Electric Fields*

Object

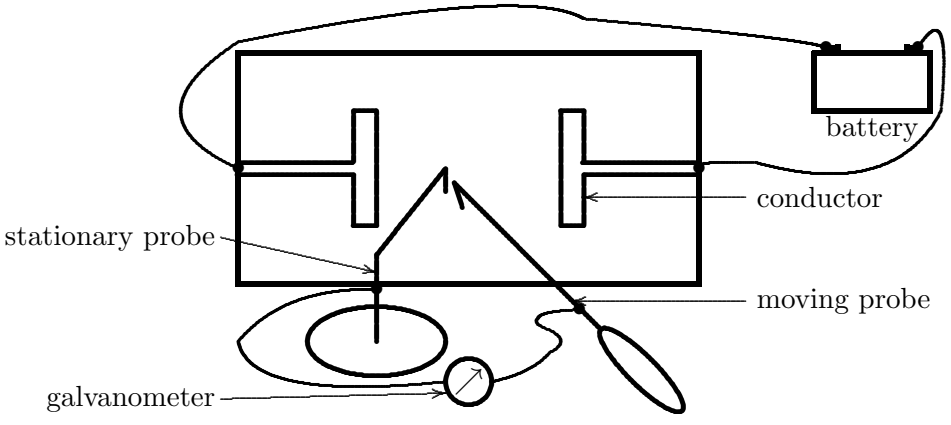
To determine electric field directions around some distributions of charge.

Theory

It is known that the direction of the electric field is the direction that a positive charge prefers to move in. If constrained in some way, the charge may move in some other directions; but it still prefers to move in the direction of the electric field. We shall use this simple principle to find directions of electric fields at various points around a collection of charges.

The measurement methods

The setup available in the lab has two clamps that are connected to the positive and negative ends of a battery. Some black colored sheets (slightly conducting) are also provided. Each sheet has a different pair of patterns marked on it. These patterns are metallic and hence are significantly more conducting than the black background. When a sheet is gently fitted under the two clamps such that the two patterns are in contact with them, they provide opposite charges on the two patterns. The electric field directions can now be found at arbitrary points around these charge patterns by using the pair of probes provided. The two probes are connected with conducting wires to the two ends of a meter that measures the amount of charge flow (a galvanometer). There are at least two methods that one can use to find the electric field direction with this apparatus.

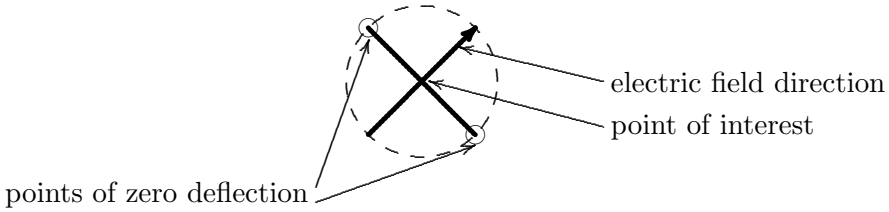


Method 1

Touch the stationary probe (the one with a base) at a point on the black surface where you want to find the field direction. Now touch the other probe at points on a circle of radius of about one centimeter around the stationary probe. Find the points of maximum meter reading (both positive and negative). The field is along the line joining these two points and it points away from the positive battery contact (see figure below). Explain to yourself why this is so using the theoretical principle stated earlier. Mark out these points of maximum meter readings on the template sheet of paper provided (DO NOT ATTEMPT TO MARK THE BLACK SHEET ITSELF!). Then determine the electric field direction.

Method 2

While you try the above method, you will soon see that the accuracy of your measurement depends on whether the moving probe is kept at the same distance from the stationary one in every direction. This is difficult to do. Besides, locating maximum deflection points is also difficult. However, the two directions in which the meter reads zero are much easier to find. The direction of maximum reading is expected to be at right angles to both these directions. Hence, joining the two zero points by a straight line and then drawing a perpendicular to it gives the direction of the field (see below).



To facilitate the process of drawing these field directions you may use the computer software tool "EFields"[†]. "EFields" is straightforward to use. Select a pattern (plates or dipole). To select a new point of interest for electric field direction, pick the drawing tool 'New Pt'. This will change the mouse cursor to a '+'. Then click at the point of interest. This will select the point and draw a circle around it. Next select the drawing tool 'Zero 1' and click at the point on the circle where you find one of the zero points. Do the same with 'Zero 2' for the other zero point. Now select the 'E Field' button. This will draw the line joining the two zeros and the perpendicular to it. You can attach an arrow head to this perpendicular by selecting the 'Arrow' button and then clicking on the side that you believe the electric field should point. For the next point of interest repeat the above process. The active point will be seen in red and the others in blue. You can always go back and edit a previous point by clicking on it and making it active. Note that an active point can always be deleted using the 'Del Pt' button. Depending on you battery connections, you may want to switch polarity using the 'Switch Polarity' button.

[†]Consult instructor for location of the software.

Some things to do

For each black sheet provided, find electric field directions at several points. Try to determine a trend. See if you can find field directions at appropriate points so as to trace out electric field lines.