Physics 112
Lab 3
Electric Fields and Charge

Names:

_____ _____

_____ _____

Instructions

In this lab, you will examine the properties of electric fields and charges by exploring six different experiments. You can do the experiments in any order, though you may have to share with other groups as you go. For each experiment, write an explanation of what's happening. Your explanation should refer to the laws of electrostatics that you have learned in class. Sketches of charge distributions are also required in a few of the experiments.

Experiment 1 - The Kelvin Water-Dropper

Your lab instructor will get the water-dropper started for you. Feel free to experiment with it to see if you can figure it out, but be gentle with it (it's just a prototype!). The Kelvin water-dropper is diagrammed in Figure 1 on the next page. Use the diagram to make notes and sketch charge distributions.

Write your explanation below:

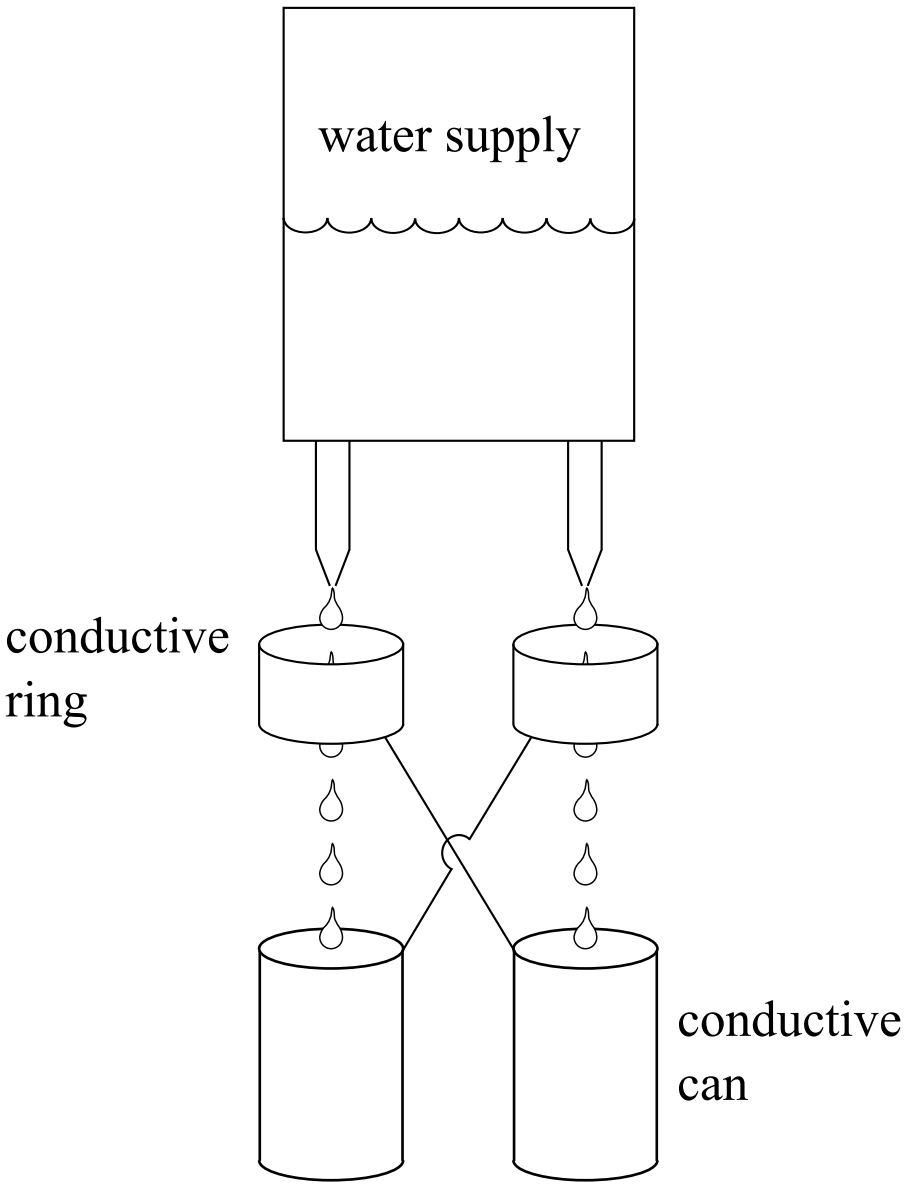


Figure 1: Kelvin water dropper

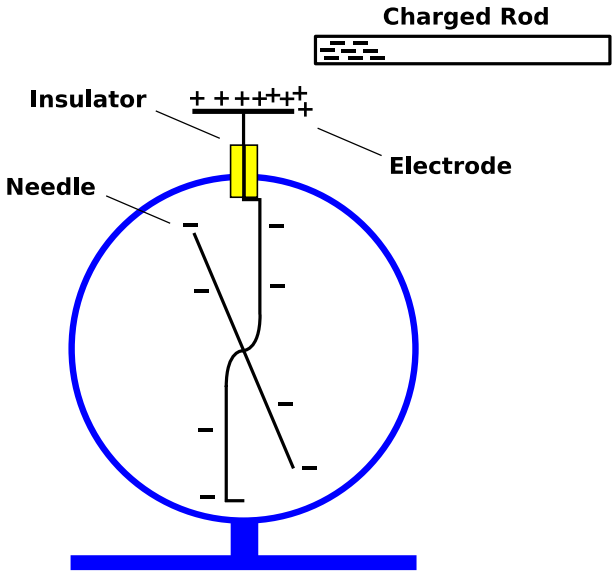


Figure 2: Illustration of the distribution of charges on an electroscope when a negatively charged rod is brought near its electrode.

Experiment 2 - The Electroscope

An electroscope is a device designed to detect the presence of charge as illustrated, for example, in Figure 2.

For each experiment described below, record what you observe, explain it, and as part of your explanation, sketch a diagram, or series of diagrams, similar to Figure 2 that accounts for your observations. Your sketches should show qualitatively the distribution of charge on the electroscope and the other objects involved.

Prior to performing each of the following experiments, be sure to ground the electroscope by touching the electrode with your finger. For best results, re-charge the plastic rod often by rubbing it with the fur.

1. Observe the electroscope while moving the rod near the electrode without touching it, and then move it away.

2. Rub the charged rod on the electrode, and then move it away again.

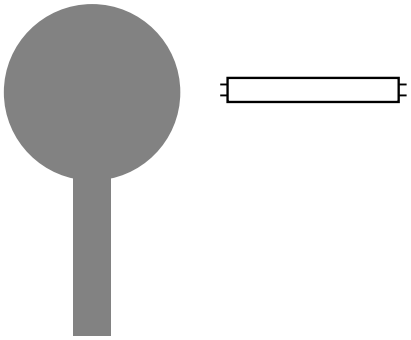
3. Touch the electrode of the electroscope with your finger and hold it there. Bring the rod close to the the electrode, but not so close that you transfer any charge to the electrode (you shouldn't hear any sparks). While still holding the rod nearby, remove your finger from the electrode. Then, move the rod away.

4. Hold a flat sheet of aluminum foil over the electrode of the electroscope, parallel to it but without touching the electrode with the foil. Observe the electroscope while you bring the charged rod close to the foil from above.

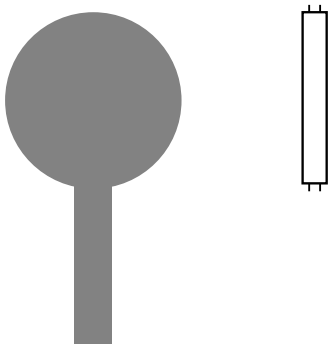
Experiment 3 - Van de Graaf Generator

1. Take the fluorescent bulb (attached to the insulating rod) and hold it near the Van de Graaf generator in the two orientations shown below.

Perpendicular:



Parallel:



What happens in each orientation and why? (You may want to sketch some electric field lines.)

2. Ask your lab instructor to affix a paper clip to the Van de Graaf. When the Van de Graaf is running, hold your hand near the paper clip. You should notice a sensation of cold. Also, if you stand near the paper clip, you might notice that your clothing presses against your body.

   Write your explanation of what's happening below:

Experiment 4 - Two Point Charges

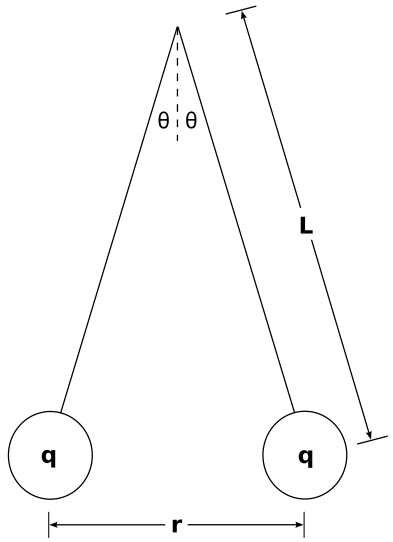


Figure 3: Two charged Styrofoam balls hanging from long threads. The electrostatic repulsion between the balls holds the threads at an angle θ with respect to vertical.

Estimate the amount static charge on a pair of Styrofoam balls hung from long threads as shown in Figure 3 by measuring their separation. Show your work below. Coulomb's law describes not only point charges but also spherically-symmetric distributions of charge. However, the distribution of charge you will create by rubbing the Styrofoam with fur will not be uniform, so we are approximating here. You make a further approximation by assuming that the balls carry equal charges, in which case Coulomb's law becomes

$$F = k\frac{q^2}{r^2} \qquad \left(k = 8.99 \times 10^9 \ \frac{\mathrm{N \cdot m^2}}{\mathrm{C^2}}\right)$$

Experiment 5 - Magic Capacitor

Your lab instructor will help to get you started on this one. Once you have seen the demonstration, repeat it yourself. Take the capacitor, which consists of an outer metal can, an inner can with a hook, and a glass bucket separating them, and hold the metal can near the Van de Graaf generator so that there is arcing between the Van de Graaf and the hook on the inner metal can. Once the charging is complete, disassemble the three pieces. You may receive a small shock from the hook, so you might want to lift the inner can out by using a non-conducting rod. Pass the three pieces around and then recombine them. Use the alligator clip to connect the inner and outer cans. What's going on?

Use Figure 4 to sketch the charge distribution in each step of the experiment and write your explanation below.

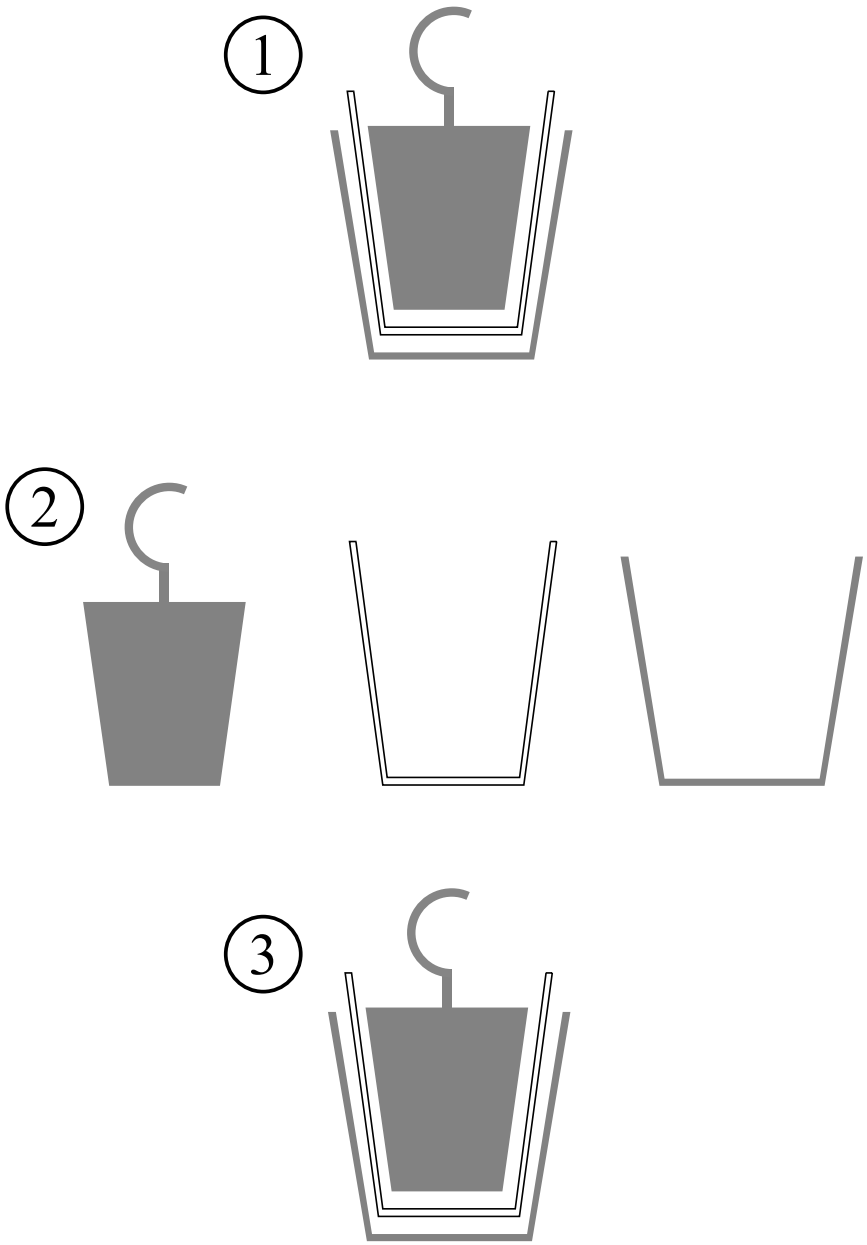


Figure 4: Magic Capacitor