Lab 3 Electric Field Plotting Experiment

Instructions:

This experiment involves the calculation of the electric field pattern around and between a pair of metal electrodes of various shapes, embedded in a semi-conductive sheet medium to facilitate measurements of electrical potential, and maintained at a fixed potential difference (approx. 1.5 volts). Three different electrode configurations will be investigated.

The electric field direction pattern can be deduced for each electrode pattern from the measurements of the voltage V (measured relative to the value at the negative electrode) at a representative selection of grid points on the semi-conductive sheets.

For data taking, after the experimental apparatus is set up according to the instructor's directions, start up the Netscape Navigator browser on the desktop computers and point the browser to the URL given by the lab instructor and follow the on screen directions to enter the voltage data into the on-screen data table. Even though the voltages will typically be in the range of 1.5 to 0 volts, enter the data in <u>hundredths of volts, and round off to the nearest hundredth of a volt</u>, e.g.. enter the reading 1.227 volts as 123 , and the reading of 0.356 volts as 36. The instructor will demonstrate the use of the digital voltmeters used to make the measurements.

Items to include in analysis

1. Select one sample grid point from each of the three electrode configurations and reproduce **in detail** the computer calculation of those electric field angles from the grid point voltage measurements, using the following finite-difference approximation formula for the electric field vector angle $\theta_E(x,y)$ at the grid point (x,y):

    where

    with

1. For the case of the dipole electrode configuration calculate the theoretical electric field angle at the same grid point analyzed in the preceeding step, based on assuming a point charge +q at the grid point (8,10) and a point charge -q at the grid point (8,2). Apply the Superposition Principle and the formulas below based on Coulomb's Law :

    Since the angle of **E** at (x,y) doesn't depend on the magnitude of q assume kq=1 in your calculations. At the previously chosen grid point (x,y) calculate the contributions to **E** using the preceeding equations. Then add the vectors and find

the direction of the resultant. Compare the theoretical model results with the previous calculations based on the voltage measurements. Express the degree of agreement or disagreements quantitatively (% difference). In what respects do the model on which the calculations in step 2 above differ from the actual situation?

1. According to the definition of the electric field, equipotential lines should be everywhere perpendicular to the electric field lines. You will now test this for the electric field pattern you generated with one of the electrode configurations. You can do this to a good approximation by using linear interpolation to locate coordinates in the selected electrode sheet of points that correspond to the same potential or voltage.

   A. Using the voltage data grid from one of the 3 cases, record the voltage reading at the point (8, 4).
   B. Using linear interpolation, calculate the vertical coordinate of the point in the $x = 6$ column that should have the same potential as that recorded in the previous step. The procedure will be illustrated in class by the instructor. Record.
   C. Repeat the previous step (B) for the columns $x = 4$, and $x = 2$. Then use the left- right symmetry of the electrode configuration to generate the vertical coordinates for the columns $x = 10$, $x=12$ and $x = 14$. Record.
   D. On your printout of the electric field map for the same electrode case, plot in the equipotential points which you have calculated in the previous steps A-D.
   E. Trace in the simplest smooth curved line which seems by inspection to be a best fit to the plotted equipotential points.
   F. Repeat steps A-E for the equipotential lines passing through (8,6), and (8,8).

   Now, inspect the equipotential lines you have just drawn in relation to the underlying electric field vectors. Make a qualitative assessment of the degree to which the electric field vectors cross the equipotential lines at right angles, as they are theoretically supposed to do.