PHYS 1402
General Physics II

EXPERIMENT 1B
ELECTRIC FIELD MAPS

OBJECTIVE
The objective of this experiment is to draw maps of the electric fields of three charge configurations. This is done by drawing the equipotential lines (lines of equal potential) of these charge configurations. The electric field lines are then drawn such that they cross the equipotentials at 90° angles.

INTRODUCTION
The concept of field lines is very useful in visualizing electric (and magnetic) fields around charges or charged objects. An electric field line, called a line of force, is an imaginary line drawn such that its direction at any point is the direction of the electric field at that point. The line starts at a positive charge and terminates on a negative charge.
By definition all the points on an equipotential line have the same potential. This implies that no work is required to move a charge from one point to another point on the same line and hence equipotential lines are perpendicular to the electric field lines everywhere. So you will draw the equipotentail lines first and then draw a number of electric field lines going from the positive charge to the negative charge and crossing the equipotential lines at right angles.
The following are the important properties of electric field maps:

1. The number of lines crossing an area at right angles is proportional to the strength of the field. In other words where the lines are crowded, the field is strong and where the lines are sparse, the field is weak.

2. The electric field vector is tangent to the electric field line at each point.

3. No two electric field lines can cross or touch each other.

4. The number of electric field lines leaving a positive charge or approaching a negative charge is proportional to the magnitude of the charge.

APPARATUS
Electric field mapping set with probes, high resistance conducting paper with silver paint applied to it to form two electrodes, 1.5 volt battery, galvanometer and coordinate paper.

EXPERIMENTAL PROCEDURE

procedure (1)

1. Assemble the electric field mapping apparatus as shown below by placing the high resistance conducting paper on the board and connecting the battery to the silver electrodes. This establishes a potential difference of 1.5 volts between them. On your graph paper, draw two electrodes the same size and at the same location as the electrodes on the conducting paper. Mark the positive (+) and negative (-) electrodes.
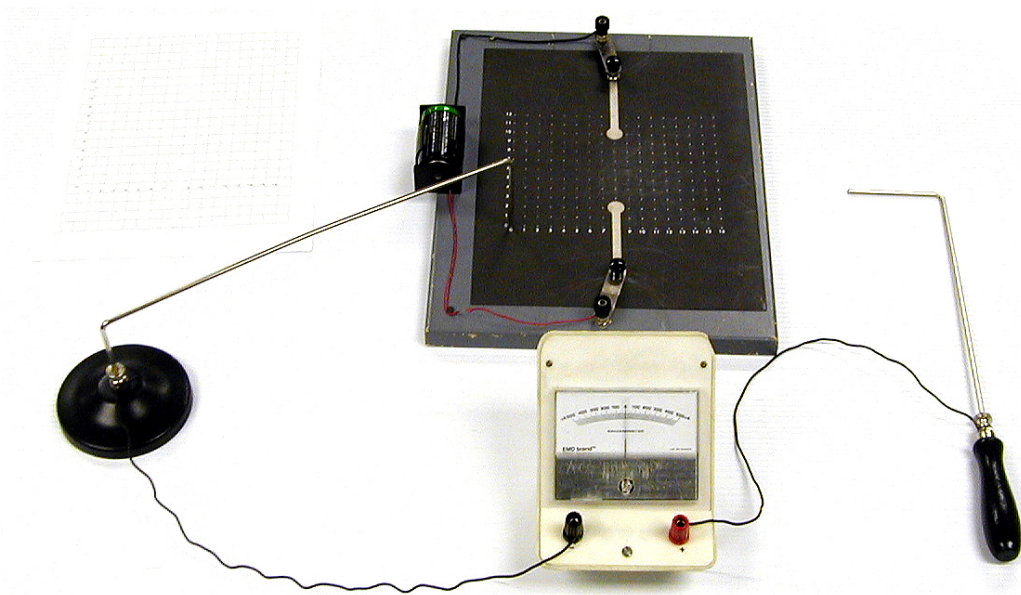

Figure 1: Field Mapping Apparatus

2. Call the axis with 12 marks the y-axis and the one with the 16 marks the x-axis. Place the stationary probe (the one with the base) at the (0,0) point.

3. Move the other probe (hand held) in the vicinity of that point (about 2 cm away) until you find a point where the galvanometer reading is zero. This indicates no current between the two points on the conducting paper and therefore they are at the same potential. Mark this point on your graph paper.

4. Keeping the stationary probe at (0,0), repeat the above process finding points where the galvanometer reading is zero marking these points on your graph paper until you have found eight points. Connect these points with a smooth line. This is an equipotential line.

5. Move the stationary probe to (0,3) and find a second equipotential line (8 points).

6. Repeat the above process by placing the stationary probe at (0,6), (0,9) and (0,12) and finding an equipotential line for each setting. Your map should have 5 equipotential lines. You will draw the electric field lines later.

7. Repeat the entire procedure for the other charge configurations.

procedure (2): optional
Theoretically for the charged parallel plate configuration, if the plates are very close to each other, the electric field points from the positive plate to the negative plate, is uniform and perpendicular to the plates. You can test these assumptions by showing the electric field component perpendicular to the plates varies by a negligible amount as you move from one plate to the other plate and that it is much larger than the electric field component parallel to the plates.

1. For the parallel plate configuration, use a voltmeter to measure the potential difference between two points (away from the edge) which are 1 cm apart in the direction perpendicular to the parallel plates. Do not set the voltmeter leads on the silvered points. Do this measurement for six different pairs of points which are 1 cm apart starting with points close to one of the plates and proceeding to the other. Find and approximate value for E_y for each case in (V/m)

$$|E_y| \simeq \frac{\Delta V}{\Delta y} \tag{1}$$

and see how much variation is there in the magnitude of E_y. Would you agree that the electric field is uniform?

2. Measure the potential difference between two points near the center which are 5 cm apart in the direction parallel to the parallel plates. Find an approximate value of the electric field in this direction (in V/m)

$$|E_x| \simeq \frac{\Delta V}{\Delta x} \tag{2}$$

ANALYSIS:

1. For each charge configuration, you should draw seven (7) electric field lines distributed around the map. Each line must cross every equipotential line at right angle.

2. Starting at the positive charge, draw smooth lines (curves) crossing the equipotentials at right angles and terminating on the negative charge. Place an arrow on the field line to indicate direction. Use two different colors to distinguish between equipotential lines and electric field lines.

3. Write a conclusion summarizing your results. Comment on the success of this experiment. Do the electric field maps you drew look like the ones you have studied in the textbook? Recall that an electric field line is a line along which a positive charge would move from a point of high potential to a point of low potential. Do the field maps seem to be in agreement with this idea? What do you think are the two most important sources of error?