UNREGISTERED

Version 1.0

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1.0 Purpose

The purpose of this document is to provide an overview of Electricity in a format that takes advantage of the capabilities of multimedia computers. Updates and expansions will make this multimedia document more comprehensive. Intended users are students and educators in settings ranging from elementary to high school. Please feel free to share the unregistered version with friends, associates, and post it on Internet sites. We hope that this multimedia document is a useful addition to your software library.

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Up to date information about Electricity can be obtained at:

http://www.fortunecity.com/skyscraper/straylight/147

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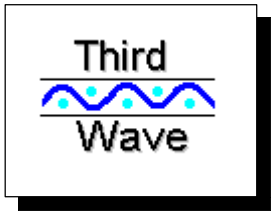


The Third Wave Corporation is a nonprofit group organized to develop and produce powerful and easy to use computer software for educational and other everyday uses. The development of this program was coordinated by R. L. Robinson, our scientific software director. We are interested in suggestions, volunteers to revise existing sections of this program, and volunteers to write additional sections for this program. We may be contacted at:

third_wave@usa.net

Please visit our web site at:
http://www.fortunecity.com/skyscraper/straylight/147
for up to date information on Electricity and our other projects.

1.30 Credits

R. L. Robinson, MS	Program Development Coordinator
J. R. Robinson	Software Consultant and Programmer
M. P. Robinson	Software Testing
W. D. Robinson	
M. Lamb	Distribution and Marketing

1.40 Registration

To provide this program at the lowest possible cost to customers, it is being distributed as shareware with a registration fee is $10.00 U.S.. For educational users, a site license can be purchased for $15 + $5 per additional machine. Registration entitles you to a full year of free upgrades and technical support. Additionally, registered users will be able to print the contents of this document. To register, please send a check or money order drawn against a U.S. bank in U.S. funds to:

Third Wave Corporation
c\o Michael Lamb
PO Box 393
Florissant, MO 63032

The check should be payable to Michael Lamb. Please be sure to include the address you wish to have the document shipped to.

2.0 What is Electricity?

Electricity is the energy that comes from electric charges. Two types of electrical charges exist, positive and negative, that are equal and opposite in character. Electrical charges are produced when an object gains (negative) or looses (positive) electrons. Because the positive and negative charges are opposite in character, they attract one another and become less charged overall. Two charges of the same type will repel one another so the amount of charge in a single place does not become too great. These electrical charges can be made to move within a conductor and used to perform useful work such as providing energy for a lightbulb.

2.1 Positive Charge

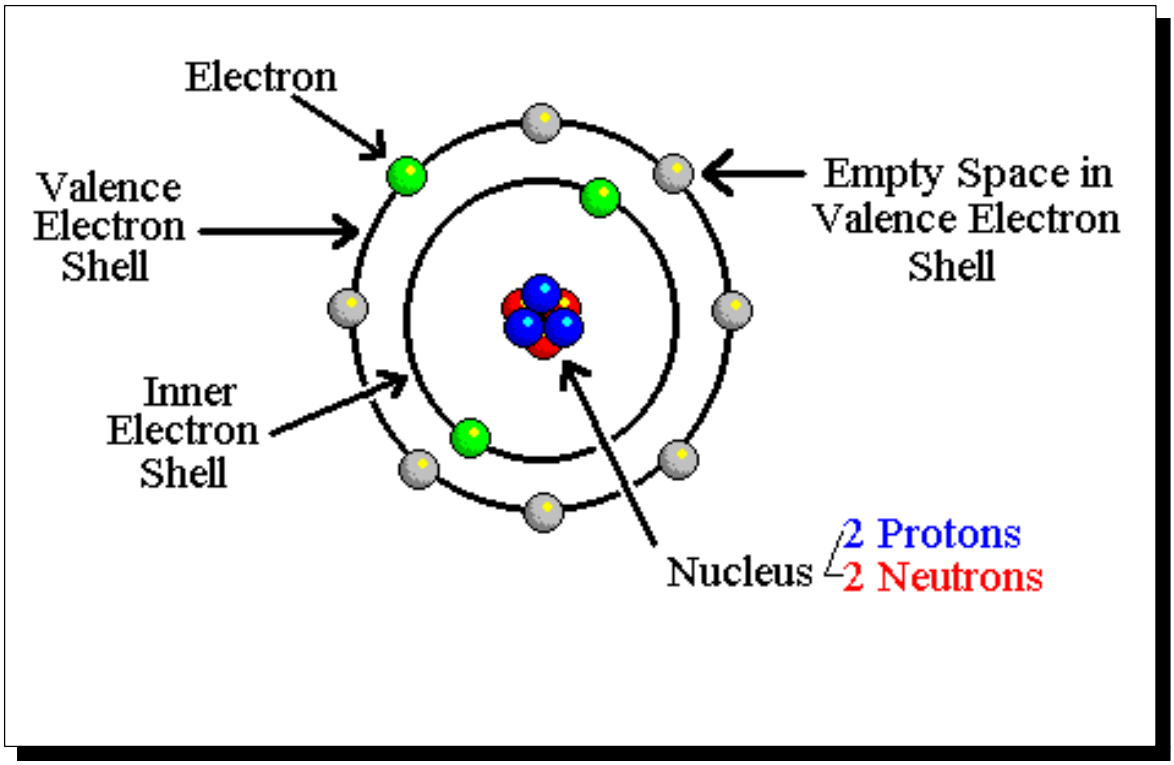
A positive charge can be produced by rubbing a plastic rod with a piece of fur. Electrons are taken from the plastic rod by the fur to make the rod positive.

2.2 Negative Charge

A negative charge can be produced by rubbing a glass rod with a piece of silk. Electrons will be taken from the silk by the glass rod to make it negative.

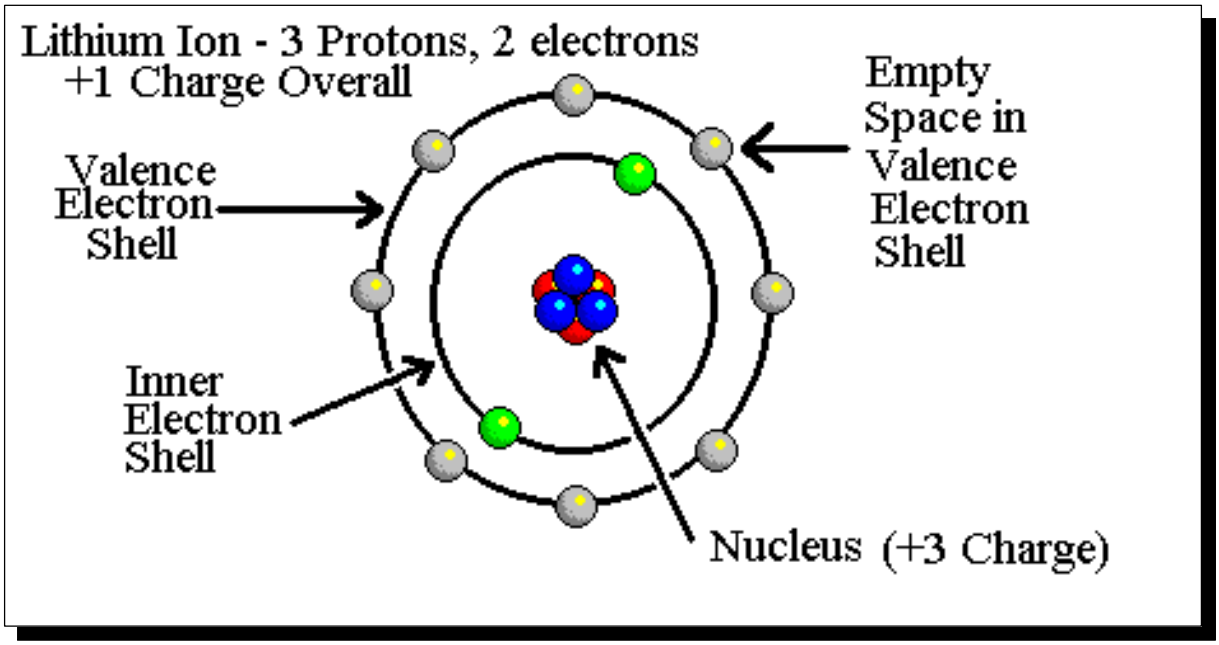
2.3 Electrons

Electrons are subatomic particles that have a negative charge. They are attracted to the positively charged protons in the nucleus of an atom, and usually the numbers of electrons and protons in an atom are equal. As they orbit the nucleus, the electrons are arranged in shells. These electron shells can only hold a defined number of electrons, and the outermost shell is called the valence shell. The first shell can hold two electrons. The second shell can hold eight electrons, and the third shell can hold up to 18 electrons. Additional shells are found in atoms that have greater than 28 protons, but it is important to note that the shells fill up in a sequential manner. If the outermost (valence) shell is not completely filled with electrons, the atom can temporarily gain or accept an electron to become an ions.



2.4 Ions

Ions are atoms that are charged. They have either gained (negative ions) or lost (positive ions) electrons in their valence electron shells.



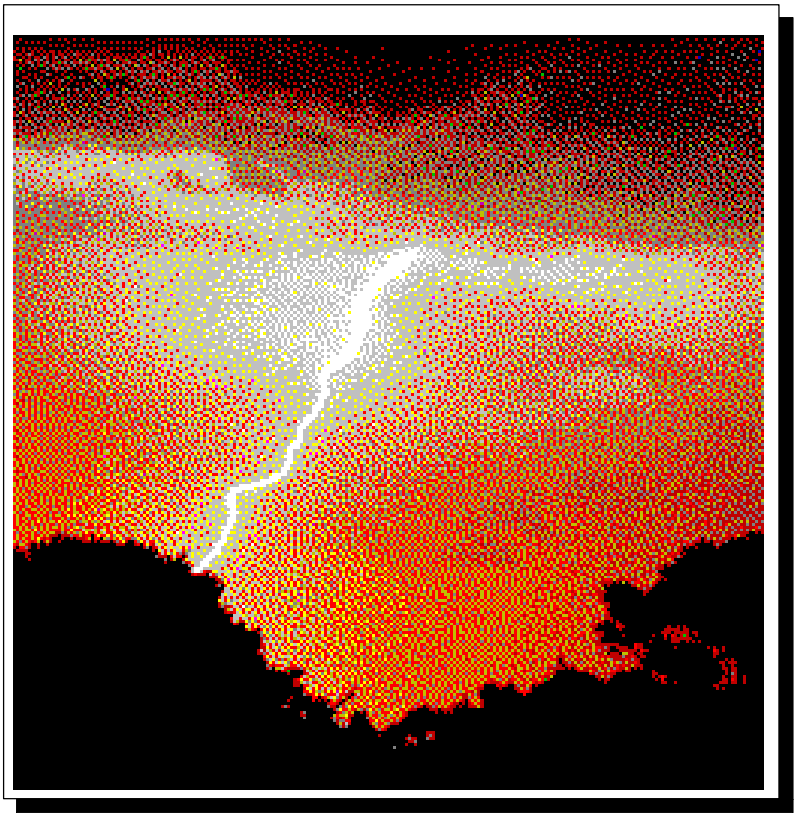
3.0 Kinds of Electricity

Electricity exists in three major forms that effect how the electricity can be used. Static electricity is unintentionally generated by walking across a carpet or in an electric clothes dryer. This static electricity is often considered a nuisance, but large accumulations of static electricity produce lightning. Alternating current and direct current are useful forms of electricity that are used to run electrical devices.

- Static Electricity
- Direct Current
- Alternating Current

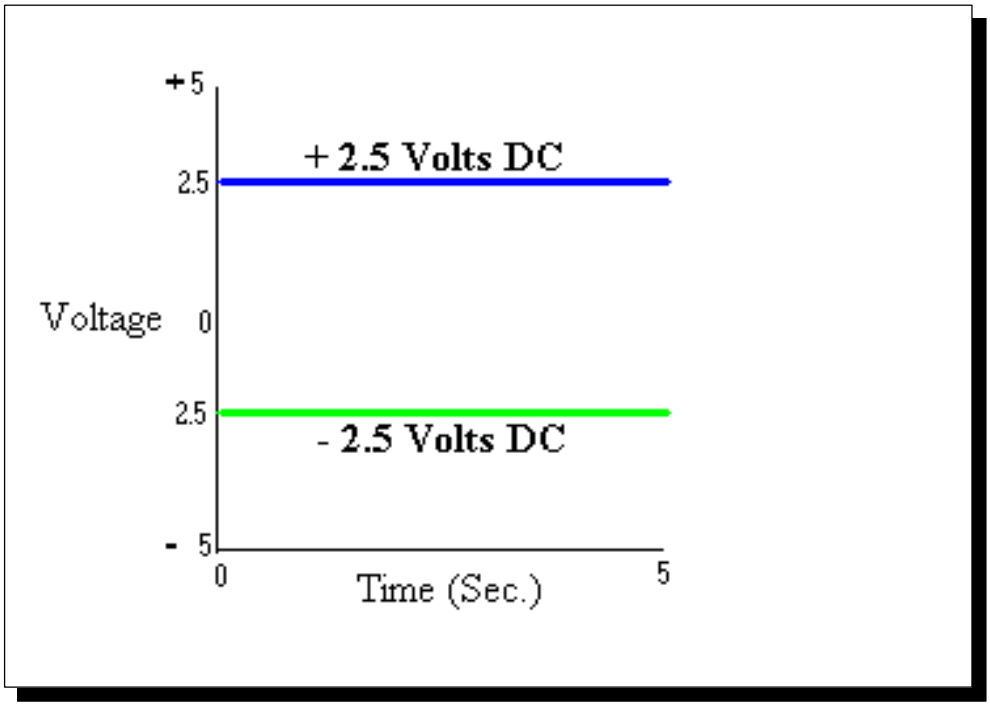
3.1 Static Electricity

Static electricity is the buildup of electric charge at rest. It is often generated by rubbing different materials together such as glass and silk. Very large static charges build up within clouds because positive ions from the clouds are drawn towards the ground and negative ions from the clouds are forced higher up because of repulsion from the ground. When a large enough positive charge builds up at the base of a cloud, it can cause a violent discharge called lightning. A lightning discharge happens when the potential difference between the cloud and the ground is great enough to break down the air molecules that separate them. This breakdown of air molecules allows electrons to travel from the ground to the cloud, producing lightning. Because of the large potential differences found in lightning, objects that separate clouds from the ground such as trees or buildings can be damaged.



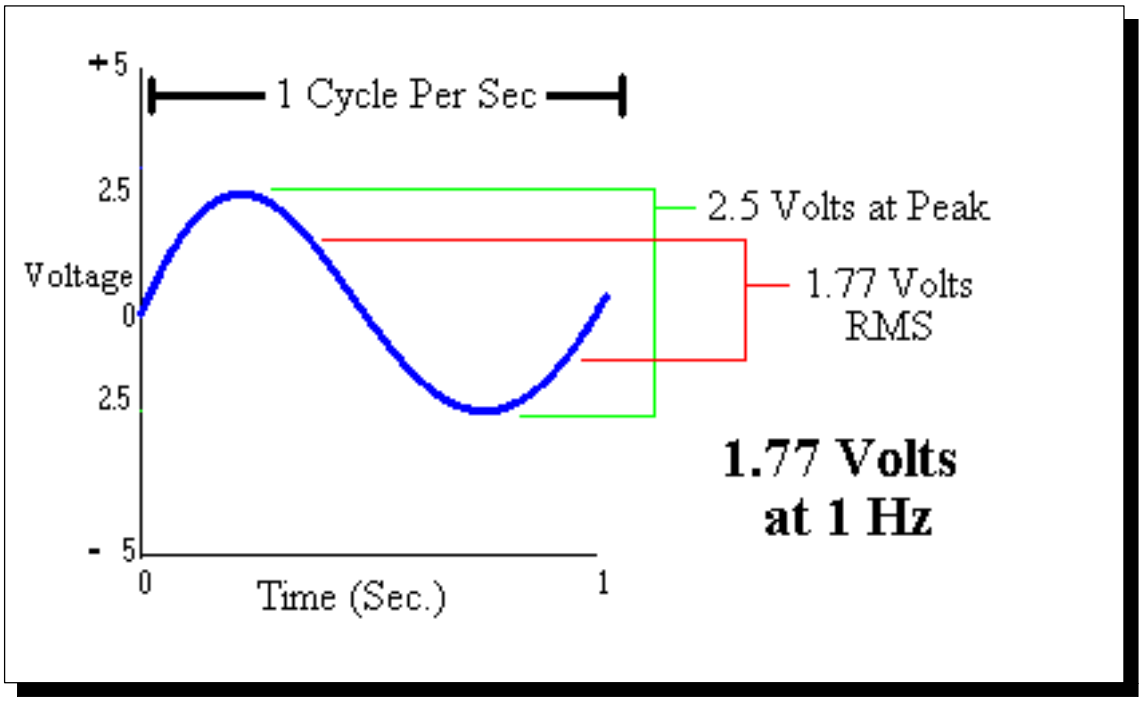
3.2 Direct Current

With direct current (DC), electrical charges always flow the same direction in a conductor. This produces a continuous supply of electricity that has a constant positive or negative nature. DC can be produced from batteries, electrical generators, and rectifiers. Many electronic devices such as computers and television sets operate on DC that is produced by converting AC from the wall socket to DC with a rectifier. A more complex device called a power inverter can be used to convert DC to AC.

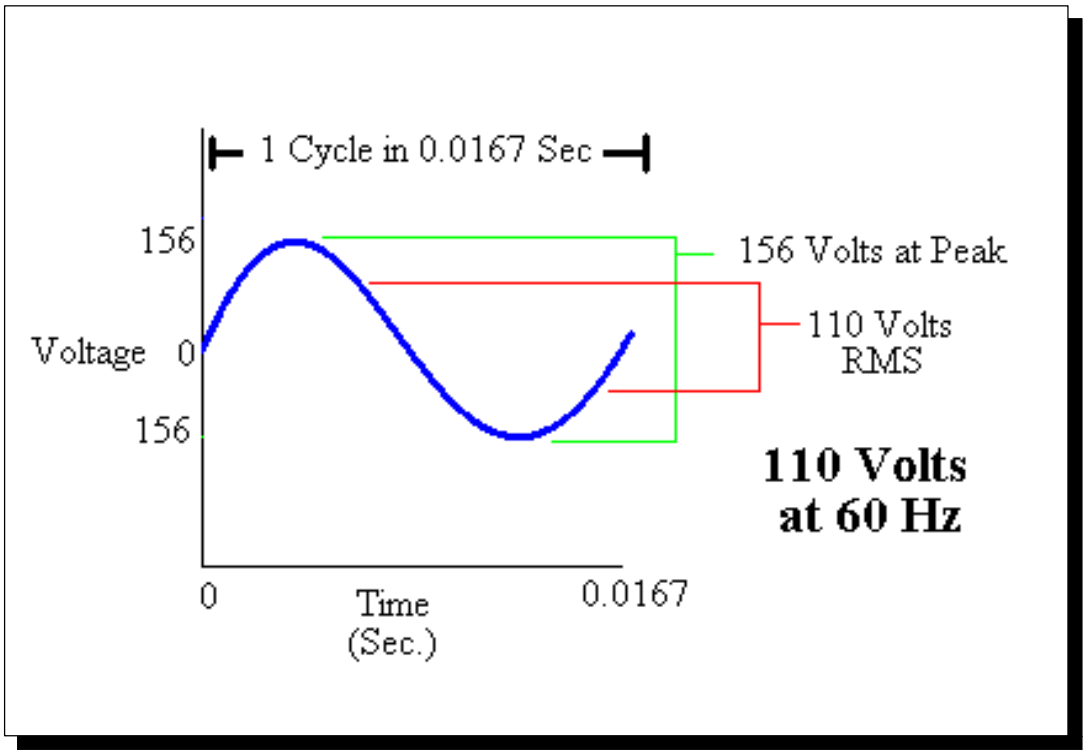


3.3 Alternating Current

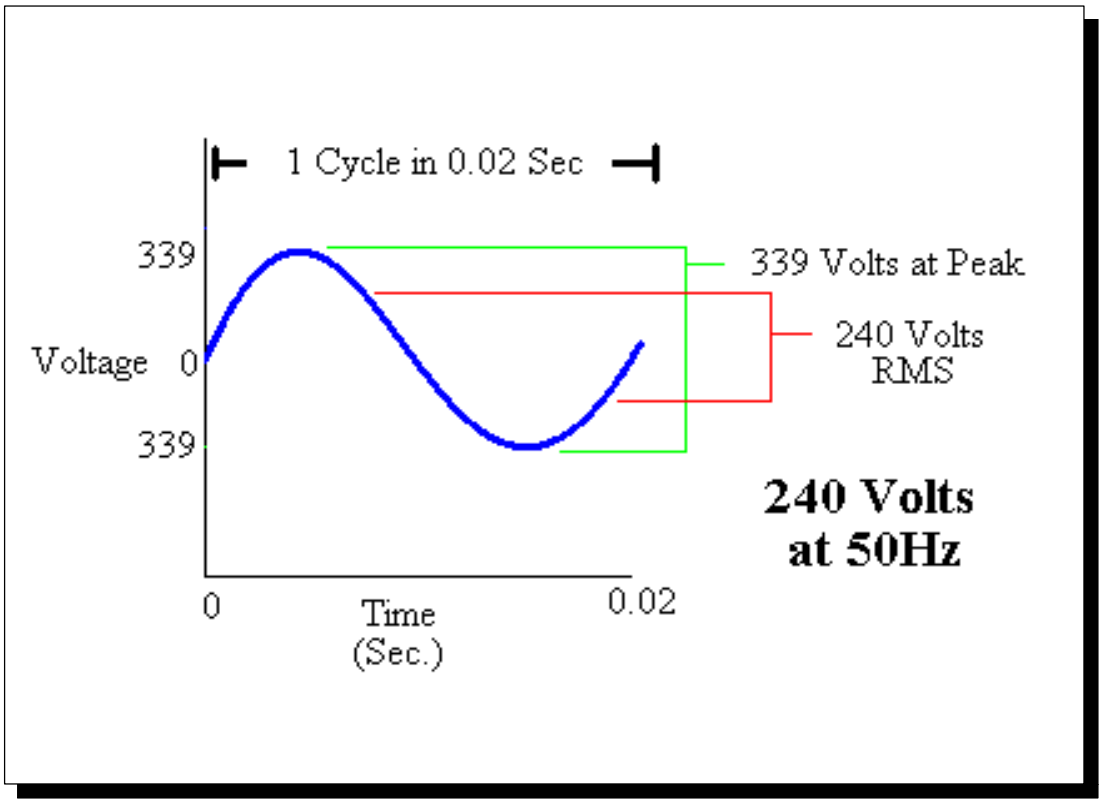
With alternating current (AC), the flow of electrical charges in a conductor are periodically reversed. One complete reversal of flow is a cycle, and the number of cycles per second gives the frequency of that alternating current in Hertz (Hz). The electricity that comes out of the wall socket is AC, and in North America it has a frequency of 60Hz. In Europe the frequency of AC is 50Hz. If the change in voltage is plotted against time, a sine wave is produced. The amplitude of the sine wave represents the maximum voltage available, but the root-mean-square(RMS) voltage is used in practice. The RMS voltage is calculated by multiplying the peak voltage by 0.707. In Europe and many other countries AC is supplied at 240 volts RMS , which means that peak voltage is 339 volts. The United States and Canada supply AC at 110 volts RMS with a peak of 156 volts. AC is well suited to many applications because AC motors have greater reliability than DC motors, and the voltage of an AC current can be easily changed with a transformer.



AC in the United States



AC in Europe

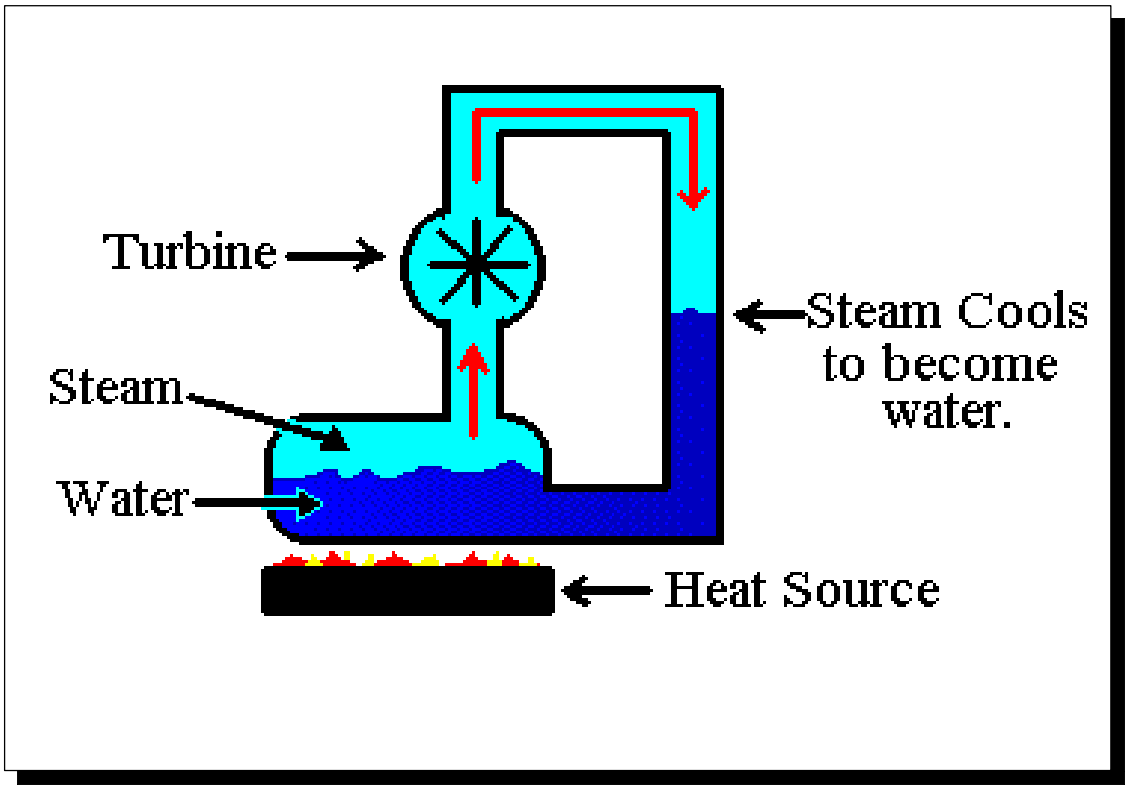


4.0 Making Electricity

Most AC current is generated by using a turbine attached to an electric generator which produces the electricity. The turbine is powered in one of two ways. Water is heated to make steam which is then used to spin the turbine, or the turbine is coupled directly to the combustion process. In the United States almost all the AC is generated by heating steam which is used to spin the turbine. DC current is produced by batteries or made from AC by rectifiers.

4.1 Steam powered turbines

The steam is generated by heating water with a combustion process or other heat source. When the water boils, the steam is able to spin a turbine that is attached to an electrical generator. The force that spins the turbine is from the expansion of water as it becomes steam. After passing through the turbine, the steam is cooled to become water again. The condensed steam can then be reheated to make more steam.



4.2 Coal

Coal is burned to heat water into steam. The steam drives a turbine which is coupled to a generator to produce electricity. This method is used to produce about 70% of the electric power in the United States. Large deposits of easily mined coal make this an inexpensive way to heat water to produce steam, making this one of the most economical methods of producing electricity. The major problem with the use of coal to produce electricity is the pollution. Coal often contains impurities such as sulfur which react with the atmosphere to produce harmful substances such as acid rain. Exhaust scrubbers remove impurities from coal are a solution to this problem, but they make coal less economical.

4.3 Oil

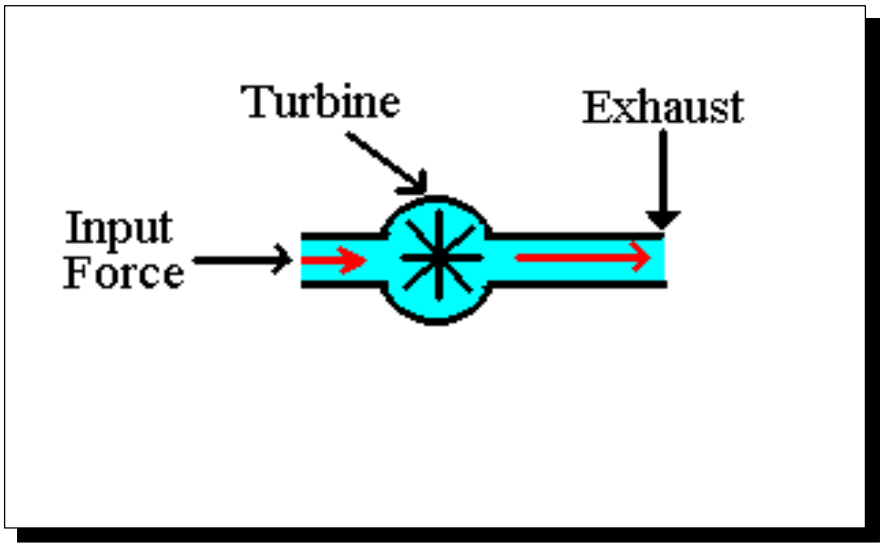
Oil is burned to heat water into steam. The steam drives a turbine which is coupled to a generator to produce electricity. Because oil is relatively clean burning, this method produces much less pollution than does coal burning. However, oil is expensive and most oil must be imported to the United States. Oil burning is not a very economical way to produce electricity.

4.4 Nuclear Fission

Nuclear fission harnesses the heat released from the splitting of atoms make steam. This steam is then used to drive a turbine which is coupled to a generator to produce electricity. As an atom is split it becomes small fragments of the original atom. These small fragments form new atoms. The splitting of the original atom releases large amounts of energy. The energy is converted into heat as the surroundings absorb the energy. Nuclear power plants are very expensive to build and the public has concerns regarding the radioactive materials used to generate electricity. A catastrophic failure of a nuclear power plant is called a meltdown, and is very harmful to the environment. During normal operation, nuclear power plants produce little or no pollution.

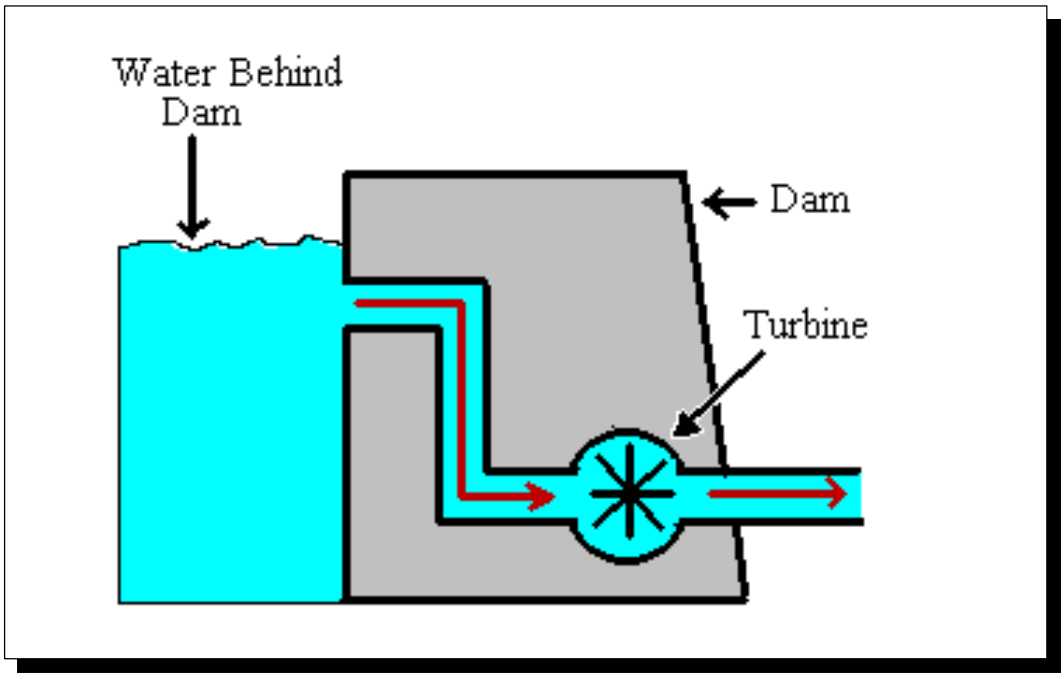
4.5 Process Driven Turbines

Some electric power is generated by moving a turbine by a specific process such as moving water or wind. Some examples are hydroelectric, gas turbines and wind power. Process driven turbines do not heat water into steam, and are more efficient than steam driven turbines.



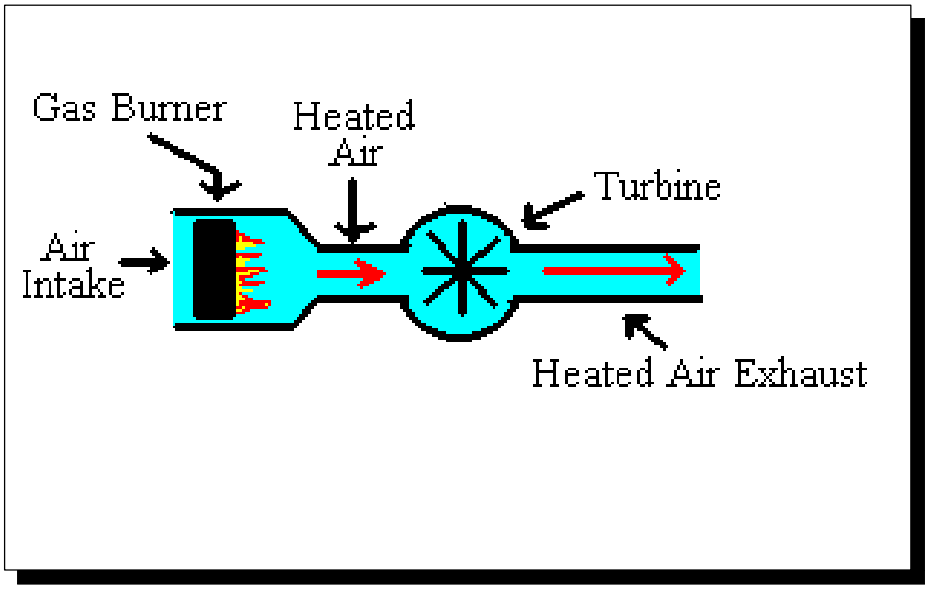
4.6 Hydroelectric Power

Electric power is generated by water forcing an electrical generator to move. This is accomplished by building a dam and placing turbines at the bottom of the dam. As the water comes out of the bottom of the dam the water spins the turbine, which then turns the electrical generator. This type of electric power generation is the cheapest and least polluting methods available today.



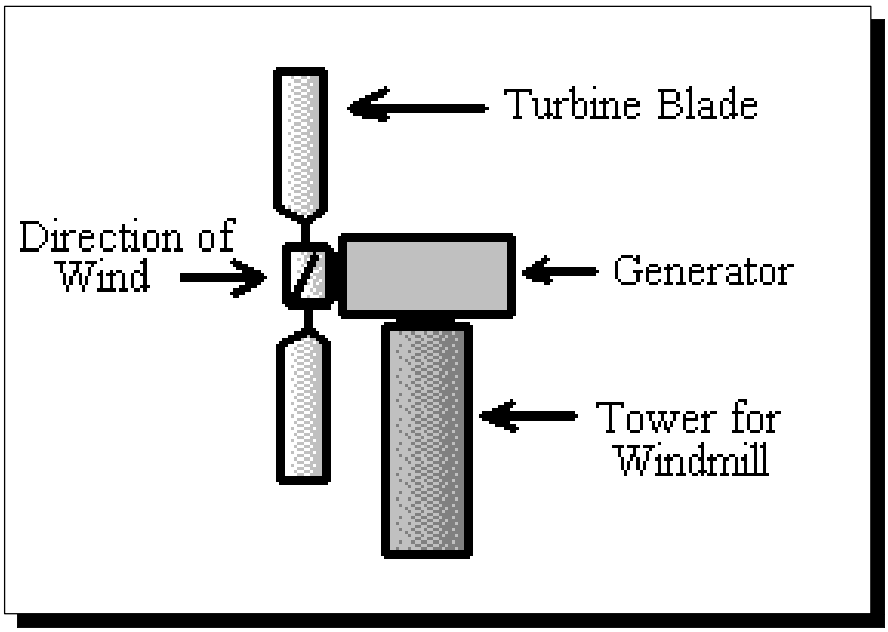
4.7 Gas Turbines

With the gas turbine process, natural gas is burned and the exhaust is used to spin the turbine. Essentially the turbines in a large jet engine turn an electric generator, producing electricity by one of the most efficient means available. Natural gas is plentiful and relatively inexpensive. Also, burning natural gas produces little pollution. These advantages make gas turbines attractive methods of generating electricity.



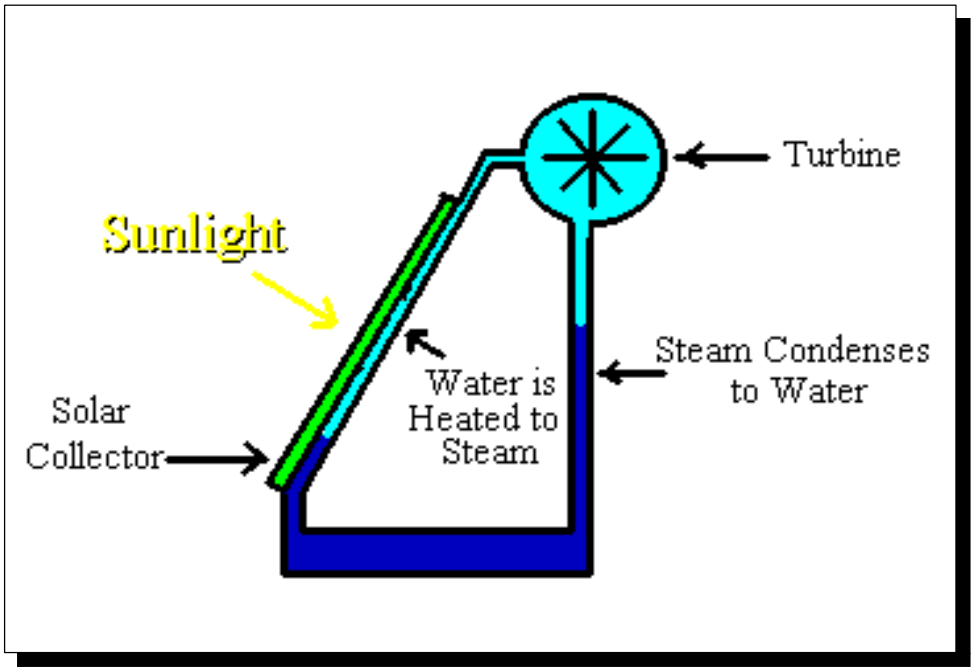
4.8 Wind Power

The wind is used to generate electricity by attaching a propeller to a electric generator. When the propeller is moved by the wind, the generator is turned to produce electricity. Wind power is only used in areas which have a relatively steady wind because the propellers are very hard to start moving. When they are turning, the propellers require very little wind to generate electricity. Because no fuels are burned to produce electricity by this method, wind power does no damage to the environment. However, because of the need of a relatively steady wind, only a few places are suitable for wind power.



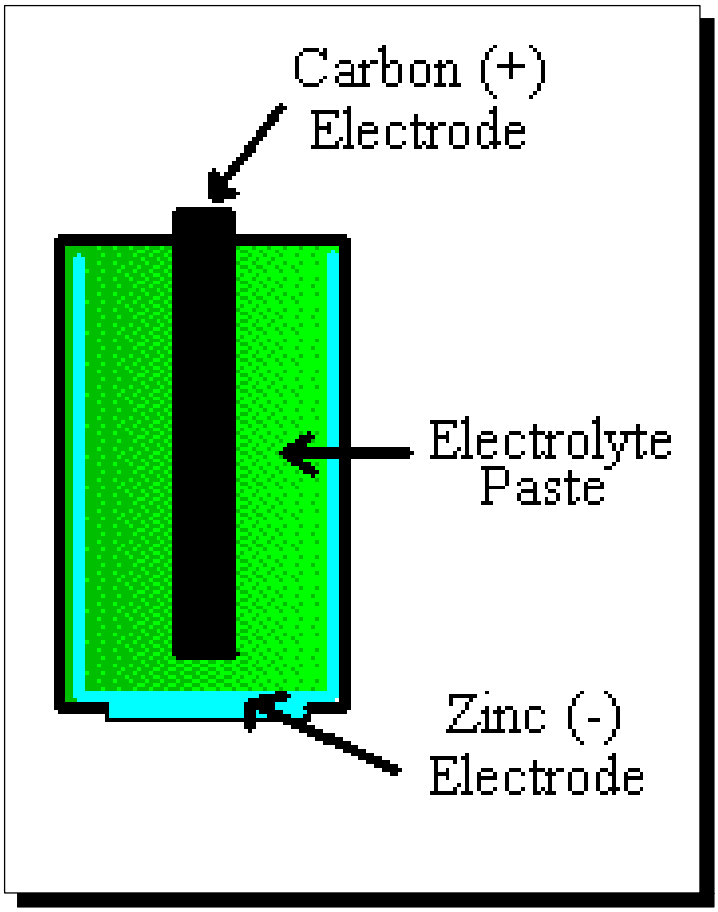
4.9 Solar

If there is a constant supply of sunlight, water can be heated to steam by focusing solar energy. The power of the sun is enhanced with the use of parabolic mirrors, which focus the sunlight directly onto the pipe carrying the water. The water is heated until it becomes steam which is then used to spin a turbine. This method of generating electricity produces no pollution, but is only practical in areas that receive a steady supply of sunlight every day.



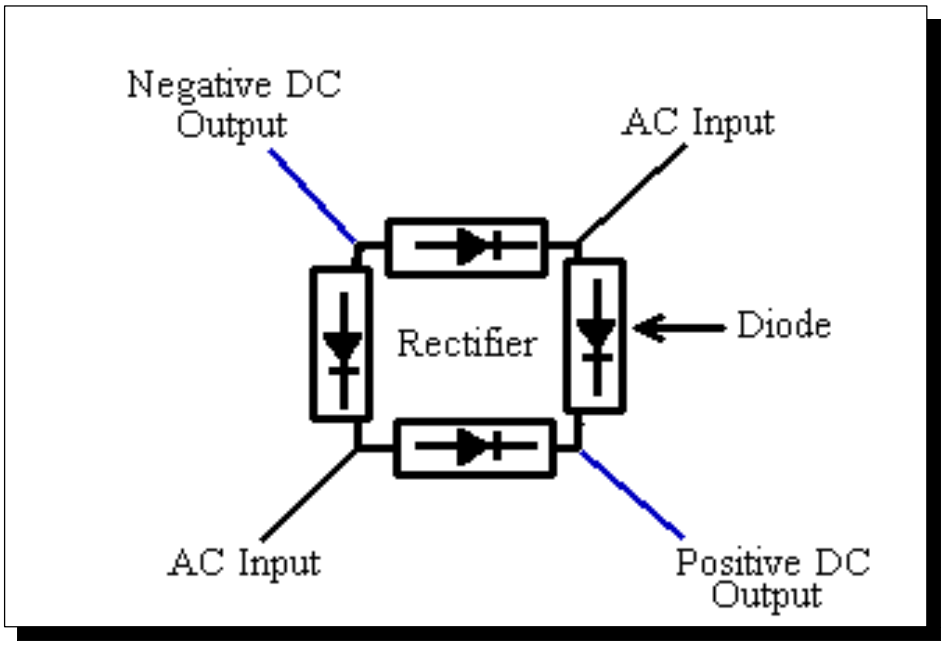
4.10 Batteries

A battery is a device that produces DC from an electrochemical reaction. This reaction involves the transfer of electrons from two electrodes that are contained within a conductive media called and electrolyte. The negative electrode gains electrons while the positive electrode gains electrons to establish an electrical potential. The electrolyte is typically an ion-conducting paste, and the electrodes are zinc and carbon. The voltage produced by a battery is determined by the free energy differences between the reactants and the products, an is typically 1.5 volts. Higher voltage batteries, such as 9-volt batteries, can be produced by connecting several smaller batteries in series to produce the desired voltage.



4.11 Rectifiers

A rectifier is a device that converts AC to DC. This device is constructed from semiconductor diodes that allow the passage of only the negative or positive portion of an AC current. Rectifiers are often mounted in finned metal plates called heat sinks to encourage the radiation of the heat generated by the rectification of AC current.

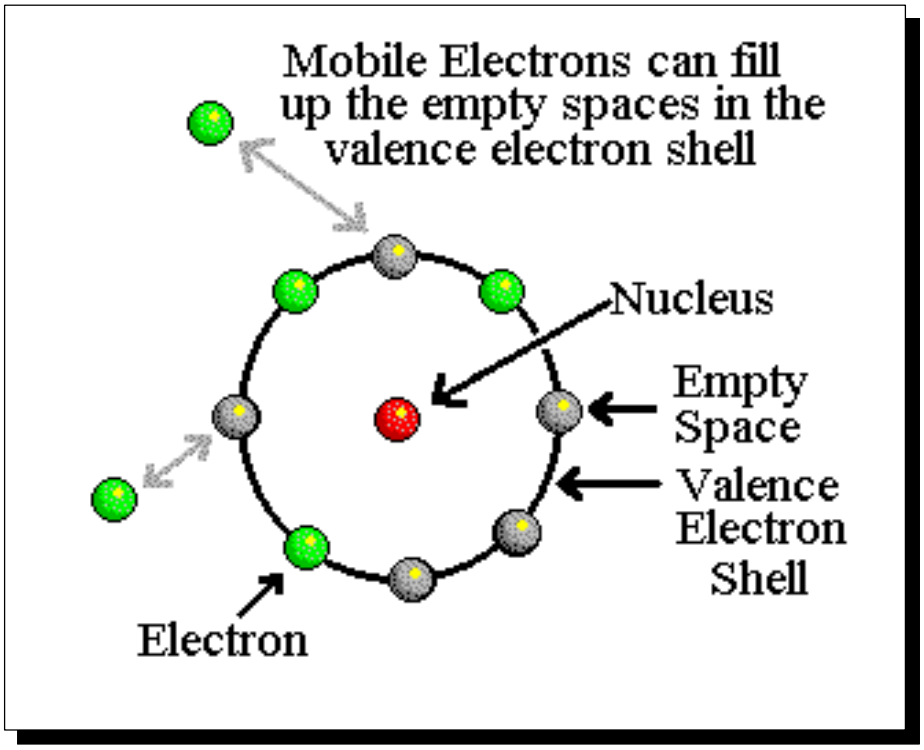


4.12 Solar Cells

Solar cells are semiconductor devices that produce DC directly from sunlight. They produce no pollution, and can produce electricity with relatively low light levels. Solar cells available today do not produce much current, but they are highly reliable means of providing small quantities of electricity.

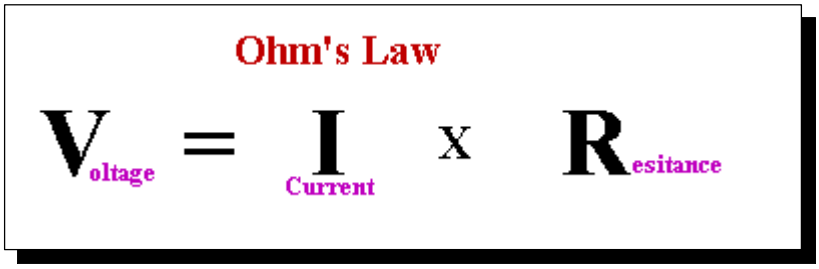
5.0 Conductors

Conductors are materials that will allow the movement of an electric charge through them. This movement of charges establishes an electric current that has a defined sign (positive or negative), current, and voltage. Conductors have a resistance to current flow less than 1 ohm/meter, as do many metals. The electrical current can move if the valence shell of electrons is not completely filled. Electrons are temporarily added to or removed from valence shell, allowing the electrons to flow through the conductor.



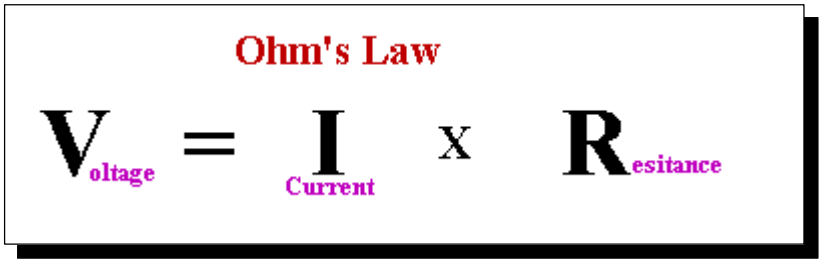
5.1 Resistance

Resistance the property of a material that slows the flow of electrons through it. Materials with high resistances do not conduct current well, while materials with low resistances are good conductors. The unit for resistance is an ohm, and it is related to voltage and current through Ohm's Law.



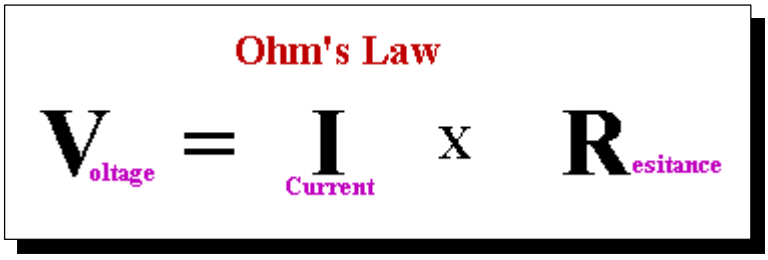
5.2 Current

Current is the force moving the charge in the conductor. The unit of current is the ampere (amp) and it is related to voltage and resistance through Ohm's Law.



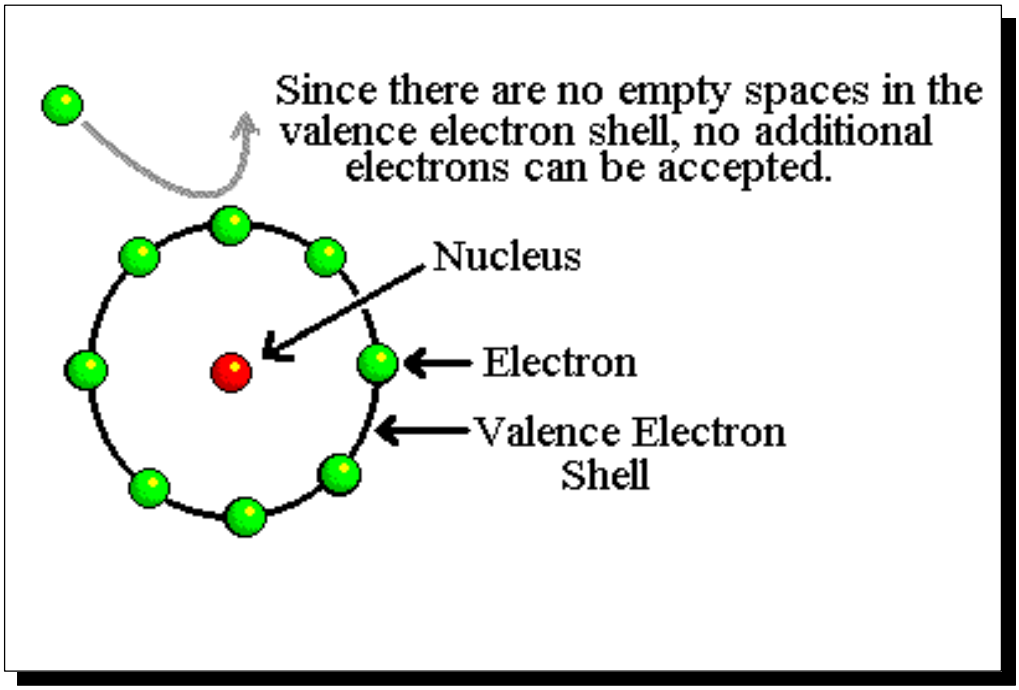
5.3 Voltage

Voltage is the size of the electrical potential. The units of voltage are volts, and it is related to current and resistance through Ohm's Law.



6.0 Insulators

Insulators are poor conductors with resistances greater than 100 million ohms/meter. Examples of insulators are glass and plastic, which have full valence electron shells. Because the valence electron shells are full, insulators cannot temporarily accept or donate electrons to move as the electric current. However, it is important to note that if the current is great enough, an insulator can conduct electricity.

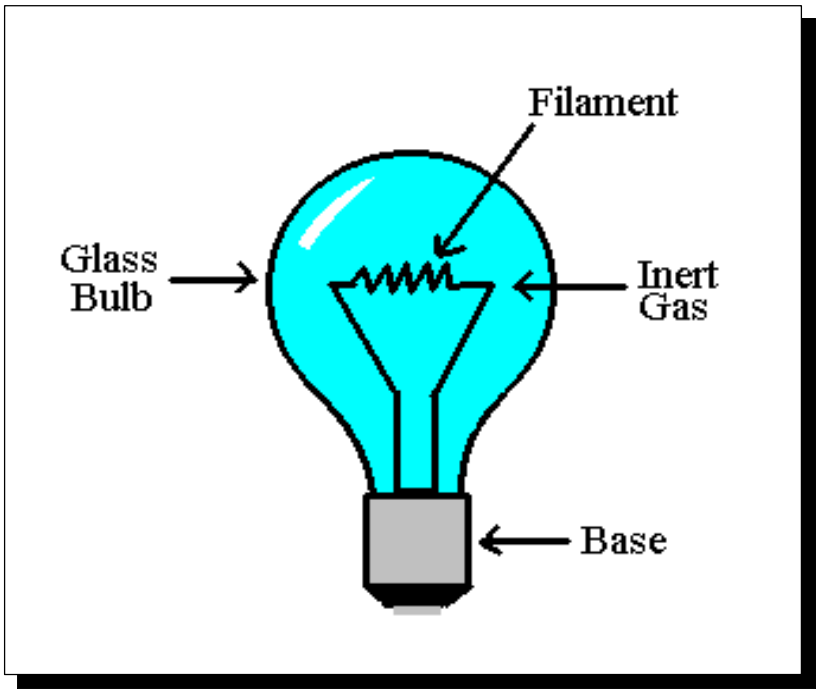


7.0 Electric Lights

Electric lights are an essential part of our society, and they consume a large portion of the electricity that is generated. Electric lights can be made to operate on DC or AC, but the bulk of electric lights use AC. They can be divided into two major classes, incandescent and fluorescent.

7.1 Incandescent Lights

Incandescent lights heat a filament, often a metal such as tungsten, until it is white-hot (incandescent) with an electric current. Because the filament is held in an inert gas such as argon it does not burn, but glows brightly to produce light. Modern incandescent lights can glow for more than 1,000 hours before the filament burns out, but they produce less light per watt than fluorescent lights.



7.2 Fluorescent Lights

Fluorescent lights are tubes that are filled with a metal vapor that is ionized by an electric current. When the metal vapor is ionized, it emits light that causes the phosphor coating inside the tube to glow, thus producing visible light. Because fluorescent lights produce more light per watt than incandescent lights, they are preferred for lighting in schools, offices, hospitals, factories, and commercial establishments.