PHYSICS IN MOTION
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Unit 5D

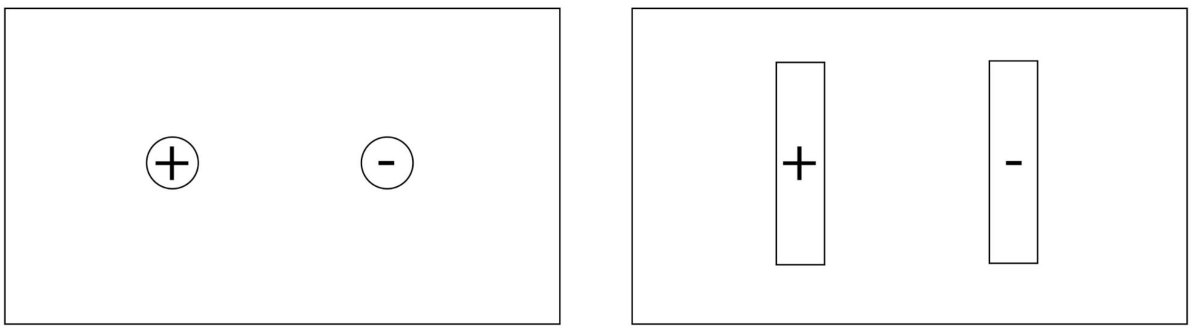
Electric Potential Energy & Electric Potential

Investigating Equipotential Lab

Name:

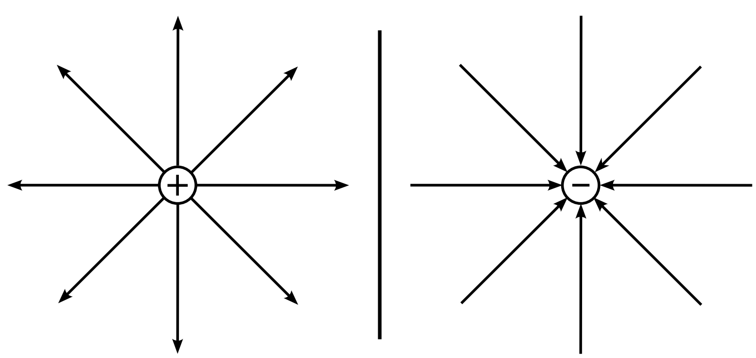
Date:

Your summer internship at Fermilab, a particle accelerator facility near Chicago, is going great. As part of a team designing a small-scale accelerator, you've been assigned to investigate electric fields and lines of electric potential. In particular, your team lead wants you to investigate two possible designs to determine which would create a more stable accelerator. The design goal is to make a pair of electric poles that will accelerate particles in a controlled and uniform direction. Particles will move between the two poles, left to right or right to left, in the direction from higher to lower potential. The first design option contains two oppositely charged circular electrodes, and the second design option contains two oppositely charged plates. The two prototypes are shown here:



Which option will provide a more stable environment to accelerate particles as they move from one charged object to the other? Look for the design that provides the most uniform and straight "lines of equipotential" between the charges.

Keep in mind that charges create electric fields and that electric fields can be pictured using arrows. For example, an isolated positive (left) and negative (right) charge create electric fields that look like this:



Electric potential (voltage) changes as we get closer to or farther from a charged object. However, it is possible to maintain the same electric potential by moving along different points in space without actually approaching or diverging from the charge. These points with the same electric potential are connected by a line of equipotential, meaning the electric potential is the same anywhere along the line.

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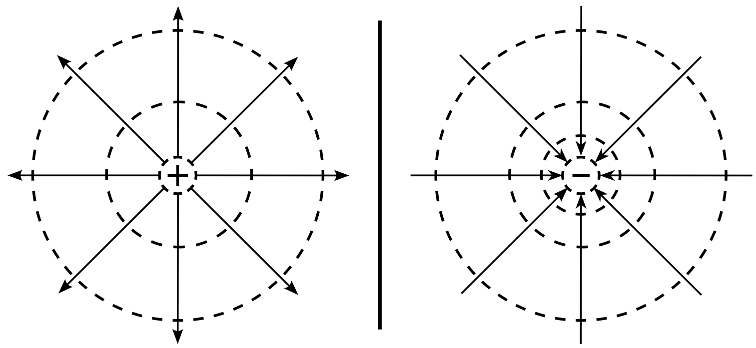
If we draw lines of equipotential on the diagrams above, they will form circles:



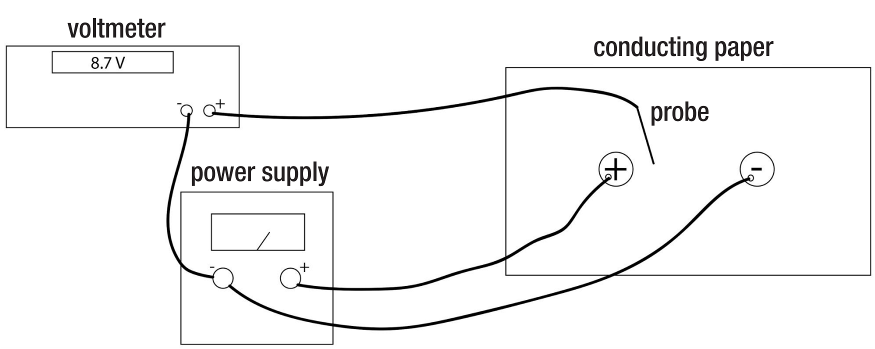
In this project, we are going to experimentally map equipotential lines for the two different charge configurations we've been tasked to analyze.

Materials:

- DC power supply (25-40 V max)
- conductive paper
- scissors
- multimeter
- copper foil tape with conductive adhesive
- cork board
- push pins
- assorted electric leads

Procedure:

a. Take two pieces of conductive paper. On one piece of paper, use a pencil to draw the outline of the charges for the first possible configuration. Draw the charges for the second possible configuration on the other piece of paper.
b. Cut out pieces of the copper foil tape in the shapes you outlined.
c. Place the first sheet of conductive paper on top of the corkboard. Use push pins at each corner to fasten the sheet in place.
d. Stick the copper tape point charges to the paper, making sure the tape is tightly adhered. If necessary, rub it with your fingernail to remove any wrinkles in the foil.
e. Set up your voltmeter, power supply, probes, and board as in the diagram below:



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f. Set your power supply so that when you move the probe from touching beside (but not directly on) one piece of foil to the other, the voltmeter measures a potential difference of 10-12 V.

1. If you measure from directly touching one piece of foil to the other, will the potential difference be more or less? Why?

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g. Position the probe about halfway between the pieces of foil, finding a spot where the potential is a whole number (e.g., 15 V rather than 15.6 V). Make a pencil mark at that point.
h. Now move the probe along the paper to find other points with that same potential. Mark each of those points until you run into the edge of the paper.
i. Congratulations, you've drawn your first line of equipotential!
j. Plot more lines of equipotential, at intervals of 2, 4, and 6 V, on either side of the first line.

2. How do the lines look? Do they bend or curve? If so, how?

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k. Now switch to your second sheet of conducting paper with the option two configuration of parallel bars. Map the equipotential lines for this configuration.

3. How do the lines from option two look? Do they bend or curve? If so, how?

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4. Based on your findings, write a recommendation to your team leader about which configuration will most evenly and uniformly accelerate particles. Include sketches of the path that particles might follow for each configuration as they travel from one electric pole to the other.

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