Circle your lab day and time.

Your name: ______________________________

TA name: ______________________________

Mon	Tue	Wed	Thu	Fri
8-10	10-12	12-2	2-4	4-6

Lab 3: Electric Potentials

INTRODUCTION

The electrostatic forces on charges will do work if they move the charge from one point to another. In this respect, electrical forces are no different from the mechanical forces we studied earlier. In everyday life we often focus more on the work that electrical forces accomplish and less on the forces themselves. Using the electric field picture, we would say that a charge in an electric field would experience a force and this force would do work on the charge if it moves. This work would change the energy of the charge, and we describe the change in energy in moving from one point to another in an electric field as a change in the **electrical potential energy** between the two points. Since work is a simple scalar with a magnitude but no direction, the same is true for the electrical potential energy. It turns out that the work done in moving between two points in an electrostatic field is independent of the path that is traversed, so that the electrical potential energy difference between two points is characteristic only of the points themselves. (Recall that the same thing was true for gravitational potential energy.) The goal of today's lab is to explore the electric potentials surrounding individual charges and between charged plates as well as the superposition of potentials from multiple charges.

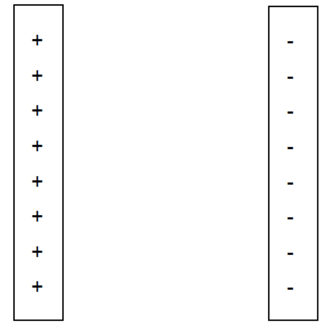
PART I: ELECTRIC POTENTIALS

A. In the lab, you should have diagrams, printed on paper and transparency foil, of the electric potential in the space around a single point charge (either positive or negative).

- Describe as many features of the electric potential of a single point charge you notice.

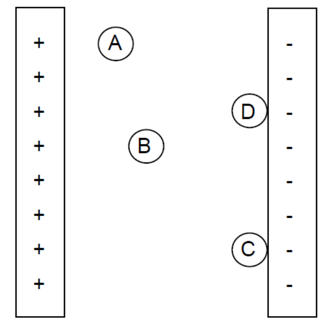
- Which of these features depend on the sign (+ or –) of the charge? Give an explanation.

- How will the electric potential change if the magnitude of the charge is doubled?



B. Now consider two (long) parallel plates, the left one charged positively and the right one negatively (see figure). Assume that both charges have the same magnitude. Equipotential curves connect points of the same potential. They are similar to contour lines on a topographical map, which connects points of the same elevation, and to isotherms (lines of constant temperature) on a weather lab.

- Draw equipotential curves in the space between the two plates.



C. A positive charge is placed at position A between the two plates (see right).

- State the increase/decrease in potential energy of the charge if it is moved from:

  (a) A to B (b) B to C (c) C to D

- How much work is done to move a charge along an equipotential curve?

PART II: SUPERPOSITION OF ELECTRIC POTENTIALS

The superposition principle applies also to the *electric potential* (which is also called *voltage*). Namely, the **total** electric potential at any given point is equal to the **sum** of the electric potentials produced by each charge: $V_{tot} = V_1 + V_2 + ...$ (Remember that electric potential is a **scalar**, not a vector.)

A. 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 III: SUPERPOSITION OF ELECTRIC POTENTIALS (REVISITED)

Go to the simulation web-site (http://phet.colorado.edu/simulations), select under “Physics” the section “Electricity, Magnets and Circuits” and then run the “Charges and Fields” simulation. 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?

Check your result by dragging the “equipotential” box to various places on the screen and press the “plot” button. This will draw an equipotential contour line that has the same electric potential as the location of the crosshairs.

B. 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?

C. 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).

POTENTIAL EXAM QUESTIONS

You may want to use the rest of the lab for an optional exam review. The following questions are not part of the lab; **you won't be graded on the answers**. Questions like these – but not identical – may appear on the exam. Feel free to discuss the questions and your answers with your classmates or the instructors.

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

a) It is possible to charge up a steel ball *positively* using a *positively* charged plastic rod and a grounding plate.

b) It is possible to charge up a steel ball *negatively* using a *positively* charged plastic rod and a grounding plate.

c) Both statements (a) and (b) are true.

d) Neither statements (a) nor (b) are true.

1. Two point charges Q_1 = 50μC and Q_2 = 3μC are separated by a distance of 2 m. Which of the following statements is/are true?

a) The force F_{12} that Q_1 exerts on Q_2 is larger than the force F_{21} that Q_2 exerts on Q_1.

b) The force F_{12} that Q_1 exerts on Q_2 is smaller than the force F_{21} that Q_2 exerts on Q_1.

c) Both forces, F_{12} and F_{21}, have the same magnitude.

d) The ratio of the forces F_{12}/F_{21} depends on the magnitudes of Q_1 and Q_2.

e) The ratio of the forces F_{12}/F_{21} does not depend on the magnitude of l.

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

a) The electric potential is a vector.

b) Electric potential has the dimensions of energy.

c) Both statements a) and b) are true.

d) Neither statement a) nor b) is true.

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

a) The electric potential is zero at the midpoint between two negative charges of equal magnitude.

b) The electric potential is zero at the midpoint between two positive charges of equal magnitude.

c) The electric potential is zero at the midpoint between a positive and a negative charge of equal magnitude.

d) Only c) is true.

e) None of the above statements is true.