**Physics 121 Lab 1 - Electrostatics**

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Partner(s)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Introduction**

Atoms consist of a central nucleus made up of protons and neutrons surrounded by electrons, and atoms often bond together to make molecules. In many materials some electrons are easily removed from the atoms or molecules and may be free to move about. A substance which has as many electrons as it has protons is said to be electrically neutral. Dissimilar atoms or molecules have different affinities for electrons. When two such objects are rubbed together, the friction may cause electrons to pass from one to the other. After separation, neither object is neutral. Each is said to have been "charged by friction."

An isolated, electrified object becomes neutral again if its electron-proton balance is restored by subsequent contact. A convenient means for accomplishing this is to connect the object to earth by means of a *conductor*, through which electrons readily travel. People, made mostly of salt water, are good conductors and so when a person touches an electrified object, charges will pass through the person and to the ground. This process is called "grounding the body." Since an electrified object is referred to as "charged," grounding is also referred to as "discharging."

Substances through which electrons do not move easily are called *insulators* or *non-conductors*. Experiment has shown that when rubber and wool are rubbed together, electrons pass from the wool to the rubber. The electrons remain on the surface of the rubber – an insulator – where they were transferred.

Metal that is isolated can also be electrified, but the electrons, which repel each other, will move throughout the metal object and disperse as far apart as possible. This can be demonstrated with an electroscope, which has a metal disk connected to a stem from which a thin metal rod hangs and can swing freely. When the disk is given a negative charge, electrons get distributed along the stem and the rod, and the rod will swing away from the stem. The functional parts of the electroscope are shown in Figure 1.



**Apparatus**

\_ electroscope

\_ rubber and glass rods

\_ wool and silk cloth

Figure 1: The functional parts of the electroscope.

**Activity 1: Charging by Friction and Contact**

1. Be sure the electroscope is discharged by touching the disk with your finger. Explain how you can know *based upon observation* that the electroscope is discharged.

2. Charge the rubber rod by rubbing it with the wool cloth.

3. **Prediction:** What will happen to the electroscope if you repeatedly touch its disk with a freshly charged (recharged after each contact) object?

4. Touch the charged rubber rod to the disk on the electroscope; rub the rod with the wool cloth and again touch the rod to the disk on the electroscope; repeat this procedure several times with freshly charged rod. Describe any changes to the electroscope.

**Activity 2: Using an Uncharged Electroscope.**

1. Ground your electroscope and then electrify one end of the rubber rod with the wool cloth.

2. **Prediction:** What will happen when you bring the electrified end of the rubber rod near, but not touching, the uncharged electroscope’s disk?

3. Bring the charged end of the rubber rod toward the disk, but do not touch it. Record what happens.

**Activity 3: Action of the Electroscope - Charges near a charged electroscope.**

Two facts explain the rise or fall of the rod of an electroscope: (a) Like charges repel (opposite charges attract); and (b) free electrons can move about in a conductor (the metal parts in the electroscope).

1. Discharge the electroscope. Then charge it by touching it with a charged rubber rod (after rubbing the rod with wool).

2. **Prediction:** What will happen when you recharge the rubber rod again and then bring the recharged rubber rod near the already charged electroscope?

3. Test your prediction; record the result; explain in terms of the movement of charges.

4. Rub one end of the glass rod with the silk cloth, and bring that end toward the disk, without touching it. Record what happens.

5. What differences were there between the exercise with the rubber rod and that with the glass rod (if any)?

6. How might you account for these differences?

7. By definition (set up by Benjamin Franklin), the electrical state of rubber after being rubbed by wool is negative, meaning that the object that has an excess of electrons. Note, though, that this is only a naming convention. If the rubber rod is said to be negatively charged, in what electrical state is the glass rod?

8. When the rubber rod approaches the disk, which way do the free electrons in the metal of the electroscope move? (There are only two options - up toward the disk or down toward the rod)

9. How does the charge on the rod and stem change?

10. In which direction do the free electrons in the electroscope move when the glass rod approaches the disk?

12. How can an electroscope be used to determine the nature of any charge? Discuss the results of the above activities with the rubber and glass rod in your explanation.

**Activity 4: Charging by Induction**

1. Discharge the electroscope.

2. **Prediction:** What will be the effect on the electroscope if you perform the following experiment: While grounding the electroscope with your finger, bring an electrified rubber rod near the disk, then take away your finger and then the rod (in that order)?

3. Carry out the experiment and describe the result. Pay attention to the location of the electroscope rod at each step of the process. State and explain the result and why your prediction agreed or disagreed with it.

4. Prediction: Note that no electrons moved between the rod and the electroscope. What charge has been induced on the electroscope?

5. Test your prediction with the negatively charged rubber rod and the positively charged glass rod. Does the test verify or contradict your prediction? Explain.

6. Draw a series of four diagrams clearly illustrating the charging of the electroscope by induction. This means only the steps outlined in activity 4 step 3 and not the subsequent testing. **Each diagram should show an equilibrium, not a transition!** Nothing is moving or changing in any of the diagrams. Be sure to indicate the electroscope rod orientation and sketch charges where appropriate (as small + or - symbols). Refer again to Figure 1 to see how to draw the functional parts of the electroscope, but your drawing should also include the location, sign, and relative amounts of charge as well as important nearby objects (hand, rod, etc). Also, in a neutral object, do not draw mixtures of charge of both signs – only draw *excess* charges.

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