

Name: _____

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Pre-Lab 5: Electric Potential

Pre-Lab Due 5/14

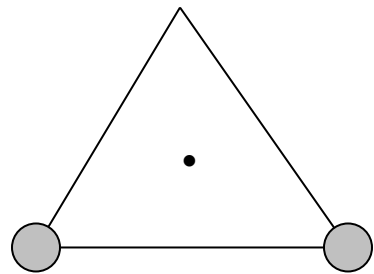
The pre-lab questions are to be answered using the provided template. Only the pre-lab work needs to be digitized into PDF format and uploaded to gradescope.com by the due date.

1. A positive test charge is released at point A and accelerates to point B . Is the potential difference $V_B - V_A$ positive or negative? Explain your answer.

2. You would like to produce an electric field of 640 N/C in the region between two parallel plates that are separated by a distance of 0.16 m . What voltage would you need to connect across the plates?

3. Give an example of a situation for which $\mathbf{E} = 0$ but $V \neq 0$.

4. (a) Positive charges $+Q$ and $+Q$ occupy two of the vertices of an equilateral triangle. What charge should be placed at the third vertex such that the total electric field at the center of the triangle is zero?



(b) What charge should be placed at the third vertex to make the total electric potential zero at the center of the triangle?

Lab 5: Electric Potential

I. Mapping Electric Fields

In this activity you will map the equipotential lines for various charge distributions. You will construct (draw) the electric field lines associated with these equipotential plots.

A plastic tray is filled to a depth of about 1/4" with tap water and two electrodes are placed in the tray. When a potential difference V is placed across the electrodes, an electric field is established in the water. Since the water is conducting and air is not, the electric current will always be parallel to the water surface. Likewise, the electric field in the water must be parallel to the surface of the water. This allows us to treat the water and electrodes as a purely two-dimensional system. There *are* electric fields in the air outside the water tank, but our test probe in the water won't measure them nor be affected by them.

As mentioned in Lab 2, we don't have a probe and device to measure the electric field, but we can easily measure potential with a voltmeter. With the voltmeter and its probe, you will map out the lines of constant potential – the *equipotential lines* - in the water surrounding the electrodes. If you find, for example, a point in the tank where the potential is 4.0 V, you can then move the probe around and find the pattern of points in the tank that are all at that same 4.0V. By doing this for several voltages between 0 V and 10 V, you can trace out a map of the equipotential surfaces for your given electrode configuration. You will make a scaled drawing of your map on graph paper. From your drawing of equipotential lines, you will draw the corresponding electric field for your electrodes.

For this set-up, we are actually applying an AC (alternating-current) voltage to the electrodes in the water tank, it's set-up so that one of the electrodes will be at +10 V and the other at 0 V.

The electric field is related to the potential by

$$E = -\frac{\Delta V}{\Delta l} \quad (1)$$

where ΔV represents the potential difference between neighboring equipotentials (which will be 1 volt for these experiments) and Δl is the distance between the equipotentials. The minus sign in these equations means that the electric field vector points in the direction of *decreasing* V . That is, a positive charge accelerates from a region of higher potential to a region of lower potential, something like a ball rolling downhill from a point of higher gravitational potential (energy) to a point of lower gravitational potential (energy). E has its maximum value when Δl is measured perpendicular to the equipotential surfaces, as Δl is the smallest it can be in that direction. This direction will also be the direction of the electric field. Recognize from Equation 1 that when the equipotentials are closely spaced (Δl is small), E will be largest and vice versa.

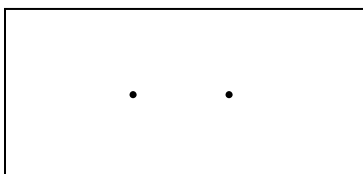
PROCEDURE:

Part 1. For the following geometries, plot the equipotentials 1 V through 9 V by taking readings with the meter probe and transferring the positions to a sheet of graph paper. Do this carefully to scale, and be sure to draw the locations and shape of the electrodes. For example, “fish” around until you find a 1.0 V point. Then move the probe slowly, finding all the points that measure 1.0 V. They will lie along some line (curved or straight depending on the electrode configuration). Draw this line to the proper scale on your graph paper. Repeat for multiples of 1.0 V up to 9.0 V. Recognize that 0 V will be one electrode; 10 V the other. Note that in practice, it may be difficult to find either the highest or lowest equipotentials (near the point electrodes, for example) so you may have to start at 2 or 3 V and end before 9 V. Keep the probe vertical, pointing straight down into the water in the tank. The main goal here is to get a general feel for the different configurations and their equipotential maps. If you pay attention to the symmetry of the configuration, you can significantly reduce the number of data points you need to take in order to make a good map plots.

Sketch the electric fields lines for each configuration, making them perpendicular to the equipotential lines at each point where they cross an equipotential line.

Use the following geometries and make the associated observations:

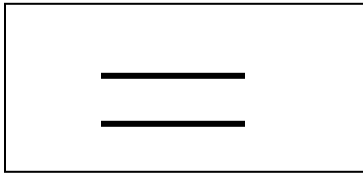
(1)



Point electrodes in water, separated by about 6 inches.

This configuration shows the equipotentials produced by two point charges. Convince yourself that the electric field is strongest along the line connecting the two points since the fields from the two points add together (as vectors) in this region. Conversely, along a vertical axis, but far away from in between the two points, the electric fields from each point are most subtractive. The total electric field must therefore be weaker in these regions.

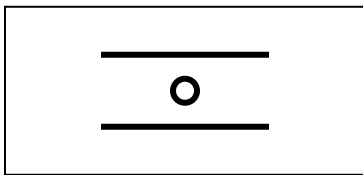
(2)



Long straight electrodes, separated by about 4 inches.

Convince yourself that the electric field in the region between the two parallel electrodes is constant to a good approximation. Note that "fringe" fields occur near the ends of the electrodes and give fields similar to those from two point sources.

(3)



Geometry of part 2 but with a hollow conducting cylinder between the two electrodes.

When you draw the field lines for this case, note that they converge toward the conducting cylinder. Convince yourself that this implies that charge polarization is being induced on the cylinder. Observe that all points within the cylinder are at the same potential as well the cylinder itself. Convince yourself that means that the electric field within the hollow part of the cylinder must be exactly zero. This shows the principle of electrostatic shielding.

II. A Quantitative Look at Charged Parallel Plates

For geometry 2, the parallel "plates", take careful measurements of the physical locations of the equipotentials. Do this near the center of the parallel plates, perpendicularly to the plate and equipotential lines. Measure the distance l from one of the "plates" to each of the equipotential lines. Record the data in the table provided. Do the calculations shown at the heading of each column.

We are interested in the functional relationship between V and l for charged parallel-plates. The electric field between charged parallel plates should be uniform (*very* uniform.)

Data Table – Electric Potential and Electric Field

Name _____

Partners _____

Parallel-plate geometry

i	V_i	l_i	$\Delta V = V_{i+1} - V_i$	$\Delta l = l_{i+1} - l_i$	$E = -\Delta V/\Delta l$
1					
2					
3					
4					
5					
6					
7					
8					
9					

1. Do your electric field calculations show that the electric field is uniform between your parallel plates? What do you expect to see from this calculation? Did you see that?

2. For the parallel electrodes in your tank, how would you move them to increase the electric field strength between the plates? Would that change the potential values measured in between the plates? How would the equipotential lines be different? (If they are different.)