ELECTRIC FIELDS SIMULATION

OBJECTIVE: To "see" the electric field generated by a single charge, and to "see" the electric field in space due to several charges.

THEORY: The **magnitude** of the electric force between two charges can be mathematically described by: $\mathbf{F = k\,q_1 q_2/r^2}$ where F is the force, k is a constant that depends on the units used and reflects the strength of the electric force, q_1 and q_2 are the two charges, and r is the distance between the two charges. Since force is a vector, it must have a direction. The direction is determined by the two charges according to the following rule: like charges repel, unlike charges attract.

But what actually CAUSES the electric force? We can think of the following: each charge sets up in space a "field". When another charged particle enters the space, the "field" actually acts on the charge. To be consistent with the electric force mentioned in the above paragraph, the electric field for a point charge must have the **magnitude** of $\mathbf{E_1 = k\,q_1/r^2}$ and the **direction** must **point away from a positive charge (and toward a negative charge)**.

When several charges are in the same area of space, the electric field at any point is merely the **(vector) sum** of the fields due to the individual charges. This is where the computer can be used. It can calculate the individual fields at any point and add them as vectors to find the fields at the different points.

PROCEDURE:

Part 1. Plotting Electric Fields by Hand:

1. a) On a blank sheet of paper, position a charge somewhere near the middle of the page. Assume this charge has a magnitude of 3 nCoul.

   b) Now locate a point one centimeter above the charge, and calculate the electric field at that point. Draw an arrow at the point in the direction of the electric field at the point and make the length of the arrow such that 1 mm corresponds to 1×10^4 Nt/Coul.

   c) Repeat part b for the following locations:
   - (1) 5 cm to the left of the charge;
   - (2) 10 cm below the charge.

2. On another blank sheet of paper, position two charges (one of +3 nCoul and one of -3 nCoul) somewhere near the middle of the page and about 8 cm apart. Calculate the electric field and draw electric field arrows at the following positions:
   - (1) 5 cm above the left charge;
   - (2) 8 cm above the midpoint of the line connecting the charges;
   - (3) 5 cm above the right charge.

Part 2. Getting Started with the Microcomputer:

1. Turn the monitor on and then turn the computer on (if they are not already on).

2. Double click on the 'ESIML17' icon on the desktop.

3. There should be an Electric Field Simulation Plot menu on the screen.
Type **I** to see the introduction which explains the idea behind the routines to be executed.

4. After you have read the introduction, you are ready to begin. Type **B** to begin the routines.
Then type **NEW** as instructed. *If you have exited either voluntarily or not and wish to continue with your plots, then do not type B, but rather type either A to add a new plot or type E to edit a plot you have already worked on.*

5. Now you are ready to enter in the charges which we will do in Part 3 below.

Part 3. Plotting Fields:

GRAPH #1. The first electric field we will investigate is that due to a **single positive charge**.
Enter in the value of the charge as some positive value (usually 1) and press ENTER. Then position the charge at point x=0 and y=0, which is at the center of the screen. (The instructions on how to do this are on the computer screen: enter 0 and press ENTER for the x, and then enter 0 and press ENTER for the y). When the computer asks for the next charge, type **P** and ENTER to start the plotting routine. Specify the starting field point somewhere near the positive charge. Do this for several points until you get a good idea of what the field looks like.
        I suggest for this part that you have your partner indicate a point somewhere on the screen and see if you can enter in the x and y coordinates of that point. After you enter the coordinates, the computer will start drawing the electric field line starting at that point so you can see if you were close to where your partner indicated.
        After you are familiar with the screen and the electric field due to one point charge, then instead of entering a new x coordinate for the next field line, type **Q** and press ENTER to quit the plot. The computer will ask you if you wish to save the plot or not. Save the plot as instructed. The computer will return you to a new screen ready for your next set of charges.
We will look at all of your saved plots at the end of the lab.

GRAPH #2. Specify **two positive charges (equal in magnitude)** somewhere on the screen - not too far apart and not too close together. Then see what the field looks like for this pair of charges. At the end the computer will save this picture and we will look at it later. (Can you tell by looking at the plot that the charges are the same magnitude?)

GRAPH #3. Next choose **one positive and one negative charge (same magnitude)** and plot the field. (Can you tell by looking at the plot that the charges are the same magnitude?)

GRAPH #4. Now choose **two charges** (either same or opposite signs) but **let one charge be at least twice the magnitude of the other**. Plot the field. (Can you tell just from the plot which charge is the larger charge?)

GRAPH #5. This time put **five positive charges all of the same magnitude in a line above the center of the screen and put five negative charges all with the same magnitude in a parallel line a little below the center**. (This is somewhat like parallel plates, an important special case we will consider later.)

Additional plots: **(reminder: the program holds only 9 graphs)**

GRAPH #6. This time choose **whatever charges you wish** and place them wherever you wish on the screen and see what the field looks like.

GRAPH #7. **Again choose charges** and observe the resulting field. (I suggest that you use both positive and negative charges, and that you make the charges vary greatly in magnitude.)

If time and interest permit, try creating one or two more plots of electric fields as you did for graphs 6 and 7.

REPORT:

1. After you have saved your last plot, then type **E** to exit from the next picture. You will be returned to the main menu for the program. You can now choose to edit any graph you have already worked on, or you can choose to review your set of graphs. Review your graphs yourself.

2. Now call your instructor over and review the graphs together.

3. After you have successfully completed the lab, exit the program by typing **X** to end and erase your graphs as prompted by the computer.