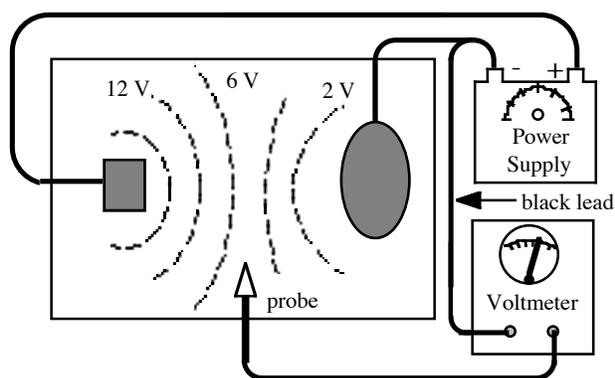


## C. Electric Field and Potential

**OBJECTIVE.** Study the electric potential and the electric field in the neighborhood of various electrical configurations.

**APPARATUS.** Slightly conductive paper, power supply, voltmeter, probes.

**THEORY.** Conducting electrodes connected to a source of potential difference  $V$  have an electric field between them. If the electrodes are firmly attached to slightly conductive paper then a small current will flow through the paper along the electric field lines. These field lines can be found most easily by first finding **equipotential curves** on the slightly conductive paper; these curves are determined by points at the same electric potential. Since the electric field  $E$  at a point is in the direction in which the reduction in  $V$  per unit length is biggest, the electric field lines will be perpendicular to the equipotential lines, and can thus be drawn if the equipotential lines are known. The equipotential lines can easily be found experimentally by probing with a voltmeter for points on the paper that produce the same reading on the voltmeter. The arrangement is shown in Fig. 1 for a particular electrode arrangement.



(Fig. 1)

It is also possible to measure the electric field directly at any desired position on the paper by putting two probes from the voltmeter on the paper simultaneously, separated by a small distance  $d$ . If the orientation of the probes is

varied around a fixed point until a **maximum** potential difference between the two probes is observed on the voltmeter, **the electric field is approximately  $E \approx V_{\text{diff}}/d$** . The direction of the field would be along the line between the two probes, from positive to negative.

### PROCEDURE.

#### 1. "Point-Point" Electrode Arrangement.

Your instructor will provide you with:

- (i) a sheet of conductive paper with two "point electrodes" on it. These electrodes are small circles of about a centimeter or so in diameter; and
- (ii) a similar grid pattern on white paper.

Connect two leads from the power supply to the electrodes. Turn on the voltmeter. Connect the black lead from the voltmeter to the negative post of the power supply. **For the positive voltmeter probe you must use a "banana plug" lead with a smooth end to avoid scratching and damaging the conducting paper.** Touch the positive voltmeter probe to the positive terminal of the power supply, turn on the power supply and slowly crank it up to 20 V.

The voltmeter should also then read 20 V if you touch it to any point of the positive electrode.

#### A. Finding the Equipotential Lines

Find a series of points on the conducting paper that are all at a potential of 2 volts; transfer these points to the corresponding position on the white paper. **PLEASE do not write on the black conducting paper.** These points you found determine an equipotential line of potential  $V_1 = 2$  volts relative to the negative electrode. Now do the same for  $V_2 = 4$  volts, . . .  $V_9 = 18$  volts; in this way obtain nine distinct equipotential curves. Be sure to label them with their voltages. An example is shown in Fig. 1.

## B. Measuring the electric field

Now you will measure the electric field on at least 10 points (make sure that the points are scattered and cover most regions of the arrangement). The procedure is just as the one you followed in the previous week. Use the set of connected probes (tips are about 1 cm apart) at several positions on the paper to measure the electric field vector at those positions, in volts/cm. Include the midpoint between the two point electrodes.

Please notice that when the line between the two probes is parallel to an equipotential no voltage is observed, and the maximum voltage results when the line between the probes is perpendicular to an equipotential line. These important observations will help you with part 3 of the report.

**2. “Point-Plane” Electrode Arrangement.** Repeat for a “point-plane” electrode arrangement (actually a small circle and a line on your paper).

**3. “Plane-Plane” Electrode Arrangement.** Repeat for a “plane-plane” electrode arrangement (actually a line-line on your paper). Don’t forget to probe around the edges and behind the “planes.”

### REPORT.

1. For each of your configurations (point-point, point-plane, etc.) overlay **electric field lines** on the white graph paper (ideally with another color). To do this, start out perpendicular to one of the electrodes. Draw about 7 to 10 evenly-spaced (along the electrode) *E*-lines following a perpendicular pattern through the equipotential lines until you run off the paper or reach the other electrode. Insert arrows so the field lines go from high to low potential.

2. Repeat exercises 2, 3 and 4 from the worksheet for each of the equipotential maps that you obtained experimentally. You are able to

place the charges (for exercise #2) and the point (for exercise #4) anywhere you want, but make sure to indicate the locations clearly.

3. Explain the important relationship(s) between electric field lines and equipotential lines.

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