XI'AN JIAOTONG-LIVERPOOL UNIVERSITY
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COURSEWORK SUBMISSION COVER Page

Lab Date (tick √)	Week 7 Tuesday Week 7 Thursday √
Team Number	T08
Students' ID Number	2251625 2252439 2251676 2253907
Module Code	CAN102
Assignment Title	Coursework1: Lab1
Submission Deadline	23:59 2024/04/14 for D1/1 23:59 2024/04/16 for D1/2

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Contribution:

Task A3 is completed by (write down the ID number): 2251625 2251676 2252439 2253907

Task A4 is completed by (write down the ID number): 2251625 2251676 2252439 2253907

Task A5 is completed by (write down the ID number): 2251625 2251676 2252439 2253907

Task B3 is completed by (write down the ID number): 2251625 2251676 2252439 2253907

Please list the ID number who does NOT contribute at all: ~~..........~~

Please confirm the above information and SIGN your name in English (Foreign students) or PINYIN (local students):

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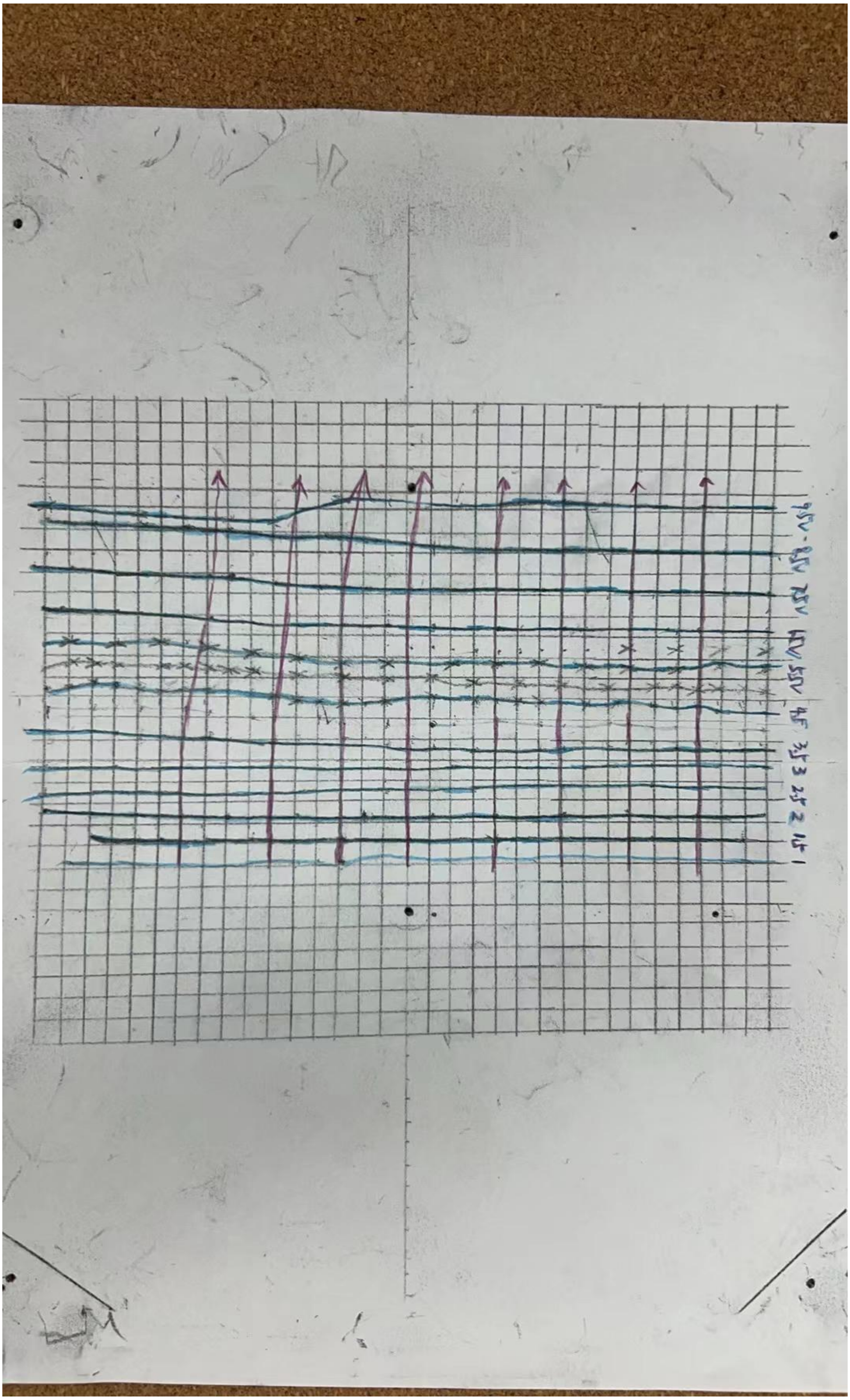
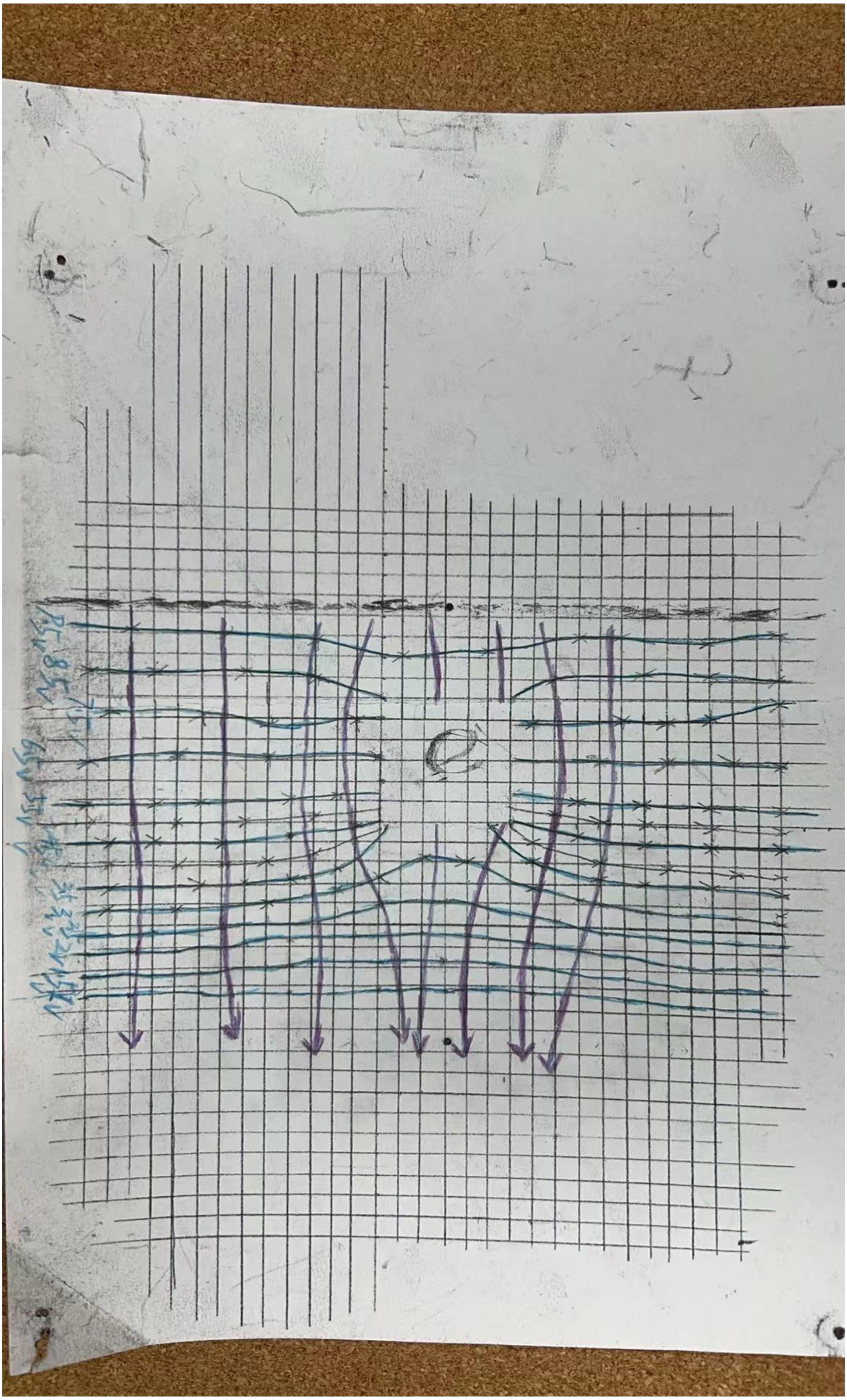
Date 2024/4/11

Schematic A-2



Schematic B-2



Task A3:

Under what conditions will the field between the electrodes of a parallel plate configuration be uniform?

Answer A3:

After weighing all possible consequences which may contribute to the change of the electric field carefully, we list 3 factors as below.

The first one we have to take into consideration is the flatness of the parallel plates. The plates should be perfectly flat and parallel to each other. Any deviation from flatness or parallel orientation will result in a non-uniform electric field.

Secondly, the size of the plates should be significantly larger than the separation between them. This ensures that the electric field near the edges of the plates, where non-uniformity is most likely to occur, has negligible impact on the overall field between the plates. The separation distance between the plates should be small compared to the size of the plates. A small separation distance reduces the likelihood of significant divergence in the electric field lines.

Thirdly, we have to assure the same dielectric medium. If the space between the plates is filled with a homogeneous dielectric material, such as air or a specific insulating material, the electric field between the plates will be more uniform. This is because the dielectric medium helps to reduce the impact of any surface imperfections or irregularities.

Considering these impacts, the uniformness of electric field can be guaranteed in maximum degree.

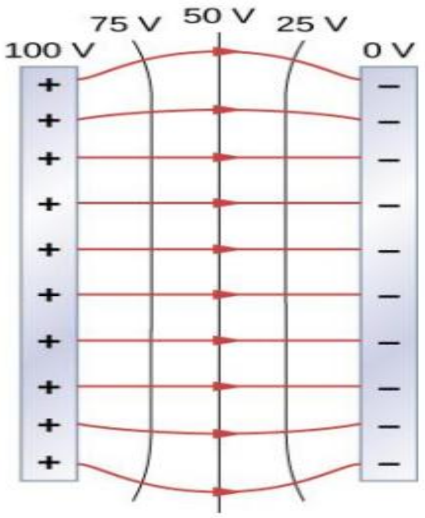
Task A4:

Explain in detail why the equipotential lines near a conducting surface are parallel to the surface

Answers:

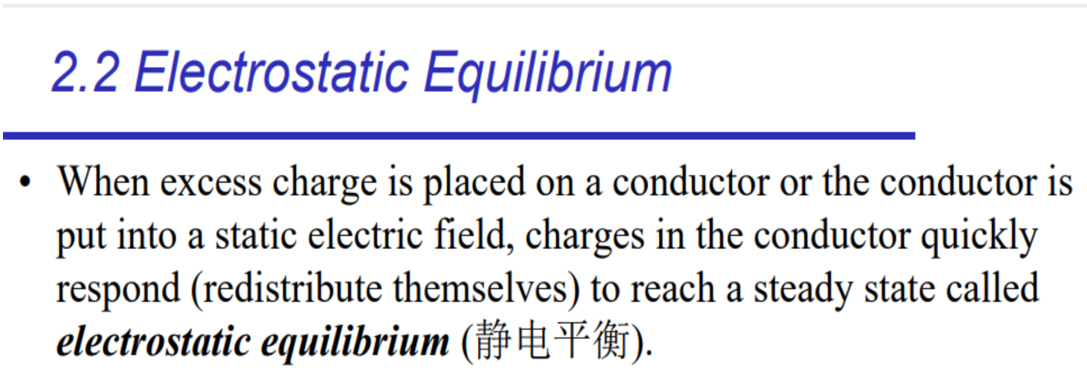
We've summarized several reasons from different dimensions to better answer such question.

Firstly, it is mainly due to the characteristic of electric field. For the vicinity a conducting surface, the electric field is perpendicular to the surface. This is due to the fact that in a conductor, charges are free to move and will redistribute themselves in a manner that cancels out any component of the electric field parallel to the surface. As a result, the electric field lines are perpendicular to the surface. *The graph I showed below is cited from CAN102 Lecture 5 p19.* This graph may help us understand such question better.



(a) Two oppositely charged metal plates;

Secondly, from the dimension of the work done because of the electric field, we can have a better command of this phenomenon. When the equipotential lines were not parallel to the conducting surface, it would imply a component of the electric field parallel to the surface. In that case, if a charge were to move along an equipotential line, work would be done against the electric field component parallel to the surface, contradicting the fact that no work is done while moving along an equipotential line. Ultimately, we can dig into this question from the stability of electrostatic equilibrium which is taught in lecture 6. *The graph I showed below is cited from CAN102 Lecture*



6 p14.

In an electrostatic equilibrium, charges will arrange themselves in such a way that the electric field is minimized. By having the equipotential lines parallel to the conducting surface, the system achieves a state of minimum energy and stability.
In summary, the parallel nature of equipotential lines near a conducting surface is a consequence of the nature of electric fields and potentials, the behavior of charges in conductors, and the principles of electrostatic equilibrium.

Task A5:

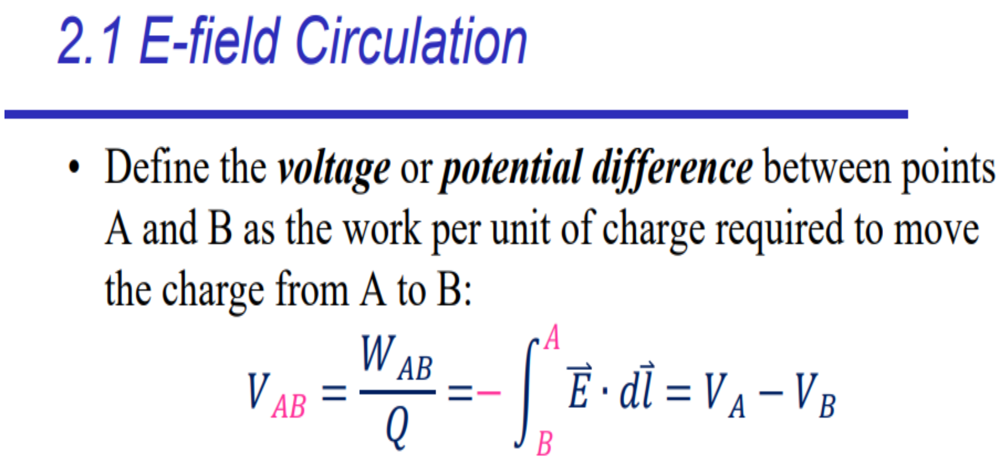
By observing the plotted equipotential lines, explain why it is impossible for two different equipotential lines to cross.

Answer:

When we observe plotted equipotential lines, we can see that two different equipotential lines cannot cross. After our discussion, we conclude 3 reasons behind it combined with the experiment and the module CAN102.

Firstly, let us focus on the definition of equipotential lines. Equipotential lines are defined as a set of points in space where the electric potential has the same value. Therefore, if two different equipotential lines were to cross, it would mean that at the point of intersection, the same point in space would have two different electric potentials, which is not physically possible.

Secondly, we can also demonstrate this via the work done as the last question. Moving along an equipotential line does not require the input of work, as the electric potential remains constant ($VA - VB = 0$). The formula we've learnt in CAN102 Lecture 5 perfectly demonstrates that. *The graph I showed below is cited from CAN102 Lecture 5 p21.*



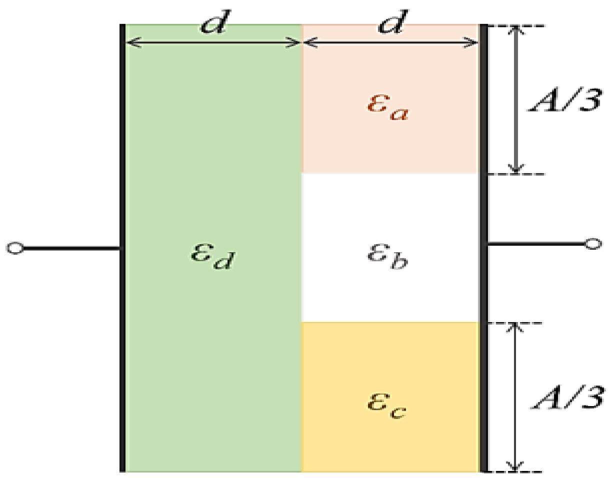
If two equipotential lines were to cross, it would imply that a charge moving from one line to another undergoes a change in electric potential, which contradicts the fundamental concept of equipotential lines.

Finally, let us come back to the nature of the electric field. The electric field lines are always perpendicular to the equipotential lines. If two different equipotential lines were to cross, it would imply that the electric field has different directions at the point of intersection, which is not consistent with the behavior of electric fields.

Therefore, based on the fundamental properties of electric potential and electric fields, it is impossible for two different equipotential lines to cross. The concept of equipotential lines is a fundamental aspect of understanding electric fields and potential, and their behavior is consistent with the fundamental principles of electrostatics.

Task B3:

A parallel plate capacitor of area S, plate separation 2d and capacitance C is filled with four dielectric materials as shown in the figure. The permittivity of each material (εa, εb, εc and εd) is shown in the figure. If a single dielectric material with permittivity ε is to be used for one parallel plate capacitor to have the identical capacitance as this capacitor, determine an expression of ε in terms of εa, εb, εc and εd. Show all your working.



Answer:

Step1: Observing the plot, we are able to find that the materials a, b, c are in parallel, and the material d is in series with the unity of a, b, and c.

Step2: Calculating the equivalent capacitance for each unity.

- ✧ For the material d unity

$$Cleft = Cd = \varepsilon d * s/d$$

- ✧ For the unity of materials a, b and c

$$Ca = \varepsilon a * s/3d$$

$$Cb = \varepsilon b * s/3d$$

$$Ca = \varepsilon c * s/3d$$

We know that the three materials are in parallel, by the formula of paralleled capacitors

$$Cright = Ca + Cb + Cc = (\varepsilon a + \varepsilon b + \varepsilon c) * s/3d$$

- ✧ The two unities are in series, by the formula of paralleled capacitors:

$$Ctotal = (Cleft * Cright)/(Cleft + Cright)$$

Take the unity of $Cleft\ and\ Cright$ into the equation above.

$$Ctotal = (Ca + Cb + Cc) * Cd/[(Ca + Cb + Cc) + Cd]$$

Then, take the value of Ca, Cb, Cc, Cd

$$Ctotal = \frac{\frac{s}{3d} * \varepsilon d * \frac{s}{d} * (\varepsilon a + \varepsilon b + \varepsilon c)}{\varepsilon d * \frac{s}{d} + \frac{(\varepsilon a + \varepsilon b + \varepsilon c)}{3} * \frac{s}{d}}$$

$$Ctotal = (\frac{s}{d}) * \frac{\varepsilon d * (\varepsilon a + \varepsilon b + \varepsilon c)}{3\varepsilon d + (\varepsilon a + \varepsilon b + \varepsilon c)}$$