PHY 252
Lab 1 – Equipotential Surfaces and Electric Field Lines

Objectives:

The objective of this lab is to illustrate the relationship between charged, conducting surfaces and electric field lines by mapping equipotential surfaces.

Theory:

The electric potential (V) about one or more charged electrodes may be represented by a series of closed, imaginary surfaces, referred to as "equipotential surfaces". On any point of an equipotential surface the value of V is the same, i.e. every point of the surface is at equal potential. **It should be noted that a conductor automatically forms an equipotential surface.**

Electric field lines may be constructed from equipotential surfaces by forming lines which go from one electrode to the other, such that they always fall perpendicular to each equipotential surface crossed. This mapping is a consequence of the fact that no work is done by the electric field when a charge moves along an equipotential surface. The equipotential surface must therefore be perpendicular to the direction of force and hence, the electric field.

Equipotential surfaces may be simulated on a two-dimensional scale by painting metallic electrodes onto a carbon infused sheet of paper. Because the paper has a finite resistance, an electric current will flow through it to yield a potential difference from one point to another, and the map of this potential may be directly read off the paper with a voltmeter.

Procedure:

1. Set up the apparatus as shown in Figure 1 below. Plastic push pins are used to hold the conducting paper in place. Metal push pins must be used to act as contact posts to the electrode configurations drawn on the conducting paper. Note: For best results, be sure that the metal push pin is pressed firmly against the silver paint.

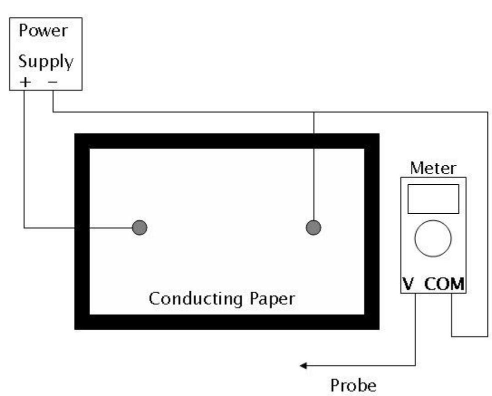

Figure 1: Laboratory setup

2. Connect the black (negative) terminal of the power supply to one of the electrode connection push pins. This electrode now becomes the V = 0 reference. The red (positive) terminal of the power supply is connected to the other electrode push pin. Connect the voltmeter as shown in the diagram with one of the wires to be used as a probe to measure the potential at any point on the conducting paper by gently but firmly pressing the probe to the paper at the desired point.

3. Ask your lab instructor to check your circuit. After getting approval, turn on the power supply and set it to about 12 V. The exact value is not critical.

4. To map an equipotential surface, move the probe along the paper until a point is found at which the desired potential (for instance, try 6 V) registers on the voltmeter. Then, move the probe along the paper such that the voltmeter reading is maintained at this value (it doesn't have to be exact, but should be within 0.1 V). The points found by the probe can be connected with a smooth curve, forming an equipotential surface.

5. Map 7 equipotential surfaces at 1 V, 2 V, 4 V, 6 V, 8 V, 10 V, and 11 V. By reference to the coordinate points printed on the conductive paper, transfer the surfaces to the coordinate paper. Mark each equipotential surface by its corresponding voltage value. One lab partner should perform the total mapping for a given configuration and call out coordinates of the points to the others.

6. Repeat this process for the other configuration given to you by your lab instructor. This configuration should be mapped by a different lab partner than the one who mapped the previous configuration.

Calculations:

1. Based on the relationship between electric field lines and equipotential surfaces discussed in lecture, carefully map 5 to 7 electric field lines for each configuration, beginning at the surface of one electrode and tracing an electric field line to the other.

2. Calculate the electric field strengths between each equipotential line along 2 of these lines which travel through different sections of the configuration by measuring the distance between adjacent equipotential lines and dividing that into the potential difference ($|E| = |V_2 - V_1|/d$). Do the electric field strengths change like you expect them to? Explain.

3. Discuss sources of error in this experiment. Which of these could by systematic sources of error? Systematic errors are errors that result from improper calibration of equipment, improper observations, or effects due to the environment.