Name: ______________________________ Section: ________ Date: ____________

Worksheet - Exp 14: Electric Fields and Potentials

Objective:

To map the equipotential lines and electric field lines of point charges and parallel plates; to measure the strength of an electric field and explore its relationship to potential.

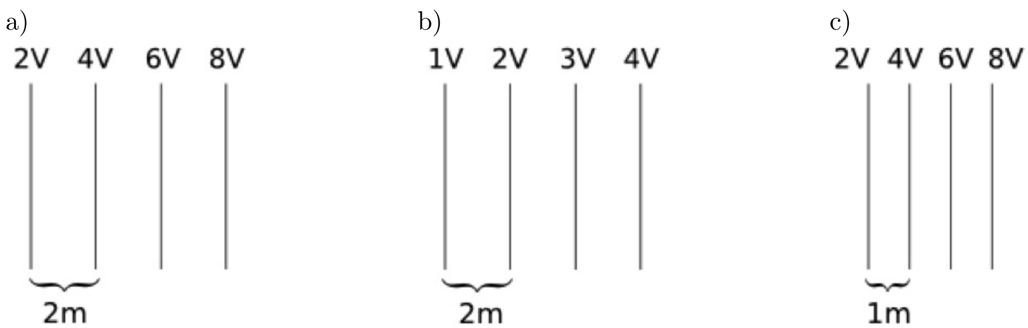
Theory:

Electric potential (voltage) at a point is defined as the amount of *potential energy per coulomb* of a charge placed at that point. An equipotential surface or line is a set of points having the same electric potential.

An **electric field** at a point is defined as the *force per coulomb* exerted on a charge at that point. Electric fields push positive charges toward a lower state of potential energy, or towards a lower equipotential. Thus, electric field lines are always perpendicular to equipotential lines.

Electric fields can also be measured by how quickly voltage is changing at that point, in volts/meter. A stronger electric field indicates electric potential is varying more rapidly over a particular distance.

1. The following are three maps of equipotential lines.
   Rank their corresponding electric fields from weakest to strongest: _____, _____, _____ (3 pts)

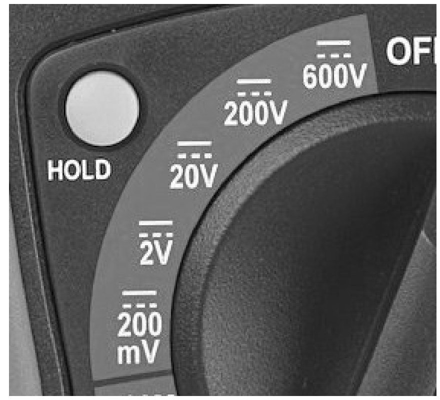


2. A test charge, 25 μC, is placed at a potential of 500 V near a stationary positive charge.
   How much potential energy has been given to the test charge? Show your work. (3 pts) __________ Joules

Procedure:

Part 1: Setup and Connections

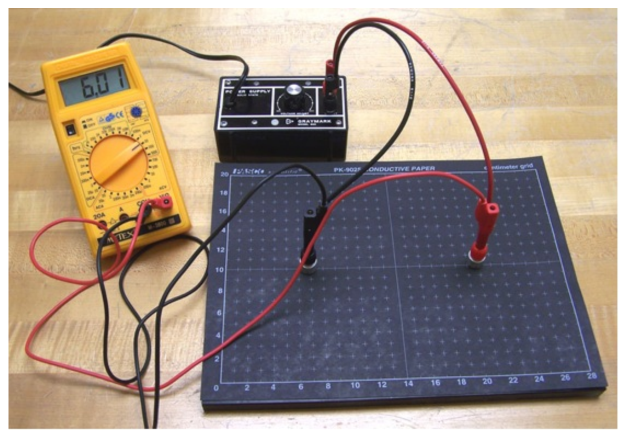
3. Connect a black lead to the COM jack and a red lead to the V/Ω jack.



4. Turn the dial to 20V DCV and turn on the DMM (it is now acting as a voltmeter).

5. Place the conductive paper on the circuit board. Poke two holes in the paper matching holes in the circuit board as shown in the point charge arrangement.

6. Place a point charge connector over each hole; affix them with one red post and one black post.



7. Connect the power supply to the point charge posts, black-to-black (ground) and red-to-red (positive).

8. Connect the voltmeter to the point charges, on top of the power supply leads.

9. Ask your TA to approve your circuit. Then, plug in the power supply and set the voltage to 6.0V.

10. Label the point charges with a grease pencil (the ground lead is at 0.0V, the positive lead is at 6.0V).. (2 pts)

Part 2: Point Charges

Equipotential Lines

11. Remove the voltmeter positive lead from the point charge and drag is across the conductive paper. Bring it closer to the ground lead until the voltmeter reads 1.00V. (Adjust the voltmeter scale to give the most significant figures without getting an overload symbol, "1.")
12. Mark a dot at this location with the grease pencil. Move the voltmeter lead around the paper until you locate eight points where the voltmeter reads 1.00 V and mark each of them.
13. Connect the dots with the grease pencil to create an equipotential line. Label this line with its voltage. (3 pts)
14. Have your partner repeat this process to locate the 2.0V equipotential. (3 pts)
15. Take turns with your partner to locate the 3.0V, 4.0V, and 5.0V equipotentials. (9 pts)
16. What sort of symmetry can be seen in your equipotential lines? (You may use a diagram, but describe the symmetry grammatically as well.) (4 pts)

Electric Field Strength

17. Measure the electric field strength (ΔV/Δx) at the 3.0V equipotential.

    (a) Measure the change in voltage between two points placed closely together, on either side of the 3.0 V line. Use the clear plastic tip holder to maintain a measurable separation of the leads (the holes are about 1 cm apart).

    (b) Calculate the field strength, in V/m, at this location. Record it in the table provided.

    (c) Mark the location on the conductive paper and label the strength of the field. (2 pts)

Δ Voltage
Distance
Electric Field

(12 pts)

18. Assume the voltage changes at this rate along the entire line between point charges. What would be the total change in voltage over that distance if that were the case? Show your work (4 pts)

    ________________ Volts

19. Is this estimate greater or less than the actual voltage drop over this distance (about 6 volts)? What does this tell you about the nature of the electric field between charged objects? (3 pts)

Electric Field Lines

20. Place the DMM leads in each end of the tip holder. Place the positive lead immediately next to the 6.0 V point charge, 15-30 degrees from a line that would connect the two point charges. Hold the positive lead steady and pivot the ground lead around it, noticing the ΔV readings on the voltmeter changing.

21. Pivot the black lead until you find the maximum reading on the voltmeter. Mark the location of the black lead by pressing the tip into the paper to make an indentation.

22. Move the red lead to the indentation made by the black lead. Pivot the black lead around this location as before, finding the direction of greatest voltage change.

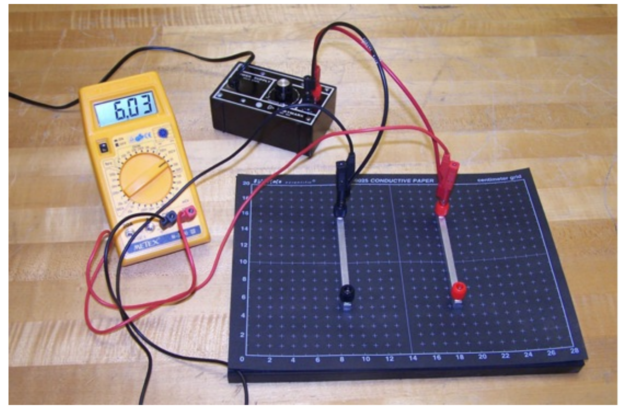
23. Continue to "walk" the leads across the paper until you reach the 0.0 V point charge. Connect the dots with the grease pencil. The resulting line is an electric field line. (5 pts)

24. Have your partner repeat this process beginning from a different position on the 6.0 V point charge. (5 pts) Remove the point charge posts and conductive paper. Keep the paper as data.

25. Are your electric field lines perpendicular to the equipotentials? (2 pts)

Part 3: Parallel Plates

26. Affix a new sheet of conductive paper to the circuit board using four posts as shown in Fig. 14.3. Use red posts for one parallel plate and black posts for the other.



27. Outline the parallel plates with the grease pencil. (2 pts)

Equipotentials

28. Locate the 2.0 V equipotential. Connect the dots and label its voltage. Extend it at least three points past the ends of the plates. (3 pts)
29. Have your partner repeat this process for the 4.0V equipotential. (3 pts)

Electric Field Strength

30. Measure the field strength at the center of the paper, between the plates.
    (a) Measure the change in voltage between two points placed closely together, on either side of the center dividing line. Use the clear plastic tip holder to maintain a measurable separation of the leads (the holes are about 1 cm apart).
    (b) Calculate the field strength, in V/m, at this location. Record it in the table provided.
    (c) Mark the location on the conductive paper and label the strength of the field. (2 pts)

Δ Voltage
Distance
Electric Field

(12 pts)

31. How does this compare to the average electric field between the two plates? Calculate the average electric field ($\Delta V/\Delta x$) between the plates, then find the percent difference of your measured value. (8 pts)

Average E-field: ______________________

% Difference: ______________

Electric Field Lines

32. It is known that the electric field between two plates is a series of parallel lines going straight from one plate to the other. Locate and draw two of the field lines *outside of* the ends of the parallel plate configuration. (10 pts)
33. Unplug and organize the equipment on your table. Keep the conductive paper as data. Staple one of the charge arrangements to the back of your worksheet; staple the other to your lab partner's worksheet.