ATech Educator News

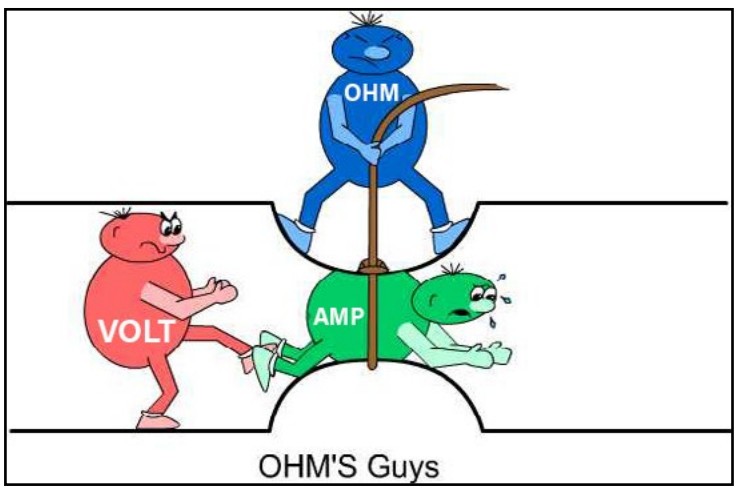
October 2016

Electricity Made Simple
Part 1 of 3

Submitted by: Monroe Sorton

This article is my perspective on one of the most important subjects in automotive service technology. Helping automotive students develop a good foundation for understanding electrical theory and its application is essential in learning effective automotive electrical troubleshooting and diagnostic skills. Automotive students are often challenged and overwhelmed by the study of electrical theory and Ohm's Law. Ohm's Law is a scientific/ mathematical formula introduced by George Simone Ohm (1789-1854; German physicist) to express the relationship between voltage, current, and resistance. Although Ohm's Law captures the mathematical relationship between these electrical terms, it is only a fraction of numerous combinations of electrical formulas used in basic and advanced electrical calculations. Visualizing and experiencing the principles and dynamics of electricity is the key to developing a good foundation for students to learn electrical theory.

Electricity is one of many forms of energy, and energy has the ability or potential to do work. The potential to do work constitutes the usefulness of energy. For example, electrical energy causes light bulbs to glow, electrical motors to spin, electrical stove burners to generate heat, spark plugs to create sparks, and electrical signals to be transmitted wirelessly through space and around the world. Energy in general, and electrical energy specifically, can be transformed into different forms of energy. Light, force, heat, magnetic waves, and radio frequencies are all common forms of energy. Energy transformation is a spectacular phenomenon. The essence of energy can be expressed in a variety of different ways, one of which will be the focus of this article: electrical energy. Electrical energy is extremely beneficial and useful. However, it can also be equally perilous and lethal, considering the electrical systems on electric and hybrid vehicles. As automotive instructors, how can we introduce such a phenomenon to students while allowing them to identify, understand, and respect the function, application, and dangers of electricity?



OHM'S Guys

The fundamental questions students should be encouraged to focus on are: What is electricity? and How does electricity come into being? I encourage students to grasp the concept of electricity from this perspective. After 20 years or more of teaching, I still enjoy the fun and excitement of attempting to explain how an invisible concept such as energy is responsible for countless visible and tangible experiences in and outside the realm of automotive service and technology. This challenge adds tremendous value to the joy, effort, and skill of teaching experiences. Teaching electrical theory is like explaining the dynamics, function, and benefits of air. Air is not visible, yet we cannot live without it. Whenever birds fly, planes take off, and people speak, we experience and enjoy the visible effects and benefits of air. We may also experience the destructive forces of energy that result in tornadoes and hurricane-force winds. It is evident how beneficial and yet detrimental the invisible energy forces of air can be. In many ways it can be compared to electricity.

To help students appreciate the function and existence

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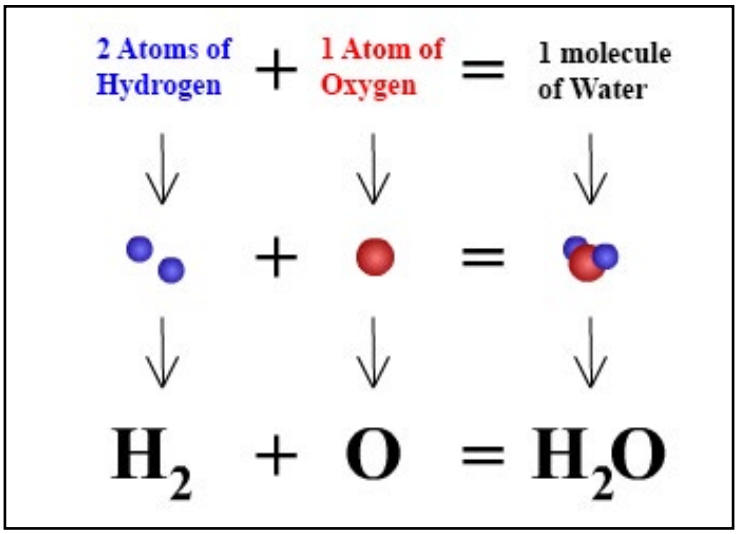
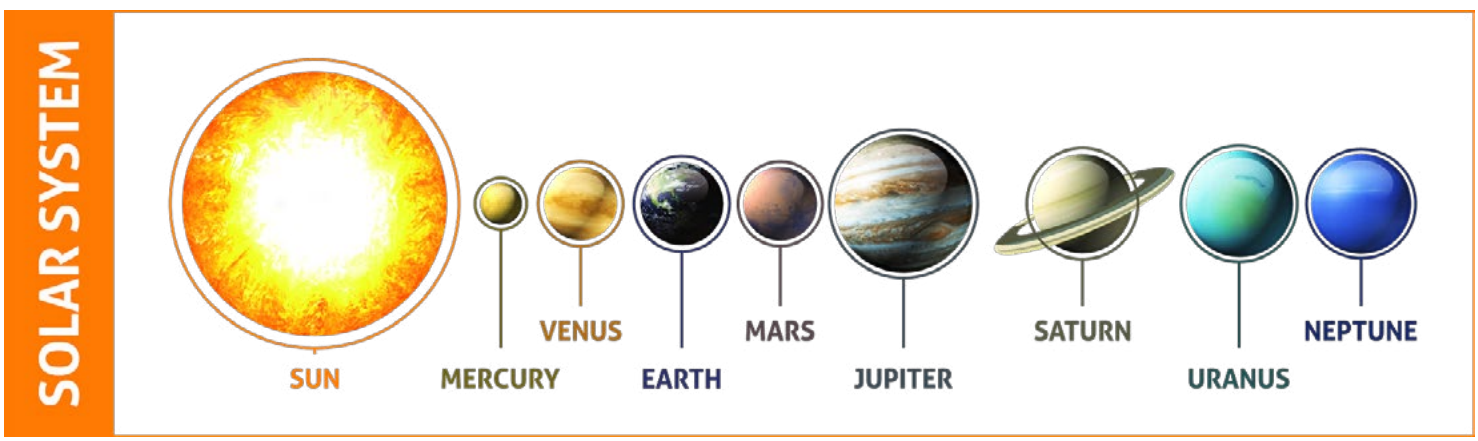


of electricity, I think it is important for them to understand the atomic and molecular structure of matter. They must first understand that solids, liquids, and gasses are constructed of atoms and/or molecules. Without getting into quantum physics, atoms are essentially the basic building blocks of solids, liquids, and gaseous substances. Molecules are combinations of two or more atomic elements chemically bonded by forces of nature to create specific or different substances. For example, a water molecule (H2O) consists of two hydrogen atoms and one oxygen atom chemically bonded together. I think chemical bonding is nature's way of providing the principles we need to maintain equilibrium from sub-atomic particles to the galaxies throughout the universe. If a water molecule is separated into hydrogen and oxygen, two gaseous substances will exist. However, if two hydrogen atoms and one oxygen atom are bonded together, a liquid water molecule will exist. If its temperature drops below 32° F, a solid ice molecule will exist. Science is so fascinating and it helps students gain an appreciation for the marvels of life. Two gaseous elements, hydrogen and oxygen, are responsible for producing water. Space can be occupied by visible or invisible substances. Students tend to grasp concepts more easily when ideas can be clearly identified or experienced by our five senses.

What makes teaching electricity more challenging, in my opinion, is the inability of students to "see" atoms and sub-atomic particles such as electrons with the naked eye. The Bohr model, introduced in 1913 by Niels Henrik David Bohr (1885-1962; Danish physicist), represents an atom as having its center, the nucleus, surrounded by revolving electrons in a manner similar to our planetary solar system. The atom's nucleus contains a cluster of sub-atomic particles called protons and neutrons. Orbiting or revolving around the nucleus of the atom are additional sub-atomic particles called electrons. To help students remain focused and not venture into quantum physics, I limit the structure of the atom to protons, neutrons, and electrons. Atoms are invisible to the naked eye, and protons are sub-particles of atoms. Electrons are said to be approximately 1,835 times smaller than protons. Imagine dividing an invisible sub-atomic particle as tiny as a proton (1,835 times smaller). The results would be infinitely smaller. Protons are said to retain a positive electrostatic charge, or force of attraction, while electrons are said to retain a negative electrostatic charge, or force of attraction. Just as the planets in our solar system emanate a gravitational force field around them, so does the sub-atomic particles of an atom. Neutrons, however, are said to retain a neutral electrostatic charge or no charge at all. The existence, movement, or flow of electricity is a result of the invisible sub-atomic particles called electrons. When electrons move from atom to atom, this is called electrical current. Current is based on the measured quantity of electrons moving from one atom to the other with respect to time. With this understanding, students can now begin to focus on the dynamics of the electrons.



Parallel to the gravitational forces within our planetary solar system, the electrostatic force field exerted by electrons is represented as a negative charge. All elec-

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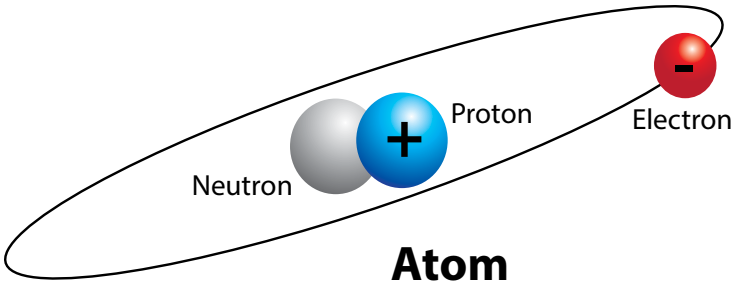

Atom

trons are said to retain a negative electrostatic charge. When two identical magnetic poles are in close proximity to each other, a repulsive force will be experienced between them. Likewise, electrons will repel each other in close proximity. Like-charged particles cause repulsion. Atoms, with the help of natural forces, remain intact and balanced with a specific number of electrons naturally arranged to revolve around the nucleus of each type of atom. The planetary arrangement of our solar system serves as a great example of the Bohr model of the atom. Planets revolve around the sun, and the moon revolves around the Earth, maintaining a balanced state of equilibrium. The structure of atoms is represented in a similar way in the Bohr model. When the correct number of electrons orbit around the nucleus of an atom, the atom is said to be balanced and in a state of equilibrium.

How does electricity come into being? According to the Bohr model, there are varieties of shells and subshells or rings of electron energy levels revolving around the nucleus of each atom. Each energy level may contain 1 to 2(n)2 electrons, where "n" equals the shell or ring number. Although the details of the atomic structure are interesting, it is more important for students to understand the significance of the furthest energy level or ring of electron(s) away from the nucleus of each atom. This energy level ring will be called the valence ring in this article, and this is the key to students understanding the concept of electricity, conductors, and insulators.

The valence ring of each atom is where understanding the nature of electricity often begins. If less than three electrons exist in the valence ring of any atom, these electrons can be easily influenced by natural forces to move away from one valence ring of an atom to the other. Therefore, when three or less electrons exist in the valence ring of any atom, these electrons are specifically called free electrons; free from nature's chemical bond that holds them in the position of the valence ring. Electrons are said to move or travel at the speed of light and light speed is documented to be approximately 186,000 miles per second or 300,000,000 meters per second. To help students identify with such tremendous speed, think of being able to travel around planet Earth approximately 7.5 times in one second. This is how fast electrons are reported to travel. If five or more electrons exist in the valence ring of any atom, it becomes extremely difficult for any of the five or more electrons to be influenced and moved away from their valence ring to valence rings of other atoms.

At this point, it is very important for students to realize that electrons are residing within all material and substances waiting to be influenced to move in a specific direction. Free electrons can be easily influenced and moved from one valence ring to the other. Therefore, electrons can be deliberately and disproportionately moved and accumulated in one area by way of friction, chemical activity, heat, or magnetism. If electrons can be made to move away from the valence rings of quintillions of atoms and disproportionately accumulated and attached to quintillions of other atoms within a structured device (i.e. a battery), nature will cause inherent natural forces to act upon all displaced and accumulated electrons with a force that obligates them to return and fill the vacancies created in the valence rings of the atoms from where they were moved. I like to compare this concept to the natural elasticity in a rubber band. When a rubber band is stretched, its elastic properties will force the stretched rubber band material to contract and snap back to its original state and form. This concept will be referred to as the rubber band effect. Students can see and feel the results of this rubber band effect.

Look for Part 2 of this article in November's ATech Educator News.

Questions or Comments:
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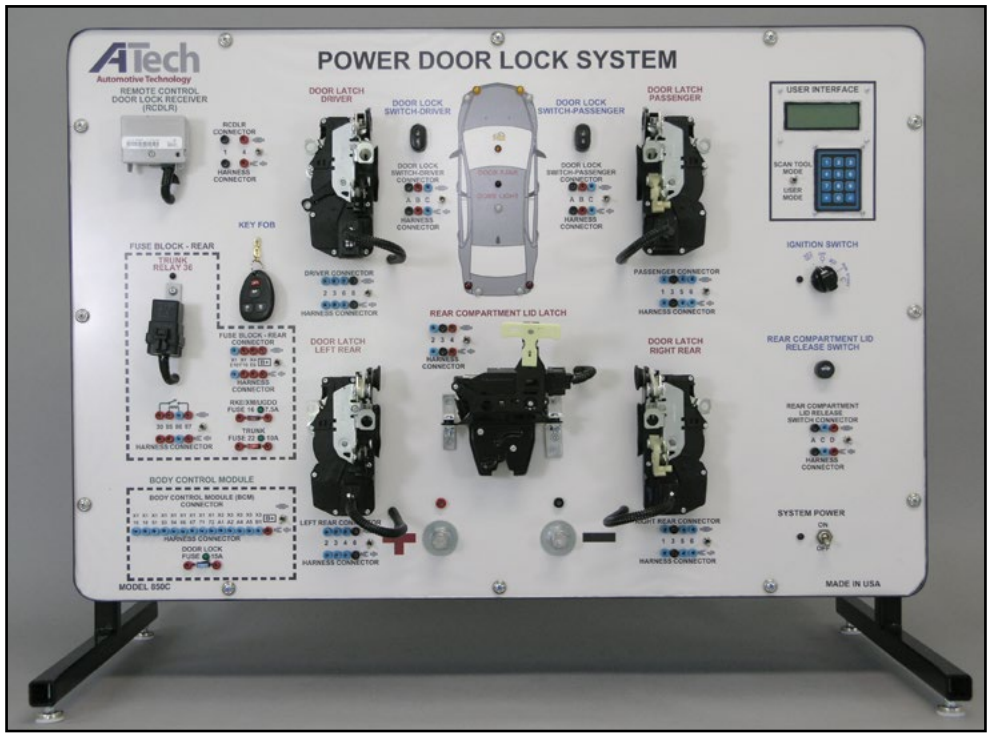
Power Door Lock System (model 850C)



The ATech Power Door Lock System Trainer (model 850C) is designed to teach computer and network-controlled automotive door lock and theft deterrent system operation. This trainer allows for instructor demonstration, student hands-on reinforcement, and troubleshooting practice. Powered by a 12VDC automotive battery or a 12VDC/23A power supply (not included).

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