

Lab 2. Electric Fields and Potentials

INTRODUCTION:

In class we have learned about electric charges and the electrostatic force that charges exert on each other. Another way of looking at this is to recognize that every charge creates an electric field all around it. When a *second* charge is placed in the electric field, it feels a force – but the field from the original charge is always there, whether or not it is acting on any other charges. In today's lab we'll explore the electric fields around charges, the electric potential produced by charges. The goals are to gain some intuition about the electric fields and potentials surrounding individual charges, and to learn how to add electric fields and potentials from multiple charges.

PART I: ELECTRIC FORCES AND FIELDS

You should have a number of diagrams, printed on paper and transparency foil, of the electric field distribution and the electric potential in the space around a single point charge (either positive or negative). Let's start with the **electric field** vector plots. Describe as many details about the field patterns as you can notice. Describe both the positive and negative charges.

In general, how does the electric field relate to the electric force felt by a charge?

In each of the figures below, draw a vector representing the **net force** felt by the **dark-colored charge**. Draw the vectors to scale, so that longer arrows represent larger forces. Assume all single charges have the same magnitude.

1.



2.



3.



4.




5.

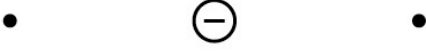



6.





In each of the figures below, draw a vector representing the **electric field** at the dot. Draw the arrows to scale, so that longer arrows represent stronger fields.


1. 

2. 

3. 

4. 

5. 

6. 

PART II: SUPERPOSITION OF ELECTRIC FIELDS

A. Overlay a transparency foil over a paper diagram, so that you can see two sets of **electric field** vectors – one set from each of two point charges. Describe the *total* electric field surrounding the charges if a **positive** charge is placed *exactly on top of* a **negative** charge. Is this similar to any situation found in nature?

B. Using a pair of electric field vector diagrams for two charges of **opposite** sign, offset the transparency relative to the paper (by some **even** number of grid spacings), and lay a piece of tracing paper over the whole thing. On the tracing paper, mark the location and sign of the charges. At each grid point, draw an arrow which represents the **total** electric field at that point.

Where is the field the strongest? Where is it the weakest? Does it go to zero anywhere? Are there any other noticeable details?

C. Repeat part B for two charges of the **same** sign.

Where is the field the strongest? Where is it the weakest? Does it go to zero anywhere? Are there any other noticeable details?

PART III: SUPERPOSITION OF ELECTRIC POTENTIALS

In the previous section, you used the **principle of superposition** to find the total electric field at a number of points. This just means that at any given point, the **total** electric field is equal to the **vector sum** of the electric field produced by each charge.

The same principle applies to electric potential. Namely, the **total** electric potential at any given point is equal to the **sum** of the electric potentials produced by each charge. (Remember that electric potential is a **scalar**, not a vector.)

A. Now using the electric potential diagrams, overlay a transparency foil over a paper diagram, so that you can see two sets of equipotential curves – one set from each of two point charges. Describe the *total* electric potential surrounding the charges if a **positive** charge is placed *exactly on top of* a **negative** charge. Does this make sense?

B. Using a pair of electric potential diagrams for two charges of **opposite** sign, offset the transparency relative to the paper (by some **even** number of grid spacings), and lay a piece of tracing paper over the whole thing. On the tracing paper, mark the location and sign of the charges. Find an **intersection** between two curves, and mark the **total** electric potential at that point on your tracing paper. Repeat this for 10-15 points, or enough so that your paper contains sufficient information to roughly describe the potential surrounding the two charges. Find any dots that have the same total charge, and connect them to create **equipotential curves** (curves where every point on the curve has the same potential).

Where is the potential the highest? Where is it the lowest? Does it reach zero anywhere? Are there any other noticeable details?

PART IV: SUPERPOSITION OF ELECTRIC POTENTIALS (REVISITED)

Go to the “Charges and Fields” simulation web-site (your TA will write the address on the board). Here you can place positive and/or negative charges wherever you like on the screen, and see the resulting potentials.

A. Start with one charge: Drag a positive charge from the red box to the middle of the screen. Make sure that the check-boxes on the lower-right panel are *unchecked*. If you were to plot equipotential lines around this single charge, what would they look like?

B. Now drag the green “equipotential” box to various places on the screen and press the “equipotential” button. This will draw an equipotential line that indicates everywhere on the page that has the same electric potential as the location of the crosshairs.

C. Now try two charges: Drag a second positive charge from the red box to a location an inch or two away from the first charge. All of the previously-drawn equipotential lines should disappear – this is because the potentials around the charges are now different. Create 10-15 new equipotential curves around these two positive charges. Do the patterns look like what you drew on paper? If not, why not?

D. Repeat part B for two charges of **opposite** sign. Where is the potential the highest? Where is it the lowest? Does it reach zero anywhere? (Hint: check the “show numbers” check-box in the lower-right panel).

What is the difference between this case and the previous case? (Hint: check the “show numbers” check-box in the lower-right panel and investigate both cases – two like charges and two opposite charges).

PART V: SUPERPOSITION OF ELECTRIC FIELDS (REVISITED)

A. Drag a positive charge from the red box to near the left side of the screen. Check the "Show E-field" box only. Notice that the strength of the field is indicated by the darkness of the arrows, rather than the arrow length as on your paper.

Now drag a negative charge to near the right side of the screen. Is the electric field pattern similar to what you drew on paper? If not, why not?

B. Leave the two opposite charges and the electric field distribution showing. Now draw about 10 equipotential lines over this charge distribution. Do you notice anything about the direction of the electric field arrows and the equipotential curves that they cross?

C. Repeat parts A & B, but now with two charges of the same sign. Describe the differences between the two cases.

POTENTIAL EXAM QUESTIONS:

1. Which of the following statements is/are true?

- a) If the electric field is zero at some location, the electric potential must also be zero.
- b) If the electric potential is zero at some location, the electric field must also be zero.
- c) Electric field vectors point in the same direction as equipotential lines.
- d) Both (a) and (b) are true.
- e) None of the above are true.

2. Which of the following statements is/are true?

- a) The electric field is zero at the midpoint between two negative charges of equal magnitude.
- b) The electric field is zero at the midpoint between a positive and a negative charge of equal magnitude.
- c) The electric potential is zero at the midpoint between a positive and a negative charge of equal magnitude.
- d) Both (a) and (b) are true.
- e) Both (a) and (c) are true.