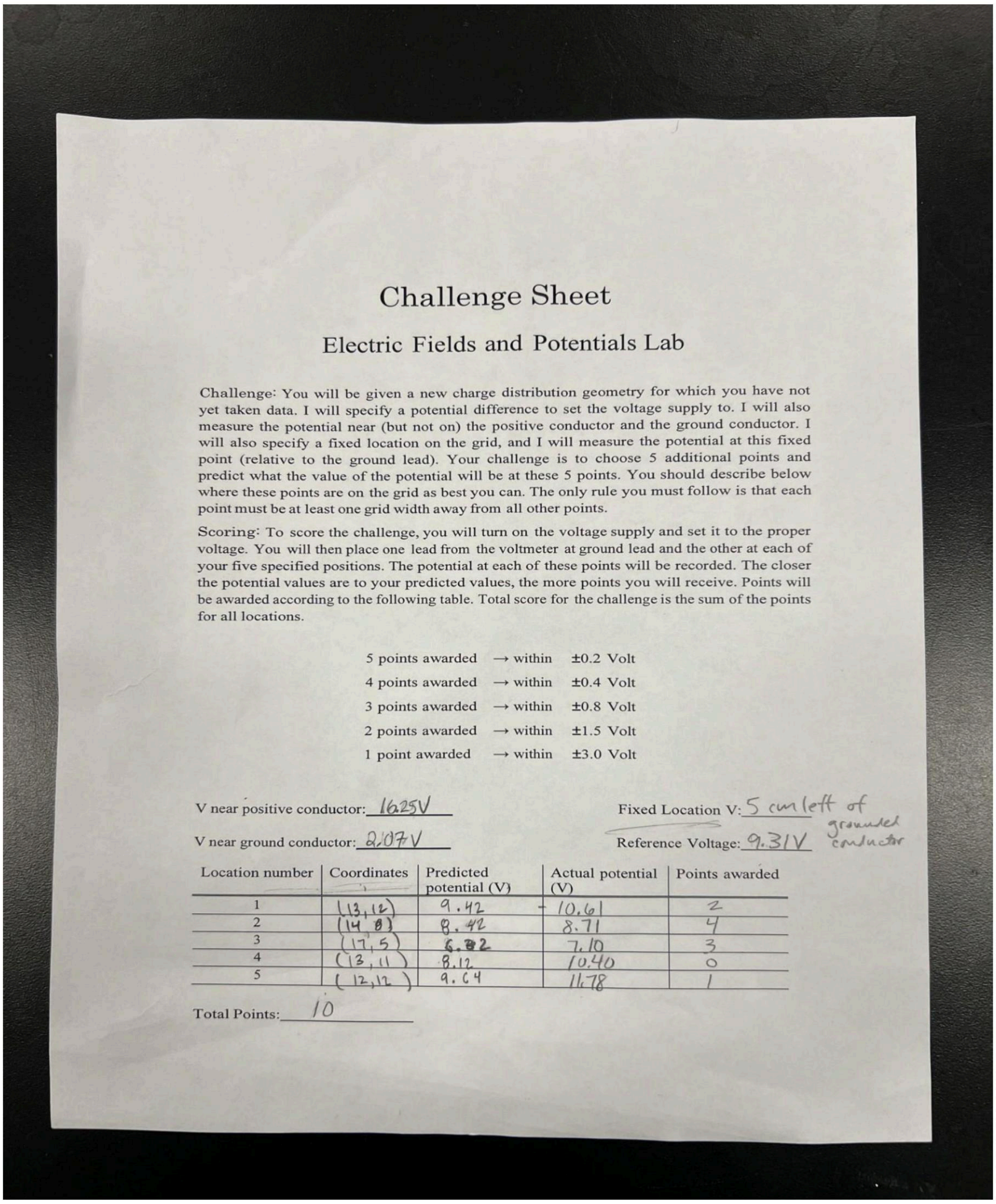
4. The E-field is larger where the field lines are closer together and smaller where they are more spread out. For the parallel bars, the field is stronger in the middle between them because the lines are evenly spaced and concentrated there. Near the edges, the field spreads out, making it weaker. For the washers, the field is strongest near the charges and gets weaker as you move away because the field lines spread out in all directions.

Error Discussion:

A reading error came from the voltmeter fluctuating, making it hard to get exact voltage values. A random error happened because the conductive paper wasn’t fully taped down which might have messed with the contact and caused bad readings. The most significant of these was systematic error since it was hard to control everything at once. I had to hold the positive probe with my left hand, read the multimeter, and type in the data with my right hand all at the same time. The voltmeter kept fluctuating and it was tough to keep the probe steady which made the readings even  less accurate.

Question assigned to the following page: 5

Challenge:



# Challenge Sheet

## Electric Fields and Potentials Lab

Challenge: You will be given a new charge distribution geometry for which you have not yet taken data. I will specify a potential difference to set the voltage supply to. I will also measure the potential near (but not on) the positive conductor and the ground conductor. I will also specify a fixed location on the grid, and I will measure the potential at this fixed point (relative to the ground lead). Your challenge is to choose 5 additional points and predict what the value of the potential will be at these 5 points. You should describe below where these points are on the grid as best you can. The only rule you must follow is that each point must be at least one grid width away from all other points.

Scoring: To score the challenge, you will turn on the voltage supply and set it to the proper voltage. You will then place one lead from the voltmeter at ground lead and the other at each of your five specified positions. The potential at each of these points will be recorded. The closer the potential values are to your predicted values, the more points you will receive. Points will be awarded according to the following table. Total score for the challenge is the sum of the points for all locations.

5 points awarded → within ±0.2 Volt
4 points awarded → within ±0.4 Volt
3 points awarded → within ±0.8 Volt
2 points awarded → within ±1.5 Volt
1 point awarded → within ±3.0 Volt

V near positive conductor: 16.25V

V near ground conductor: 2.07V

Fixed Location V: 5 cm left of grounded conductor

Reference Voltage: 9.31V

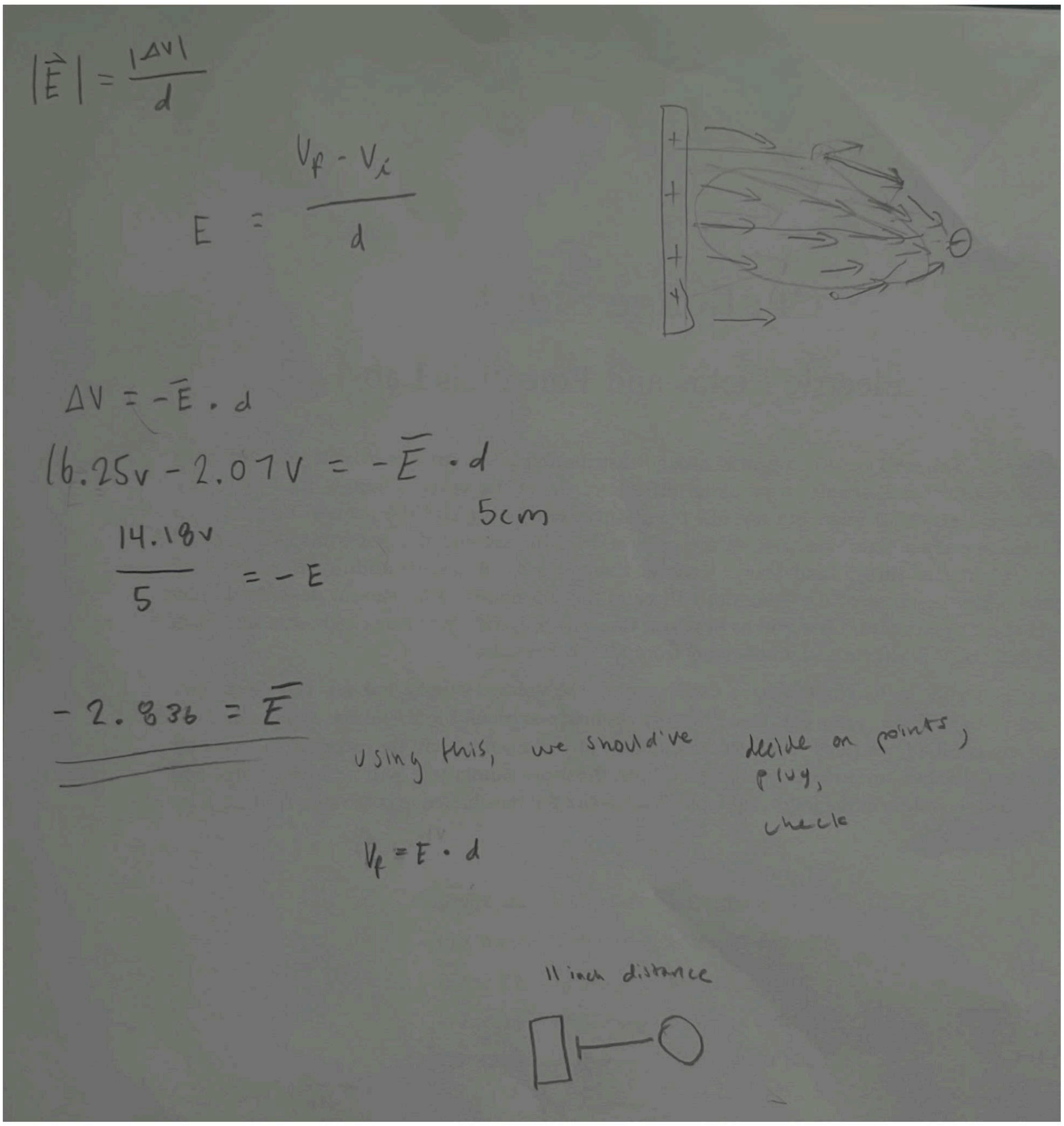
| Location number | Coordinates | Predicted potential (V) | Actual potential (V) | Points awarded |
|---|---|---|---|---|
| 1 | (13, 12) | 9.42 | 10.61 | 2 |
| 2 | (14, 8) | 8.42 | 8.71 | 4 |
| 3 | (17, 5) | 6.82 | 7.10 | 3 |
| 4 | (13, 11) | 8.12 | 10.40 | 0 |
| 5 | (12, 12) | 9.64 | 11.78 | 1 |

Total Points: 10

1. During the challenge, I think we had the right setup and idea but wrong approach along with doubt keeping us from approaching the problem more mathematically. Personally, I started by expanding the formula |E| = |{theta} v| / d extracting it into v_f = E * d, however, I am not fully familiar with all of the notation, so I had plugged in 5cm for d leading to the incorrect value and from there completely threw me off my approach. This leads to far too much time trying nonsensical algebraic manipulation which leads to

Question assigned to the following page: 5

nothing. This is when we decided to switch over to “rolling the dice” using the reference voltage, but again, a major mistake I made was for some reason assuming we couldn’t just use points on a straight line near each other, giving better odds for our prediction to the actual potential but I did not express that to my partner as we were running out of time.

2. 


3. I believe the fundamental problem I had with this challenge was just not understanding what I was supposed to do or what values would be given to us directly. We should’ve just stuck with the v_f = formula that we were able to extract early on instead of

Question assigned to the following page: 5

beginning to search for other mathematical approaches and confusing ourselves further. We should have been able to extract the electric field (E) value quickly then we would pick a coordinate right along the source path so we could easily get the difference in the distance between the given point in the two conductors and plug that into the final value, then we could've made more sound predictions if the coordinate is in a certain position away from a certain conductor might reduce or increase, but overall would have given us far closer predicted potential (V).

4.

$$|E| = \left|\frac{\Delta V}{d}\right| \longrightarrow E = \frac{16.25V - 2.07V}{.15m} \cong 97.87\ V/m$$

$$\Delta V = -\bar{E} \cdot d$$

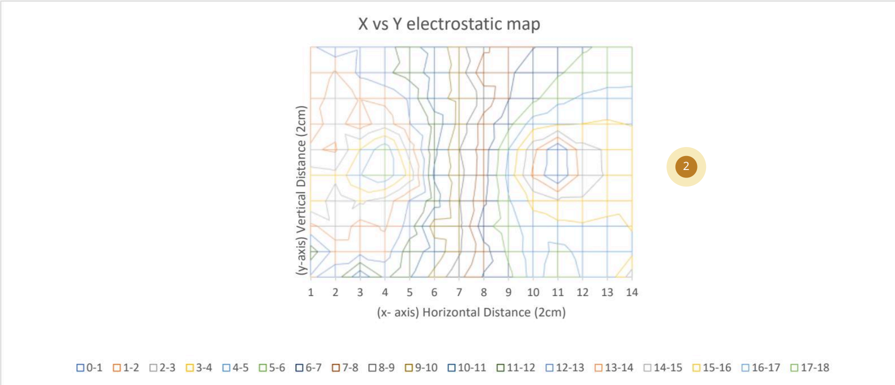
$$V_f - V_i = -\bar{E} \cdot d$$

$$V_f = V_i - E \cdot d \longrightarrow V_f = 2.07V + 97.84\ V/m(.05m) = 2.07V + 4.89V = 6.96V$$

which is far closer to the 7.10V in location 3 showing we overthunk the challenge given.

Question assigned to the following page: 2

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 13.13 | 12.6 | 10.19 | 12.24 | 11.09 | 9.65 | 8.29 | 6.904 | 6.292 | 4.542 | 5.634 | 4.926 | 4.796 | 2.417 |
| 17 | 11.44 | 13.4 | 13.36 | 13.53 | 11.41 | 10.68 | 9.14 | 7.426 | 5.782 | 4.424 | 5.326 | 4.734 | 4.399 | 4.316 |
| 15 | 13.73 | 14.72 | 13.59 | 14.12 | 12.59 | 9.43 | 9.26 | 6.331 | 5.453 | 4.467 | 4.282 | 4.148 | 4.405 | 3.924 |
| 13 | 15.89 | 14.43 | 15.13 | 14.58 | 12.94 | 11.54 | 9.07 | 7.2 | 5.107 | 3.723 | 3.09 | 3.107 | 3.35 | 3.564 |
| 11 | 15.43 | 15.27 | 16.94 | 17.73 | 15.67 | 10.83 | 9.39 | 7.42 | 4.694 | 1.803 | 0 | 2.43 | 3.11 | 3.133 |
| 9 | 14.12 | 13.86 | 16.02 | 17.73 | 14.52 | 11.23 | 9.05 | 7.509 | 4.995 | 2.268 | 0 | 2.63 | 3.119 | 3.232 |
| 7 | 13.66 | 14.33 | 13.51 | 14.55 | 13.04 | 11.68 | 9.71 | 7.455 | 6.34 | 4.468 | 4.053 | 3.993 | 3.847 | 4.063 |
| 5 | 13.81 | 14.15 | 13.97 | 13.77 | 12.85 | 10.29 | 9.76 | 8.72 | 7.05 | 6.254 | 5.282 | 4.865 | 4.71 | 4.657 |
| 3 | 13.44 | 14.06 | 12.76 | 12.19 | 11.6 | 10.54 | 9.65 | 7.24 | 7.2 | 6.408 | 6.125 | 5.601 | 5.396 | 5.396 |
| 1 | 13.2 | 12.33 | 12.86 | 12.61 | 11.16 | 10.79 | 9.31 | 8.227 | 7.34 | 7.04 | 6.588 | 6.127 | 5.802 | 5.601 |
| 0 | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 |



No questions assigned to the following page.