Unit 5D

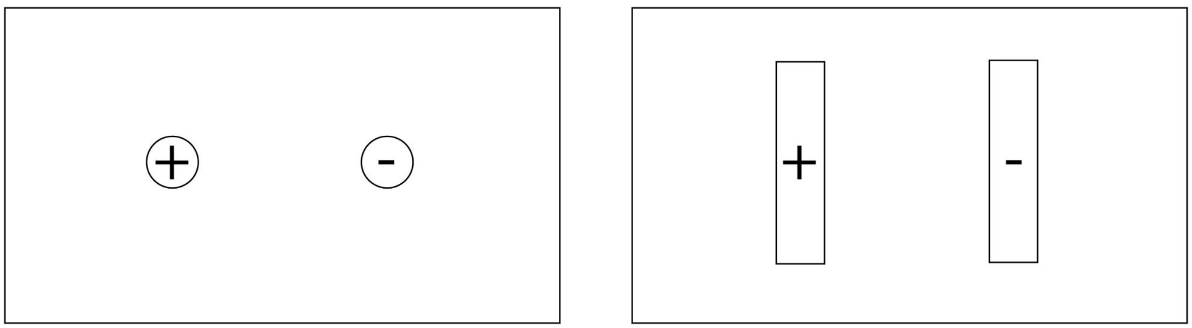
Electric Potential Energy & Electric Potential

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 potential designs, to see which one makes for a more stable accelerator. The design goal is to make a pair of electric poles that will accelerate particles in a well controlled, 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 candidate design is two oppositely-charged circular electrodes. The second candidate is two oppositely-charged plates. The two design ideas are shown here:

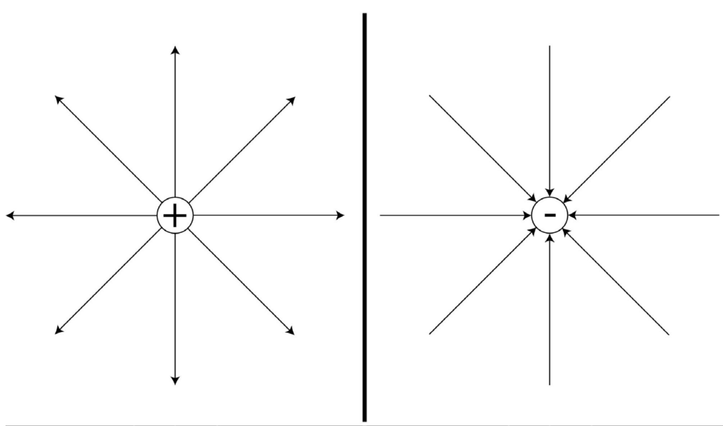


Which design will provide a more stable environment to accelerate particles as they move from one charged object to the other? You'll know by measuring how uniform and straight the 'lines of equipotential' between the charges are. And to do that, you'll need some materials….

Materials:

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

We know 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:



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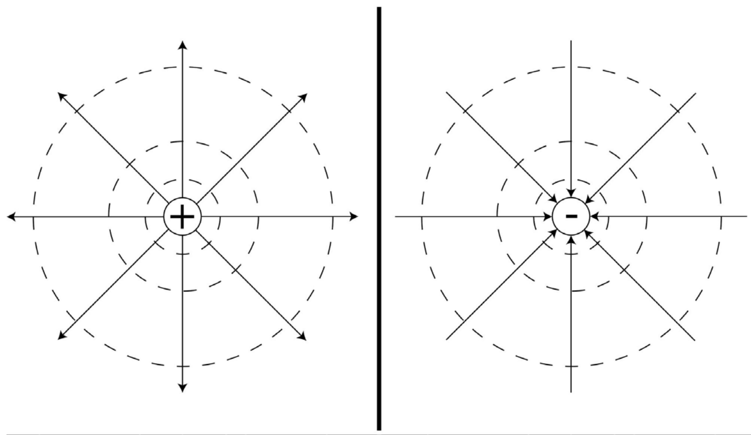
Electric potential (voltage) changes as we get closer to or farther from a charged object. But if we move so that we're not getting nearer to or farther from the charge, the electric potential will stay the same. Different points in space that have the same electric potential are connected by what's called a line of equipotential. This is a fancy way of saying the potential is the same anywhere along the line!

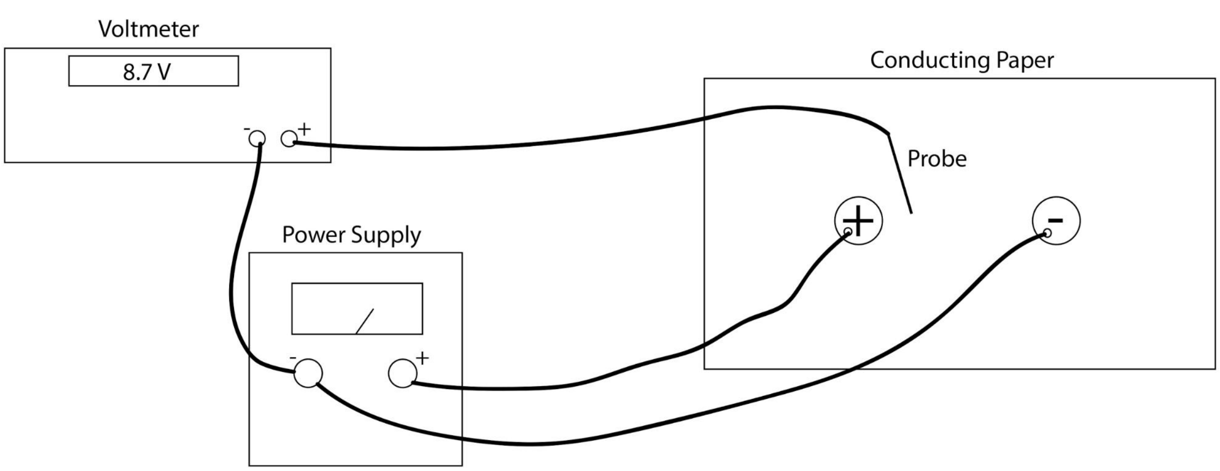
If we drew in somes lines of equipotential on the diagrams above, they would look like these dashed-line circles:



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

Procedure:

a. Take two pieces of the conductive paper. On one piece, use a pencil to draw the outline of the charges in the first candidate configuration. On the other piece, do the same for candidate #2.
b. Use the scissors to cut out pieces of the copper foil tape that match the shapes you outlined.
c. Starting with the first sheet of paper, place the sheet on top of the corkboard. Use push-pins at each corner to fasten the sheet in place.
d. Affix the point charges you cut out to the paper. Make sure the tape is tightly adhered - if necessary, rub with your fingernail to remove any wrinkles in the foil.
e. Setup your voltmeter, power supply, probes, and board like this:



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f. Set your power supply so that you when you move the probe from right next to (but not touching) one of the pieces of foil to right next to the other, the voltmeter measures a potential difference of 10-12 Volts.

1. If you measure right on the foil, from one piece to the other, would the potential difference be more or less? Why?

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g. Move the probe to about halfway between the pieces of foil, and find 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, enough points until you run into the edge of the paper.
i. Congratulations, you're drawn your first line of equipotential!
j. Plot more lines, at intervals of 2, 4, and 6 Volts from the first line, on either side of the 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 - the one with candidate configuration to #2, the parallel bars. Repeat the mapping of equipotential lines from before.

3. How do the lines from candidate #2 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 on which configuration will most evenly and uniformly accelerate particles. Include sketches of the path a particles might follow for each configuration, as it travels from one electric pole to the other.