Experiment A

Electric Charges

OBJECTIVE

- To investigate the behavior of electric charges
- To investigate charging an object by contact
- To investigate charging an object by induction
- To investigate the distribution of charge on a conducting object

APPARATUS

- Glass and plastic rods, wool, silk, fur
- Scotch tape
- Electroscope
- **Charge Sensor** connected to a computer via an interface with software
- Spherical conducting shell
- Proof plane (rod with metal disk at one end)
- Electrostatic Generator (Van de Graaf)

THEORY

When working with charged bodies, most phenomena can be explained by thinking about what the electrons are doing.

- Are the electrons free to move? If so, what will they do? What attracts them? What repels them? What kind of a substance is this that allows electrons to feely move?
- If the electrons can't move, what kind of substance are they in?
- If only a few electrons can move, or electrons move, but not easily, what do we call these substances?

In performing the following experiments remember that electrical charge cannot be created or destroyed. Electrical effects are produced only when the equal amounts of positive and negative charge in neutral matter are somehow separated. This separation requires an external force, since positive and negative charges attract each other. On the other hand like charges repel each other, and the deflection of the electroscope leaf is due to this repulsion.

PROCEDURE AND REPORT (*Answer all the questions indicated by* ♦)

To experimentally investigate electrostatics, some charge detecting or measuring device is needed. A common instrument used for this purpose is the electroscope, a device with a thin gold foil (called a leaf) suspended from a metal bar. When a charged object is brought near the electroscope, the gold leaf separates due to repulsion of like charges. The degree of separation of the gold leaf roughly indicates the magnitude of the charge. However, a quantitative reading and direct determination of the sign of the charge is not possible.

You also have available a Charge Sensor which is an "electronic electroscope" capable of giving a measurement of both the sign and the size of the charge. The Charge Sensor is already set-up and is connected to the computer for you to use in this experiment. The instructor will give instructions on how to use it and tell you which file to open to start the Charge Sensor.

1. Behavior of Charges and Charging by Contact

a) Rub the plastic rod with the fur; this should leave a negative charge on the plastic rod. Bring the charged rod near the electroscope without touching it and then move it away.

♦ What happens? What is the reason for this behavior?

Touch to and rub the rod on the electroscope and then move it away.

♦ What happens? What is the reason for this behavior?

♦ Now bring the rod near the Charge Sensor and determine the sign of the charge. Record the sign indicated by the Charge Sensor.

b) Rub the glass rod with the silk; this should leave a positive charge on the glass rod. Make sure the electroscope is uncharged by touching it with your hand. Bring the charged rod near the electroscope and then move it away.

♦ What happens? What is the reason for this behavior?

Touch the rod to the electroscope and then move it away.

♦ What happens? What is the reason for this behavior?

♦ Now bring the rod near the Charge Sensor and determine the sign of the charge. Record the sign indicated by the Charge Sensor.

c) Pull a couple of strips of Scotch tape from a roll. Each one should be about 15-20 cm long. Hold them up by their ends then slowly bring the <u>non-sticky</u> sides close together, but not touching.

♦ What happens as they come closer?

♦ What is the reason for their behavior?

♦ Do they carry opposite or like charges? Verify using the Charge Sensor.

♦ Bring one of the strips near the electroscope, what happens? Remove the first strip and touch the electroscope with your finger to discharge. Then bring the other strip near the electroscope, what happens?

d) One at a time, pass each strip of tape lightly, but completely, between your fingers to neutralize them. Check with the Charge Sensor and if they still have charge repeat the process. If you are unable to neutralize this way, you can drag the non-sticky side of the tape across a moistened sponge. Be careful not to get the tape wet.

Fold over the end of each strip to give you a non-sticky handle to work with. Carefully stick the two strips to each other so the sticky side of one strip adheres to the non-sticky side of the other. Now grasp the handles and rapidly peel the strips apart. Keep them separated and slowly bring the non-sticky sides close together, but not touching.

♦ What happens?

♦ Do they carry opposite or like charges? Verify using the Charge Sensor?

♦ According to theory, electric charge is conserved. Does your Charge Sensor reading confirm this? Explain.

e) You are now going to repeat part d) again, but this time stick the strips together with their sticky sides facing each other.

♦ Do the tapes become charged? Explain why or why not.

♦ From the observations and measurements you have made so far, which side of the tape tends to give up electrons? Which side tends to take them?

2. Charging by Induction

You will charge the proof plane by induction (without directly putting charges on it). First, by using the Charge Sensor verify that the proof plane is neutral. Then hold the proof plane so that the metal is touching the grounded metal bar at your station. After charging the plastic rod negatively by rubbing it with fur, bring it near to (but not touching) the proof plane and keep it there for a second. Then, while keeping the plastic rod near (but not touching) the proof plane, move the proof plane away from the grounded bar. Once contact between the proof plane and the bar is broken, you can move the charged rod away from the proof plane.

♦ Use the Charge Sensor to verify that there is charge on the proof plane; record the sign of the charge.

♦ Check to verify that the rod had negative charge using the Charge Sensor.

♦ Explain how the proof plane acquired this charge without making contact with the charged rod.

3. Electrostatic Charge Distribution on a Conductor

Charge the conducting spherical shell using the Electrostatic Generator. Your instructor will show you how to do this safely. The spherical shell can hold a fairly large amount of charge so keep it at a distance from the Charge Sensor otherwise it may affect your reading. Touch the metal part of the proof plane to the grounding wire or your hand to neutralize it first and verify its neutrality using the Charge Sensor. Touch the proof plane to the outer surface of the spherical shell to pick up charge and then bring the proof plane near the Charge Sensor.

♦ Were you able to pick up any charge with the proof plane from the outer surface of the shell?

Neutralize the proof plane by grounding it and verify using the Charge Sensor. Now gently insert the proof plane into the spherical shell without touching the outer surface or the edges of the hole. Rub the proof plane on the inside surface of the shell and take it out without touching the outer surface or the edges of the hole.

♦ Were you able to pick up any charge with the proof plane from the inner surface of the shell?

♦ On a conducting object where does the excess charge reside?