Equipotential Lines and Electric Fields
Plotting Equipotential and Electric Field Lines

PURPOSE
In this experiment, the concept of electric field will be developed by investigating the space between a pair of electrodes that are connected to a source of direct current. You will plot equipotential lines and sketch in lines representing the electric field between the electrodes.

MATERIALS
- field plotting set from PASCO™ or equivalent
- set of alligator clips (4 per set)
- 2 sheets of carbonized paper
- container of conductive ink
- high resistance voltmeter
- DC power supply or 2 9-volt batteries
- colored map pencils (2 colors)
- 6 metal push pins or 4 plastic pins and two metal pins

Safety Alert
1. Do NOT short out the power supply or exceed the 25 volts specified in the lab.
2. Avoid breathing the fumes from the conducting ink.
3. The conductive ink is flammable.

PROCEDURE
1. Attach the carbonized paper to your tack board and attach the leads from the battery or power supply. Push the two metal pins into the ink electrodes drawn on the conductive paper. Place a fresh drop of conductive ink under the pin to make sure it makes good contact with the paper. Connect the negative lead from the battery or power supply to one of the pins on the electrode on the paper. Connect the positive lead to the other pin. Connect the negative lead (common) of the voltmeter to the negative lead of the battery or power supply; use the positive lead from the voltmeter to probe the field. See Figure 1.

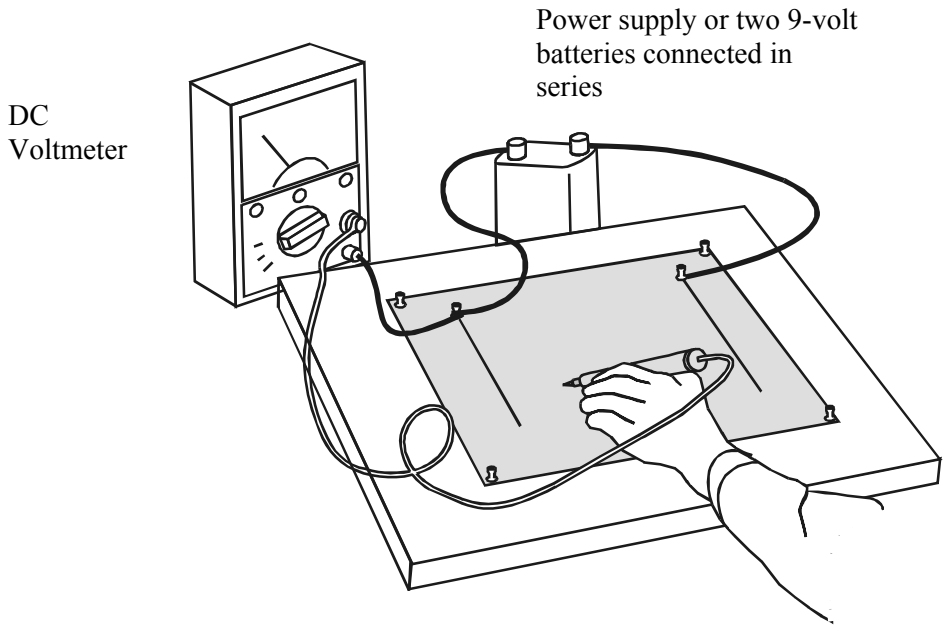

Figure 1

2. Set the power supply to no more than 20-volts DC. Touch the pushpin connected to positive to make sure the circuit is working properly. The voltmeter should read whatever voltage is selected on the power supply, or the terminal voltage of your battery combination. If it does not, check your circuit.

3. Move the positive probe to the negative terminal. The voltmeter should read zero volts.

4. Move the positive probe between the two pins and find a point which reads 2 volts, and mark the point with your colored pencil. Move the positive probe around in the same area until you find another point nearby which also reads 2 volts, and mark the new point with your colored pencil. Continue to trace the around the pin with the positive probe to find several other points which read 2 volts, and mark each point. You should be seeing that the points you are marking form a closed figure around the pin. Every point on the closed figure should read 2 volts. When you have determined the shape of this closed figure, draw it in with a continuous line. Do not use a regular pencil, since the graphite in the pencil lead conducts electricity and will affect the rest of the experiment. The lines that you have drawn on the carbonized paper are called *lines of equipotential in the electric field* between the two electrodes.

5. Move farther away from the positive pin until you find 4 volts. With the probe, determine and trace a closed figure which reads 4 volts at every point around the pin, and complete the drawing for the 4-volt equipotential line.

6. Repeat these steps at 2-volt increments until you reach 20 volts (assuming your power supply was set at twenty), or 18 volts if you were using two 9-volt batteries in series.

7. Obtain your second sheet of conductive paper. This paper has two parallel conductive-ink lines rather than circles for the electrodes. When you change the sheets of paper, put the pin in the center of the line drawn on each side of the paper, and put a fresh drop of conductive ink under the pushpin so that it makes good contact with the paper.

8. Repeat steps 4–6 with the second sheet of conductive paper.

Name _____

Period _____

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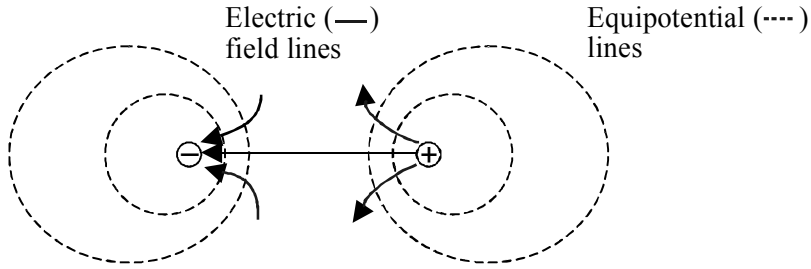
DATA AND OBSERVATIONS

After both sets of equipotential lines are drawn, draw a set of electric field lines starting from the positive 20 volts and going to 0 volts, **crossing each equipotential line perpendicular to the line**.



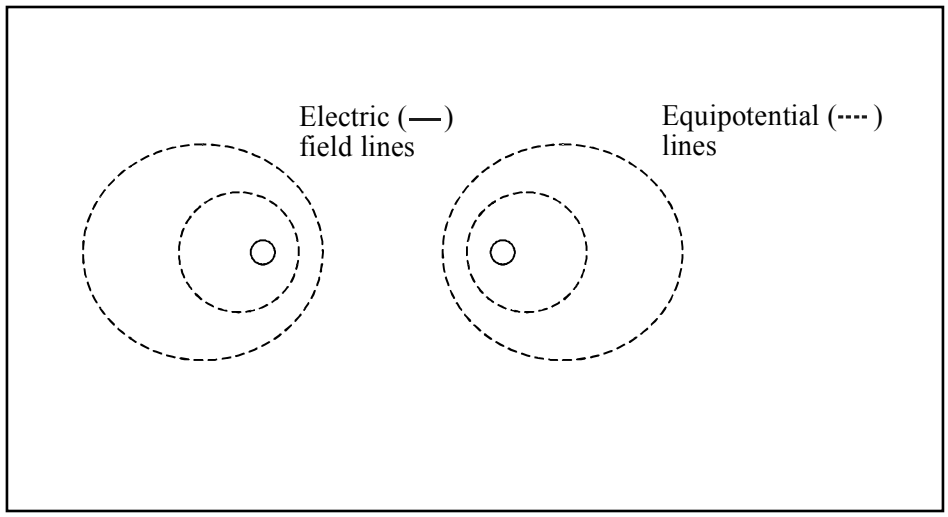
Begin by drawing the first line straight between the two pins. Draw five additional lines above and five lines below this straight line, keeping the newly-drawn lines perpendicular to each equipotential line. Repeat this step for the other sheet. These perpendicular lines that you have drawn on the carbonized paper represent the *electric field* between the two electrodes. The electric field lines are always directed from positive to negative (or from higher positive potential to lower positive potential).

ANALYSIS

1. The strength of an electric field is measured in units of volts per meter. The field strength at a point is found by selecting a second point fairly close to the first and dividing the difference in voltage between the two points by the distance in meters between the electric field line.

$$E = \frac{V}{d}$$

Make a sketch of the equipotential and field lines in the box provided. Where is the electric field constant?

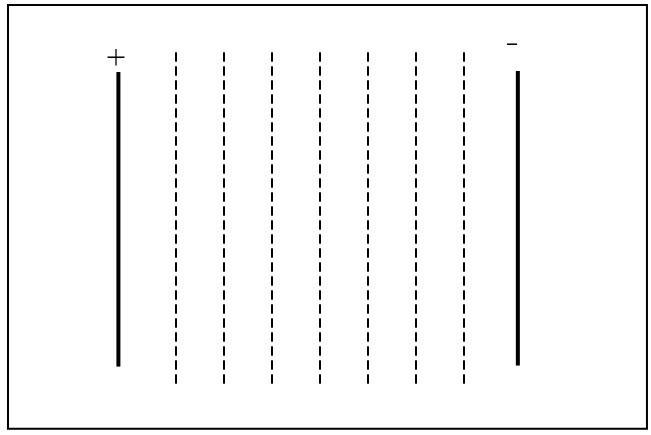


2. Using the sheet with the parallel conducting lines, select two points along the same field line. Then measure the difference in potential between the points and the distance between the points. Use these values to calculate the strength of the field.

$$E = \frac{V}{d}$$

Calculate the field strength for 5 pairs of points between the parallel lines from the second sheet of carbonized paper. Record your values in the table below and make a sketch of the equipotential and field lines in the box provided on the next page.

Table: Parallel Lines			
Line	**Voltage (volts)**	**Distance (m)**	**Electric Field (V/m)**
1			
2			
3			
4			
5			



3. Compare the variations that are observed in electric field strength between electrodes that are small points and between electrodes that are long parallel lines.

CONCLUSION QUESTIONS

1. Compare and contrast electric field and electric potential. How are they related to each other?

2. In general, how are electric field lines drawn in the vicinity of electric charges?

3. Define *equipotential line.* How are electric field lines and equipotential lines drawn relative to each other?

4. Describe the amount of work would you have to do to move a positive charge along an
   a. electric field line

   b. equipotential line

5. Describe the strength of an electric field which is represented by electric field lines which are
   a. closely spaced

   b. equally spaced