Experiment 16
Electrostatics

Advanced Reading:
Openstax- **University Physics Vol 2**
Chapter 5, Sections 1 & 2

Equipment:
1 ebonite rod
1 lucite rod
1 piece of fur
1 piece of silk
1 electroscope
rubbing alcohol
conducting pith ball on stand
1 hair dryer
1 Electrophorus

Objective:
The object of this lab is to study fundamental properties of electric charges in a qualitative manner.

figure 16-1

Theory:

There are two kinds of charges in nature, positive and negative. Positive charge is carried by protons and negative charges are carried by electrons. When we say an object has a charge on it, we mean that it has a <u>slight</u> excess of either positive or negative charge. For instance, in this lab the ebonite rod will be given a negative charge by rubbing it with the fur. We have not "created" more electrons on the ebonite rod, but rather, have moved some electrons from the fur onto the rod. In so doing, the fur has excess protons and is positively charged. This basic fact is commonly referred to as conservation of charge, and is a fundamental concept of electromagnetic theory.

During this experiment, an electroscope will be charged by two methods, *conduction* and *induction*. To charge the electroscope by conduction negatively, the end of a charged ebonite rod is touched to the ball on top of the electroscope and electrons flow from the rod to the ball and the foil leaves, leaving a net negative charge. Because the leaves have like charges on them, they repel from each other.

To charge the electroscope positively by conduction, the lucite or glass rod is rubbed with silk and touched to the ball on the electroscope. This time electrons flow out of the electroscope onto the rod leaving a net positive charge on the electroscope foil leaves.

To charge the electroscope negatively by induction, a positively charged rod (lucite rubbed with silk) is brought near one side of the ball on top of the electroscope. At the same time, touch the ball on the opposite side from the charged rod. The positively charged rod causes a slight polarization on the ball, with electrons being attracted to the rod, leaving more positive charges than negative on the side of the ball opposite the rod. When you touch the ball, electrons flow from your finger to the ball, giving the electroscope a net negative charge. When the charged rod is removed from near the ball, the leaves repel.

Procedure:

Note: This lab does not work well in humid conditions. Moisture allows conduction of charge preventing static charges from building up. One way to combat this problem is to clean and dry the rods, silk, and fur. Before attempting this experiment, clean the rods with alcohol, which removes moisture, and dry the silk and the fur with the hair dryer. You will probably need to repeat this process again as moisture from your hands gets on the rods, silk, and fur.

Part 1 – Behavior of insulators & conductors

Dry scraps of paper (or pieces of dry wood) are **insulators.** Wet scraps of paper, pieces of aluminum or silver coated pith balls are **conductors**. Use this information to analyze what you observed. Explain using a series of diagrams and text.

1. Rub the ebonite rod with the fur to charge it. Bring the rod near dry scraps of paper. Note the behavior of the paper scraps when the rod is near.

2. Bring the charged ebonite rod <u>near</u> the conducting pith (or aluminum) ball, trying not to touch it. Note its behavior. Is the behavior the same or different from the ball?

3. Bring the charged ebonite rod near the dry paper, **this time letting the paper touch the charged rod**. What did you observe?

Next bring the charged ebonite rod near the pith (or aluminum) ball, **this time letting the ball touch the charged rod**. What did you observe?

Explain using a series of diagrams and text.

Part 2 Charging an Electroscope by Conduction

4. Charge the electroscope *negatively* by *conduction*. Draw a series of diagrams indicating the movement of charges during this process. Explain the steps in the drawings.

5. Charge the electroscope *positively* by *conduction*. Repeat drawings and explanations.

Part 3: Charging an electroscope by induction

6. Charge the electroscope *negatively* by *induction.* Repeat drawings and explanations.

7. Charge the electroscope *positively* by *induction.* Repeat steps above.

Part 4. Discharging electroscope using plasma

8. Charge the electroscope positively. Hold a lighted match near the bulb on the electroscope. Note and explain the behavior of the electroscope. (The flame of the match is a plasma, consisting of a mixture of positive ions and free electrons. Plasmas are conductors.)

Questions/Conclusions:

1. Why do (either positively or negatively) charged balloons (an insulator) hang on a wall (which is also an insulator) if the wall is neutral?

Explain using words and diagrams similar to what you used in the experiment. **You will need at least three diagrams:** 1) wall and balloon far apart, 2) wall and balloon near each other, and 3) wall/balloon stuck together.

2. **'Google' question:**
a) Is 'regular" water a conductor or an insulator? Explain.
b) Is ultrapure water a conductor an insulator?
c) Why does high humidity affect this experiment in the way that it does?

3. In part 4 of the experiment you created a **plasma** by having a match burn in air. To explain what you saw you assumed only electrons were moving. This is not true, although it is a good assumption.

Explain why the assumption that **only negative charges move)** is this not true, but why this a good assumption.

Hint- Explain or show what happens to both a **positive ion** (assume nitrogen) in the presence of an electric field and what happens to an **electron** in the presence of the **same electric field**.

You will need to compare the mass of (nitrogen) nuclei to the mass of an electron.

Using Newton's 2^{nd} Law, explain whether the electron or nitrogen ion will accelerate at different rates and why. Show all work and suppositions.

4. Since charge is always conserved, what do you think happens to a black hole when it "absorbs" a charged particle. Since mass is always conserved, what do you think happens to a black hole when it "absorbs" a particle with mass. Since angular momentum is also conserved what do you think happens when a **nonrotating** blackhole "absorbs" a spinning object. Keep it simple here.