

PH102 Lab I: Equipotential and Field Lines

Needed:

- 1 laboratory box
- 3 banana cables, rounded ends

- 1 banana cable, probe end
- 1 plastic tray with one plastic sheet of graph paper
- 1 flat conductor
- 2 non-flat conductors

Introduction

One basic problem in electrostatics is the determination of the electric potential distribution (and thus the electric field) between two conductors. That is, given two conductors at different voltages, what is the voltage at various points between them? The solution clearly depends strongly on the shapes and separation of the two conductors, and can be determined mathematically by applying the laws of physics and supplying the values of the voltage on each conductor. This is well beyond the scope of this course, but we can still get some qualitative predictions from the physics and compare them to actual measurements that we will make in this lab.

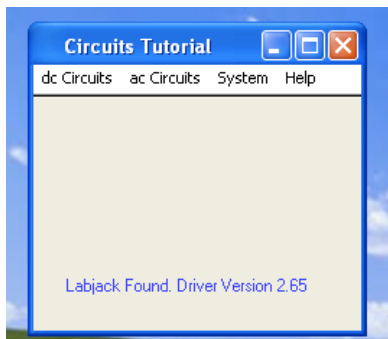
To measure a potential distribution, one might imagine applying the proper potentials to the two conductors and measuring the potential everywhere. Unfortunately, electrostatic potentials are very difficult to measure, and any measuring instrument will likely distort the field hopelessly. Our measurement is based on the fact that in a uniform medium the potentials arising from current flow (a nonstatic situation) between two electrodes satisfy the same mathematical equations as does the electrostatic potential. As a result, a two-dimensional electrostatic potential distribution can be simulated by the potential distribution resulting from the current flow among given conductors lying in a shallow tray of electrolyte, in our case ordinary tap water.

Preliminary Problems

Sketch the equipotentials and field lines for:

(a) parallel conducting plates

(b) an electric dipole



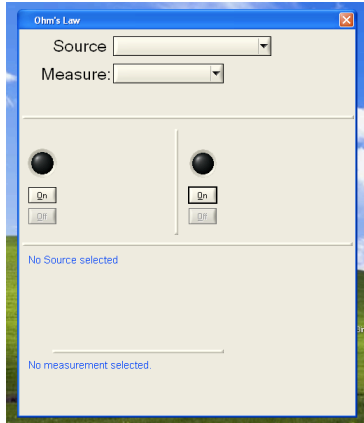
Procedure: Starting the Software

(1) From the Start menu / All Programs, open “A Circuits Tutorial.” You should see a window like the one at left.

If you see “Labjack Found” on the window, everything is functioning properly. If your window says “Demo Mode” on it, ask for assistance.

(2) From the “dc Circuits” menu, select “Multimeter.” This should bring up a new window like the one below (next page).

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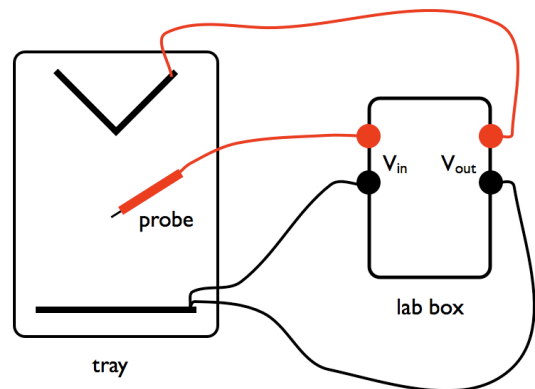
- (3) From the “Source” pull-down menu, select “Voltage”
- (4) From the “Measure” pull-down menu, select “Voltage.”

Procedure: Setting up the Hardware

Place a sheet of graph paper in the bottom of the tray and put about 1/4 inch of water in the tray, which should be as nearly level as possible. Place your conductors in the tray in the configuration shown at left. Start with one flat conductor and one right-angle conductor.

Connect the electrodes to $+V_{out}$ and $-V_{out}$ on your lab box. Make the flat electrode negative (connected to $-V_{out}$, black terminal). This will supply the potential difference between your two electrodes.

To measure the potential difference at various positions, we need one point as a reference, the flat conductor. Connect a second wire from the flat conductor to the $-V_{in}$ terminal on your lab box to serve as the reference point. We will use the $+V_{in}$ terminal to measure the voltage at various points between the two electrodes, so connect your probe wire to the $+V_{in}$ terminal.



Procedure: Beginning the experiment

The source voltage we will use is 5V. From the “Multimeter” window, set the voltage output to 5.0V (maximum) and press the “on” button.

In order to measure the voltage at various points, click the “on” button on the “Voltage Measurement” portion of the multimeter window. Place your probe wire (connected to $+V_{in}$) somewhere in the tray of water between the two electrodes and double click the “on” button. The needle gauge on screen should now be reading a value somewhere between 0 and 5V.

To trace the equipotential, place the probe vertically in the water, and move the probe until the voltmeter reads the desired potential (e.g., 2.0 volts). Read the coordinates of the probe location from the graph paper, have a lab partner plot the point on a dry sheet, and move the probe to a new location on the same equipotential. Once an equipotential has been traced over the desired region, repeat the process for a different potential.

Plot equipotentials at 0.5-volt intervals, 0-3V, from one electrode to the other. Near the conductors, it is recommended to use a finer voltage spacing to accurately reproduce the behavior of the equipotential lines. Using these equipotentials, sketch the electric field lines, which are perpendicular to the equipotentials. Do this for two differently shaped sets of electrodes.

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Laboratory Report Form

Names:

Date:

Data

For each of two sets of differently shaped electrodes, trace out and plot the equipotential lines at approximately 5-volt intervals on a sheet of graph paper. Close to an electrode, a finer voltage spacing is recommended to better see how the equipotential lines behave near a conductor.

Analysis and Questions

1. For each set of equipotential lines, sketch the electric field lines on the same plot.
2. At which points are the equipotential lines closest together? Farthest apart? What does this imply about the value of the electric field at these points
3. Calculate approximate values of the electric field at the places where it is strongest / weakest.
4. Discuss the symmetry of the equipotential lines and compare with the symmetry of the conductors. Why do the equipotential lines near the electrodes tend to follow the shape of the electrodes?