CH 20: THE STRUCTURE OF MATTER

There is a large overlap of the world of static electricity and the everyday world that you experience. Clothes tumble in the dryer and cling together. You walk across the carpeting to exit a room and receive a door knob shock. You pull a wool sweater off at the end of the day and see sparks of electricity. During the dryness of winter, you step out of your car and receive a car door shock as you try to close the door. Sparks of electricity are seen as you pull a wool blanket off the sheets of your bed. You stroke your cat's fur and observe the fur standing up on its end. Bolts of lightning dash across the evening sky during a spring thunderstorm. And most tragic of all, you have a bad hair day. These are all static electricity events - events that can only be explained by an understanding of the physics of electrostatics.

Not only do electrostatic occurrences permeate the events of everyday life, without the forces associated with static electricity, life as we know it would be impossible. Electrostatic forces - both attractive and repulsive in nature - hold the world of atoms and molecules together in perfect balance. Without this electric force, material things would not exist. Atoms are the building blocks of matter depend upon these forces. And material objects, including us Earthlings, are made of atoms and the acts of standing and walking, touching and feeling, smelling and tasting, and even thinking is the result of electrical phenomenon. Electrostatic forces are foundational to our existence.

1. ***Atoms depend on what force?***

One of the primary questions to be asked in this unit of The Physics Classroom is: How can an object be charged and what affect does that charge have upon other objects in its vicinity? The answer to this question begins with an understanding of the structure of matter. Understanding charge as a fundamental quantity demands that we have an understanding of the structure of an atom.

Application of Atomic Structure to Static Electricity

All material objects are composed of atoms. There are different kinds of atoms known as elements; these elements can combine to form compounds. Different compounds have distinctly different properties. Material objects are composed of atoms and molecules of these elements and compounds, thus providing different materials with different electrical properties.
An atom consists of a nucleus and a vast region of space outside the nucleus. Electrons are present in the region of space outside the nucleus. They are negatively charged and weakly bound to the atom. Electrons are often removed from and added to an atom by normal everyday occurrences.

The nucleus of the atom contains positively charged protons and neutral neutrons. These protons and neutrons are not removable by usual everyday methods. It would require some form of high-energy nuclear occurrence to disturb the nucleus and subsequently dislodge its positively charged protons. These high-energy occurrences are fortunately not an everyday event and they are certainly not the subject of this unit of The Physics Classroom. One sure truth of this unit is that the protons and neutrons will remain within the nucleus of the atom. Electrostatic phenomenon can never be explained by the movement of protons.

2. ***What determines if an atom is charged or neutral?***

Charge as a Quantity

Like mass, the charge of an object is a measurable quantity. The charge possessed by an object is often expressed using the scientific unit known as the Coulomb. Just as mass is measured in grams or kilograms, charge is measured in units of Coulombs (abbreviated C). Because one Coulomb of charge is an abnormally large quantity of charge, the units of microCoulombs (μC) or nanoCoulombs (nC) are more *commonly used as the unit of measurement of charge.*

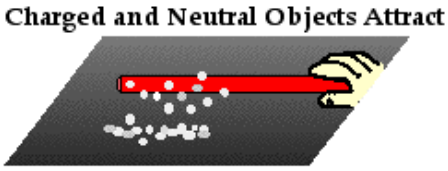
3. ***What is the unit for a charge quantity?***

Suppose that you rubbed a balloon with a sample of animal fur such as a wool sweater or even your own hair. The balloon would likely become charged and its charge would exert a strange influence upon other objects in its vicinity. If some small bits of paper were placed upon a table and the balloon were brought near and held above the paper bits, then the presence of the charged balloon might create a sufficient attraction for the paper bits to raise them off the table. This influence - known as an electric force - occurs even when the charged balloon is held some distance away from the paper bits. The electric force is a non-contact force. Any charged object can exert this force upon other objects - both charged and uncharged objects. Opposites attract. And likes repel.

4. ***How can an object be charged and what affect does that charge have upon other objects in its vicinity?***

Interaction Between Charged and Neutral Objects

The interaction between two like-charged objects is repulsive. The interaction between two oppositely charged objects is attractive. What type of interaction is observed between a charged object and a neutral object? The answer is quite surprising to many students of physics. Any charged object - whether positively charged or negatively charged - will have an attractive interaction with a neutral object. Positively charged objects and neutral objects attract each other; and negatively charged objects and neutral objects attract each other.



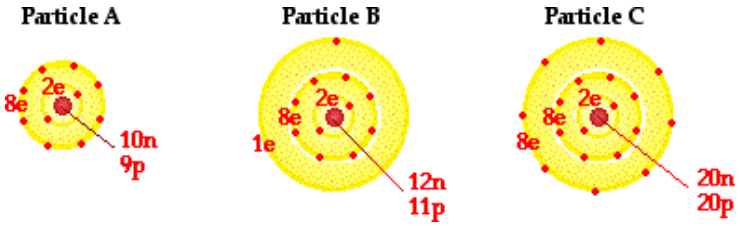
A plastic golf tube charged by rubbing with animal fur will attract neutral paper bits.

For instance, if a charged balloon is held above neutral bits of paper, the force of attraction for the paper bits will be strong enough to overwhelm the downward force of gravity and raise the bits of paper off the table. If a charged plastic tube is held above some bits of paper, the tube will exert an attractive influence upon the paper to raise it off the table. And to the bewilderment of many, a charged rubber balloon can be attracted to a wooden cabinet with enough force that it *sticks* to the cabinet. Any charged object - plastic, rubber, or aluminum - will exert an attractive force upon a neutral object. And in accordance with Newton's law of action-reaction, the neutral object attracts the charged object.

Check Your Understanding

5. **TRUE** or **FALSE**: An object that is positively charged contains all protons and no electrons.

6. Identify the following particles as being charged or uncharged. If charged, indicate whether they are charged positively or negatively. (n = neutron, p = proton, e = electron)



7. Electrical forces ____.
   a. can cause objects to only attract each other
   b. can cause objects to only repel each other
   c. can cause objects to attract or repel each other
   d. have no effect on objects

8. Miss Chiff, the seventh-grade science teacher, greets her students in an unusual manner. She stands at the door of her classroom, scuffing her feet back and forth on the carpet. As she does so, electrons move from the carpet to her shoes to her body. Miss Chiff is now charged with a _____ (positive, negative) type of charge. Then, Miss Chiff reaches out and touches her students on the nose as they enter the classroom. As she does, some electrons leave Miss Chiff and move onto her students. Miss Chiff is now _____ (more, less) negatively charged than before the contact with the student. And the student is now charged with a _____ (positive, negative) type of charge.