

# Physics

## Lab - Mapping an Electric Field

**Purpose:** To make a map of an electric field and to learn first-hand how electric field lines and equipotential surfaces relate to each other.

**Materials:**

- a plastic tray
- a digital voltmeter and leads
- a 200-400mL beaker (use clean or distilled water)
- a DC power source
- graph paper
- a pencil with graphite lead sharpened at both ends

*electrodes:*

- 10-15 inches of romex wire
- a 1 in by 6 in metal strip

**Discussion:** The world that we live in is literally swarming with electric and magnetic fields! They are all around you. How would they look if you could see them? We represent electric fields with *electric field lines*. By convention, electric field lines always start on positive charges and end on negative charges, they go out in all directions and are pictured as arrows. The number of lines in a given area tells of the **strength** of the field in that region.

In this experiment you will make a visual map of an invisible electric field and draw some conclusions about the nature of that field.

fig. 1.1 - measuring V

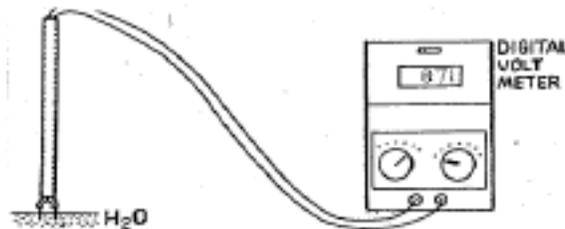
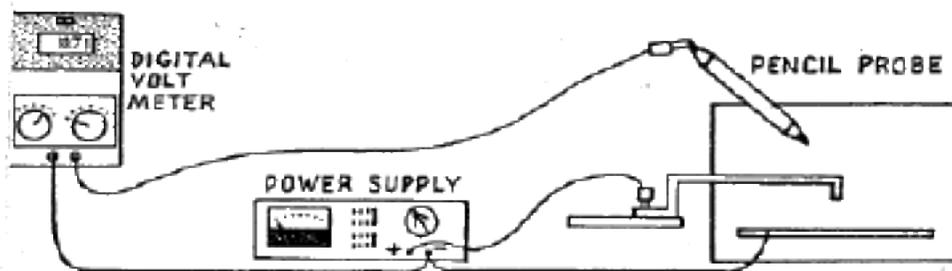


fig. 1.2 - measuring E



**Procedure:**

*Building Your Field*

- Write your names on the paper that you will draw on. Draw a small circle where each electrode will be and label them +/-.
- Cut a piece of romex wire 10 to 15 inches long, strip the casing off the wire about one inch on one side and 4 inches on the other, strip the insulation off the black and white wires about 1/2 inch on each side, clip or bend the ground wire out of the way.
- Place a piece of graph paper in the plastic tray and cover with a thin (about 5mm) layer of water, try to keep the tray level with clay or paper shims.
- Position your electrodes as shown in figure 1.3 (it may help to tape the wire down or put a large mass on top of the base so it doesn't move later).
- Turn the DC output of the lab station off by rotating the knob counterclockwise as far as possible. Plug your alligator clips into the DC output of the lab station's power supply. Leave it **off**.

fig. 1.3 possible electrode configurations



*Plotting Equipotential Lines*

- You will first plot lines where the electric field is *constant*. What are these called? Connect the black terminal of the voltmeter to the black terminal of the power supply (or the black wire of the electrode). Connect the red lead of the voltmeter to your probe (pencil). Note: when holding the probe do not touch the clip, it may effect your readings.
- Set your volt meter to the DC voltage function and the 20V range. Touch the probe to the (+) electrode and adjust the power supply until you get a reading of about 8V on your meter. Check this occasionally during the lab to make sure the power supply voltage does not change.
- Carefully outline the electrodes with a pencil (by drawing under water). Label the (+) electrode. Find a place where the meter reads about 6V. Now, watch the meter, not the pencil and draw the 6V *equipotential line*. You may want to draw a series of dots and connect them later.
- Do the same for the 4V, 2V, and 1V equipotential lines (or any arbitrary voltage that is easy to draw). Also, draw equipotentials very close to the electrodes (how do they look?). Note that these potentials are slightly different than the potentials of the electrodes due to chemical effects taking place at the electrodes. Record these readings as the “effective potentials” of the two electrodes.
- Label all the lines and electrodes according to their voltages (if you get good at plotting you may want to plot lines in increments of 1V instead of 2V).

### Plotting Electric Field Lines

- On the same drawing, you will plot *electric field lines*. Make a probe that has positive and negative leads separated by a set distance (you may wish to tape two probes together). **It is very important that the distance between the probes remains constant during the whole lab.** The electric field strength is  $E=V/d$  so if your probes are 1.0cm apart then you will be measuring the field strength in Volts/cm.
- Start at one of the electrodes. Hold the probe in the water and pivot around  $180^\circ$  on one point. What happens? Experiment with this until you understand *polarity* (direction of the field) and what happens to the voltage as you pivot.. Record observations:

- Next, rotate the probe and stop where the meter reads a *maximum*. The position for maximum has to be found carefully. It is best to rock the probe back and forth a bit when you think you are at maximum to zero in on it. Read the meter and then rotate  $180^\circ$ . What happens? Is the field symmetric? From time to time you may want to wipe the points off to remove surface film that could skew your readings.
- After you find the maximum have your partner draw a line directly between the two points of the probe. Label it with the meter reading (it may be easier to make a "copy" of the under water field on a scrap paper b/c it is hard to write under water. Later, you can transfer the readings to the real lab data sheet.. Indicate the direction of  $E$  with an arrow head (the arrow should go on the tip of the negative electrode). Record the reading you get from the voltmeter next to each arrow you draw.
- Now, move the pivot end of your probe to the front of the arrow you drew and repeat the process. Keep doing this and plot out one *field line* from positive electrode to negative electrode. Plot at least five complete field lines (keeping in mind that the field should be symmetric).
- Remove your drawing and blot it dry or leave it to dry over night. Enhance the picture by drawing the electric field lines and equipotential lines in two different colors. Shade or color the areas covered by the electrodes in a third color. Label all important info.
- If there is time, your partners can now do the same thing with different electrode configurations.

### Questions:

1. What can you say about the angle at which field lines cross equipotential lines? What about the angle at which field lines start out from electrodes?

2. Look over your partners drawings and look at other groups. Did anyone get two field lines or two equipotential lines crossing?
3. Add up all the volt meter readings you wrote down for part two (field lines). How do they compare to the effective potentials of the electrodes?
4. What would gravitational field lines near the surface of the earth look like? What would gravitational equipotentials look like? Make a sketch.
5. In your own words describe what equipotential and electric field lines are and what they represent.
6. Why is it important to keep the water level and the probe spacing constant?

**Error**

Discuss any sources of error in this lab that you were not able to control.

**Conclusion:**

What did you do? What did you find? What generalizations can you make?