Electron Theory

This unit discusses basic electrical science principles.

At the conclusion of this training unit the trainee should be able to:

Explain the basic principles of electricity.

Following this objective, you should be able to:

Recall the basic principles of electrical science.

Relate electrical science to work applications.

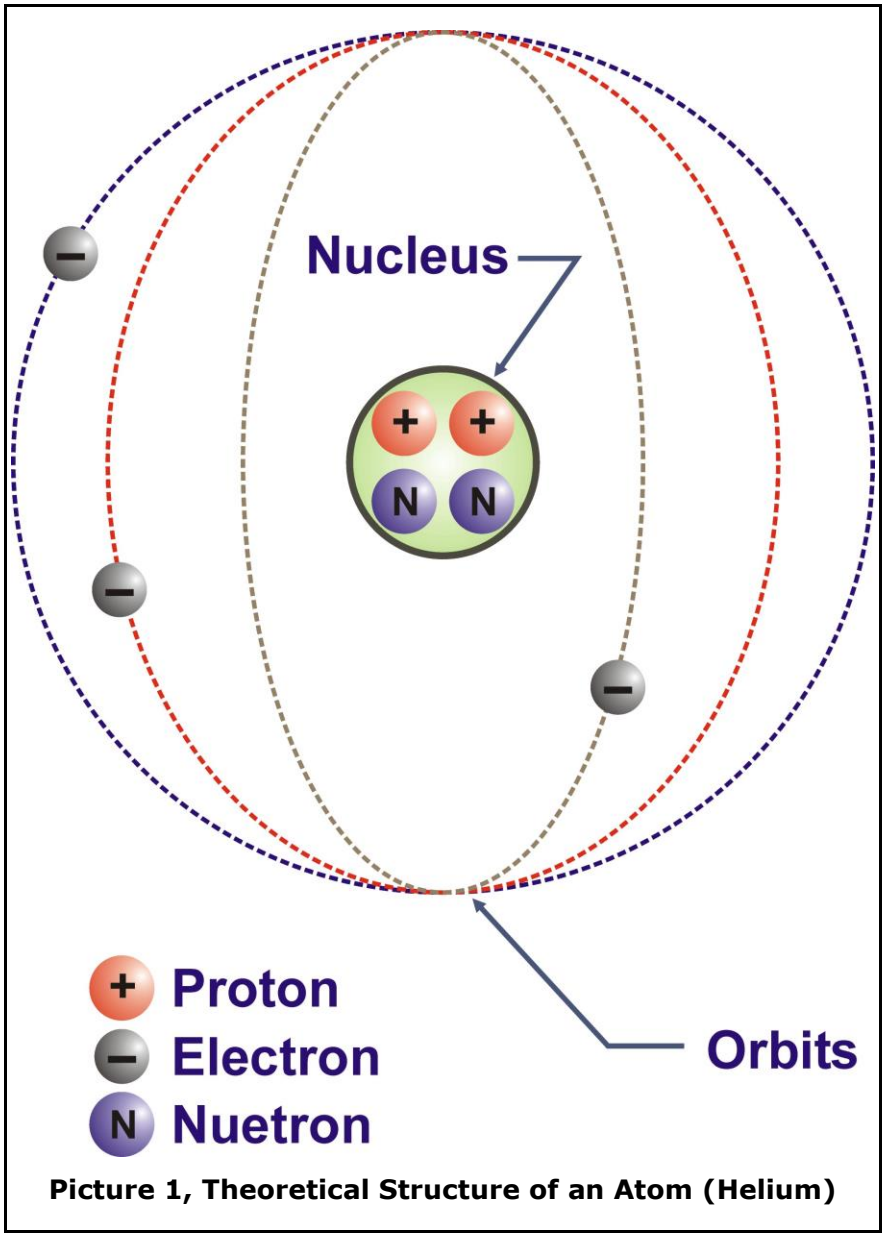
Identify how electrical science is applied to work.

At the conclusion of this training unit the trainee should be able to apply electrical science and relate these principles to their individual job. Trainees may be evaluated by completing a written exam comprised of questions from this training unit and others included in this course. A minimum of 80% accuracy is required to satisfactorily complete this training.

A. Electron Theory

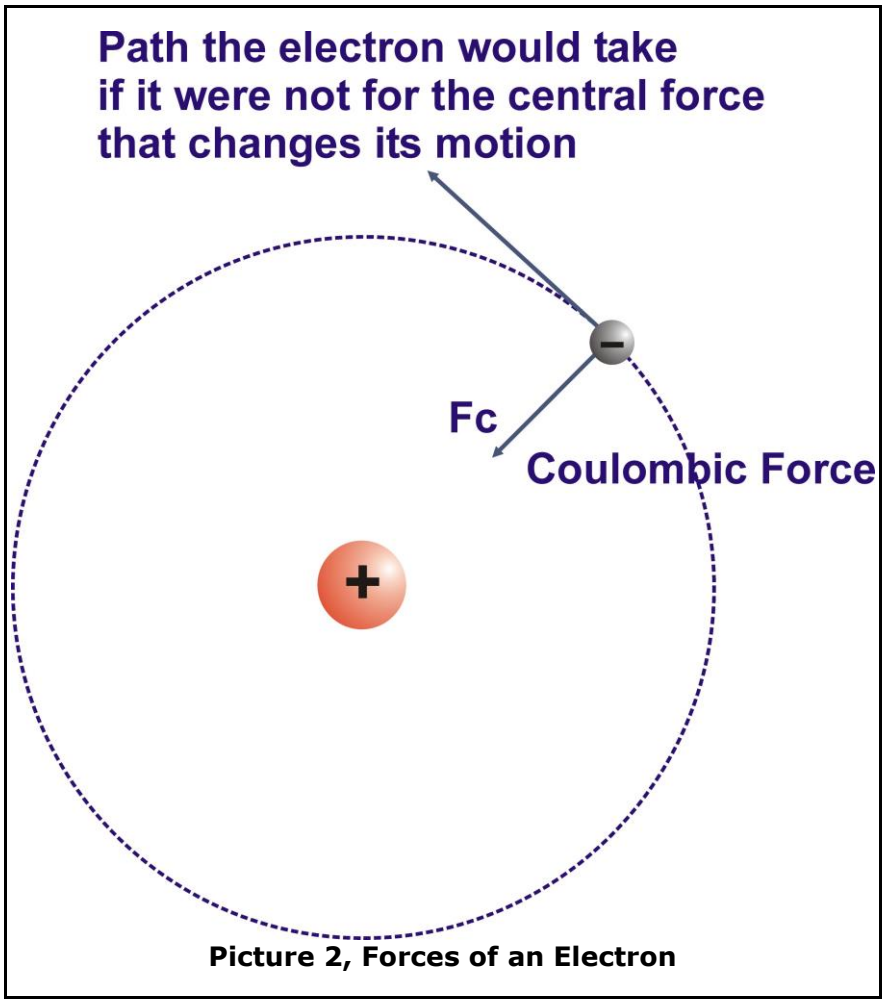
1. Review of Atomic Structure
2. Electricity is the flow of electrons through a conductor. An electron is one of the particles that make up the atom. The atom is the smallest particle in which a chemical element can retain its physical and chemical characteristics.
3. There are many kinds of molecules or chemical substances, but only approximately 100 kinds of atoms. Once shown the atom could be broken into smaller pieces, the electron theory of the structure of matter was developed. According to the electron theory, all matter is composed mainly of three types of particles:
   a. electrons - particles carrying a negative electrical charge;
   b. protons - particles carrying a postive electrical charge; and
   c. neutrons - particles that carry no electrical charge.

4. The atom is made up of an inner core (nucleus) surrounded by a number of electrons in different shells or energy levels, originally called orbits (illustrated below).



Picture 1, Theoretical Structure of an Atom (Helium)

1) The nucleus consists of protons and neutrons bound together by a force of attraction. This force overrides the mutually repelling effects between protons and causes them to bind to the neutrons very tightly. Electrons revolve around the nucleus in an orbit or electron shell.



Picture 2, Forces of an Electron

5. We know that an object in motion will continue motion along a straight line unless acted on by an external force. The electrons motion at any instant is tangential to the circular orbit. (Picture 2) The electron would continue along this tangential path except for the fact that it feels a central or centripetal force due to the coulombic attraction of the nucleus. This central force holds the electron in its orbit.

6. The electron's negative charge is equal and opposite to the proton's positive charge. Hence, these charges tend to neutralize each other. The nucleus contains all the protons and carries a total positive charge equivalent to the number of protons present. The normal atom has no net electrical charge. Although opposite electrical charges carried by an electron and a proton are

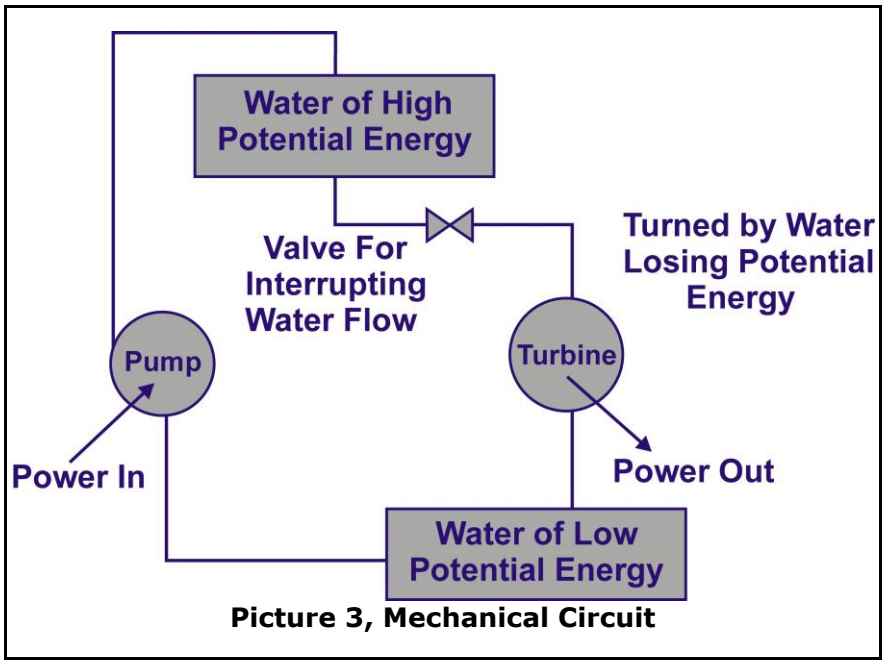
equal in magnitude, the mass (or weight) of the proton is about 1,840 times as great as the mass (or weight) of the electron. "Concentric Shells" only apply to the Rutherford/Bohr model atom. The concentric shell model has been replaced by a more sophisticated quantum mechanical model. Even though the shell model is not strictly correct, it can serve as a valuable learning and conceptualization aid. For this reason we will use it here.

7. As previously stated, the normal atom has one electron for each proton in the nucleus. These electrons revolve around the nucleus in an orderly fashion. Their orbits (or paths) are concentric shells or layers around the nucleus. There are a maximum number of electrons that each shell can contain. Excess electrons arrange themselves in the next outer shell.
8. Except for electrons in the outermost shell, the atom's particles are held together tightly. Tremendous forces are required to pry them apart. The most difficult to disrupt is the nucleus, then the electrons in the shells closest to the nucleus. Orbital electrons are held in place by the attraction between their negative charges and the positive charges of the protons in the nucleus.
9. Electrons in the outermost shell are the least difficult to disturb. Most electrical theory is possible because these outer-shell electrons are loosely attached to the nucleus.
10. The normal atom is uncharged because the number of electrons and protons are equal. However, when an orbital electron is removed from an atom it is called a free electron and the electron-deficient atom is called a positive ion. Some electrons of certain metallic atoms are so loosely bound to the nucleus that they are comparatively free to move from atom to atom. Thus, a very small force will cause such electrons to become free electrons. These free electrons constitute the flow of an electric current through electrical conductors.

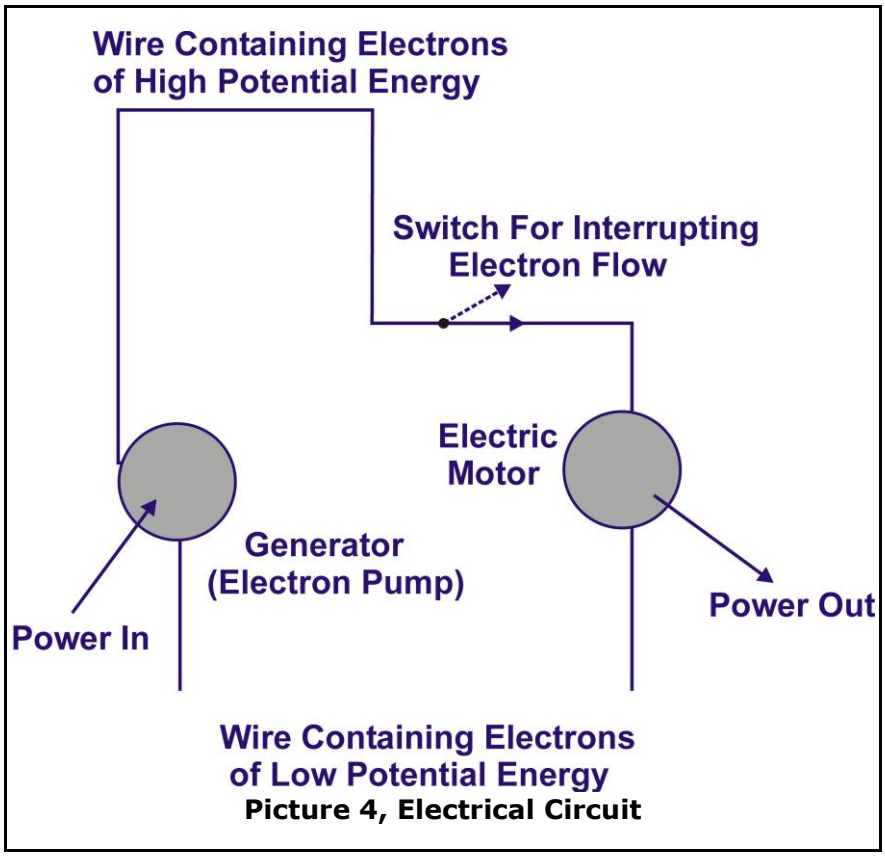
1) A body that loses some electrons (or negative charges) is positively charged. Similarly, a body that gains electrons is negatively charged. If the positively charged body comes in contact with one having a normal charge or a negative (too many electrons) charge, electrons will flow between them. Electrons leave the negative body and enter the positive body. Electron flow continues until both bodies have equal charges.

B. Mechanical to Electrical Component Analogy

1. Various materials and mechanical devices control the flow of electrons and harness them for work. If the flow of electrons through a wire is compared with flow of water through a pipe, the study of moving electrical charge is simplified. Consider the mechanical system (Picture 3) and its analogous electrical system (Picture 4).



Picture 3, Mechanical Circuit



Picture 4, Electrical Circuit

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PRACTICE:

1 Off what is the nucleus of an atom composed?

2. What force keeps an electron from leaving its orbit?