Topic 1 - Electric Charges

When you get a 'shock', feel a 'jolt', or, a 'spark', you are experiencing the same type of electrical effect that makes lightning. Static electricity happens when there is an imbalance of electrons (which have negative charges).

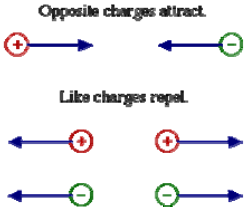
Producing Charges

Materials that attract or repel other materials are said to be charged, or carry an electric charge. Charges, which can be detected by an electroscope, are produced when materials are rubbed, touched or moved together and then separated. To refer to charges as stationary or 'static', would be inaccurate, because the charges are moving. *'Unbalanced charges'* is a more accurate way of describing this electricity. The quantity of electric charge is measured in *coulombs*.

Van de Graff (VDG) Generators These generators build up an excess of static charge using friction. A rubber belt rubs a piece of metal and transfers the charge to a sphere. When you touch the sphere the charge builds up on you. (Remember! - *like charges repel* - that is why your hair strands separate as you touch the sphere as the charge builds up on your body.)

Making Sense of Electrical Charges

Most objects have the same number of positive (proton) and negative (electron) charges. This makes them neutral (no charge).
When there is a difference in the electrical charge, certain actions are predictable, because of *the Laws of Electrical Charges.*



Benjamin Franklin was the first to describe the charges as 'positive' or 'negative'. When amber is rubbed with fur - some of the *electrons* in the fur move to the amber - the amber becomes negatively charged and the fur is positively charged. Charge separation occurs, when a charged object is brought close to a neutral object. The charged electrons repel the electrons in the neutral object and the charged object is then attracted to the protons of the neutral object (balloon on a wall)

Conductors, Insulators, and In-Between

In *insulators* electrons are bonded closely to the nuclei (allowing little movement), while in *conductors*, the electrons are free to move easily. Most metals are conductors and non-metals are insulators. A special type of conductor, called a r*esistor* allows electrons to flow, but provides some resistance (so it is sort of in-between a conductor and insulator).

Semiconductors are almost perfect conductors - they have almost no resistance to electron flow. Silicon semiconductors are used extensively to make computer microchips. The largest obstacle is to get the semiconductor to work at reasonable temperatures for practical applications. *Superconductors* are materials that offer little, if any, resistance to the flow of electrons.

Neutralizing Unbalanced Charges

Electrical Discharge is the movement of charges whenever an imbalance of charges occurs. The action results in neutralizing the objects. The over-charged electrons repel the electrons in the object and the positive protons attract the charged electrons causing a discharge or 'miniature lightning bolt'. There is now an electron balance. An ionizer can be used to neutralize charges on non-conductors.

Preventing Electrostatic Buildup

'Static cling' is a build-up of unbalanced charges on different materials. This build-up can be very costly because of the damage it can cause. Anti-static materials have to be used when handling charged objects, so that a discharge (which could cause harm or damage) does not occur. Anit-static sprays, coating or grounding strips.

Topic 2 - Electricity Within a Circuit

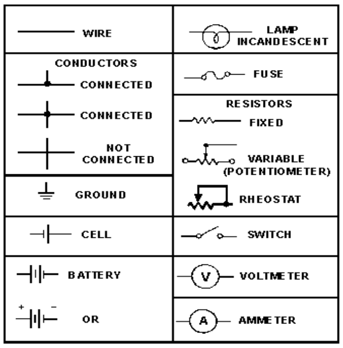
Circuit Elements and Diagrams

A circuit is a pathway that allows the flow of electricity. Most electrical circuits use wires (as conductors), although others may use gases, other fluids or materials.

All circuit diagrams have four basic parts:

- *source* - provides energy and a supply of electrons for the circuit … Battery
- *conductor* - provides a path for the current …Wires
- *switching mechanism* - controls the current flow, turning it off and on, or directing it to different parts of the circuit …Switch
- *load* - converts electrical energy into another form of energy … Bulb

Basic circuit symbols

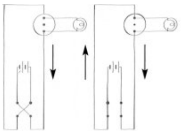


A drawing made with these symbols is called a *schematic* or schematic diagram.
The rules to follow when making schematic diagrams:

- Use a pencil and ruler on graph or unlined paper
- Place the components in a rectangular or square arrangement
- Conducting lines should be straight with 'right-angled' corners
- Do not cross conductors
- Be neat and make the sizes of the symbols consistent and easy to see

Example - Bulldozer

The toy bulldozer has 2 loads, a motor and a bulb. 2 1.5V cells act as the energy source. A switching mechanism connects to 4 wires. A circuit diagram representing this toy is as follows.



Measuring Current

The steady flow of charged particles is called electrical *current*. The flow continues until the energy source is used up, or disconnected. The rate at which an electrical current flows is measured in *amperes* (A). This flow varies from a fraction of an ampere to many thousands of amperes, depending on the device. An instrument used to measure very weak electric current is called a *galvanometer*. Larger currents are measured with an *ammeter*.

Measuring Voltage

Electrical energy is the energy carried by charged particles. *Voltage* is a measure of how much electrical energy each charged particle carries. The higher the energy of each charged particle, the greater the potential energy. Also called '*potential difference*', the energy delivered by a flow of charged particles is equal to the voltage times the number of particles. Voltage units are *volts* (V), and for safety purposes, the voltage of most everyday devices we commonly use is relatively low, while industries and transmission lines are relatively high. A simple way to measure voltage is with a *voltmeter*. [red to positive (+) and black to negative (-)] Some voltmeters can measure a wide range of voltages. These *multi-meters* should be used with caution, so that the sensitive needle is not damaged (by testing a low range with high voltage).

Rivers of Electricity

Electric circuits are often compared to water systems. Electric charge is like the water, as it flows (input) it makes changes in the energy that results (output). *Microcircuits* (Integrated Circuits) - *transistors* are used with three layers of specially treated silicon, with the middle layer (receiving a small voltage, allowing it to control the voltage in the outer layers, allowing them to *act as switches*. ***Microcircuits are made up of transistors*** and resistors and are built on an extremely small scale. Integrated circuits put all of the components in one chip, reducing the size of the circuit.

Topic 3 - Resisting the Movement of Charge

Resistance is a measure of how difficult it is for the electrons to flow through a conductor. Resistance also converts electric energy into other forms of energy. Generally, it can be said that conductors have *low resistance* and insulators have *high resistance*. The standard unit for resistance is *ohm* (**Ω**). Resistance can be measured directly with an *ohmmeter*, but a *multi-meter* is used more often to measure resistance.

Calculating Resistance

Electrical resistance is calculated by finding the ratio of the *voltage* across the load (V) to the *current* through the load (I). This is called ***Ohm's Law***. $R = V / I$
The more resistance a substance has, the greater the energy gain it receives from the electrons that pass through it. The energy gain is evident in heat and light energy (light bulb filament, wire in a toaster). Solutions can also be resistors. 'Lie detectors' are also special applications of resistance within the body (skin resistance, blood pressure and respiration). An increase in stress (usually associated with a lie) will improve conductivity and show a 'peak' in the recording device. If the temperature of a resistor changes, the resistance changes as well (resistance is usually low when the resistor is cool, and as the temperature increases, so does resistance).

Model Problem - Applying Ohm's Law - Sample textbook problems ***p. 282***

Resistors

Different resistors are used for different applications, especially in electronics. There are many styles, sizes and shapes. The major application for resistors is to control current or voltage to suit the specific needs of other electrical devices within the same circuit. The two most common resistors are the wire-wound and carbon-composition types. The colored strips on a resistor usually indicate the level of resistance and quality.

Variable Resistors

To change electron flow gradually, a variable resistor, or *rheostat* is used (a dimmer switch, volume control knob).

Rheostats (dimmer)

Thermistor (heat-sensitive)

Varistors (surge-protector)

Types of Circuits

http://www.autoshop101.com/trainmodules/elec_circuits/circ101.html
A *series circuit* provides only one path for the current to flow.
A *parallel circuit* provides multiple pathways.

House Wiring

Practical wiring in the home uses parallel circuits. The voltage across each load is the same, and by turning on one appliance in the circuit, the energy will not be reduce to the other devices. Caution – current through wires connected to the source increases whenever another branch in the circuit is closed.

- *Factors that affect the Resistance of Wire*

Factor	***Effect***
Length -	Resistance increases with length
Cross-section area -	Resistance decreases with area (gauge – AWG #)
Temperature -	As temperature increases, resistance increases
Material -	Determined by the structure of the atoms in the material

Power cables are composed of many thin copper stands, separated in groups by paper insulation, and covered by a rubber insulation material, which reduces resistance and heating in the cable, while still making it flexible enough to handle.

Topic 4 - The Energy Connection

The scientific definition of energy is *'the ability to do work'*.
The four most common forms of energy are:

- *chemical - potential or stored energy stored in chemicals, released when the chemicals react.*
- *electrical - energy of charged particles, transferred when they travel from place to place.*
- *mechanical - energy possessed by an object because of its motion or its potential to move.*
- *thermal - kinetic energy of a substance*

Electricity and Heat

A *thermocouple* is a device that can convert *thermal energy* into *electrical energy*. It consists of two different metals (bimetal) joined together that conduct heat at slightly different rates. When heated, the difference in conduction results in electricity flowing from one metal to the other.
The basic principle of the thermocouple was discovered by Thomas Johann Seebeck in 1821, and was named the *Seebeck Effect*.
Thermocouples are useful for measuring temperatures in areas that are difficult to access or too hot for a regular liquid-filled thermometer. Ovens and heaters do the opposite. They convert electrical energy into thermal energy.
A *thermo-electric generator* is a device based on a thermocouple that converts heat directly into electricity without moving parts. Several thermocouples connected in a series is called a *thermopile*. Thermopiles are extremely reliable, low-maintenance devices and are often used in remote locations for emergency power generation.

Electricity to Motion

The *piezoelectric effect* produces sound by converting electricity into motion (vibrations). When a piezoelectric crystal, such as quartz, or Rochelle salt is connected to a potential difference, the crystal expands or contracts slightly. Material touching the crystal experiences pressure, creating sound waves or vibrations.

Motion to Electricity

A barbeque spark lighter uses the *piezoelectric effect in reverse*. When a crystal or Rochelle salt is compressed or pulled, a potential difference is built up on the opposite sides of the crystal. Conductors then take this through a circuit to produce electric energy (a spark).

Electricity to Light

An incandescent resistance filament (load) glows white-hot when electricity is passed through it. In fluorescent tubes a gas glows brightly and when crystals are struck together they can produce light. *LED's* (light-emitting diodes) are solid –state components that use a fraction of the power. When connected to a semiconductor chip in the right direction, they will produce light and last for many years.

Light to Electricity

Solar panels, containing photovoltaic cells can convert light into electrical energy. The *photovoltaic (PV) cells*, or solar cells, are made of semiconductor materials, such as silicon. When light is present, the material, breaking electrons loose – allowing them to flow freely, absorbs some. This current is drawn off by metal contacts on the top and bottom of the cell and then used in devices such as calculators, heater, or emergency telephones. Individual solar cells are combined in modules, to form arrays to produce larger amounts of electric current.
Certain animals, namely, the electric eel, can produce electric shock, to kill or stun prey. They have a special organ that contains specialized muscle cells called *electroplaques*. Each cell produces a small amount of electricity. When all the cells work together, a large amount of electricity is produce and used to help the eel survive. This type of electricity is like static electricity, which builds up and then discharges.

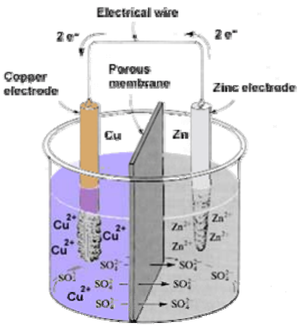
Topic 5 - Portable Power

Electrochemical Cells

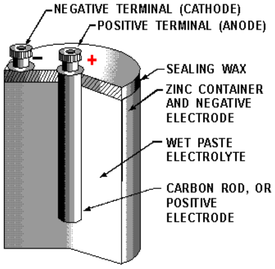
Two metal *electrodes* are surrounded by an *electrolyte*. These cells supply a steady current. The chemical reaction in a cell releases free electrons, which travel from the negative terminal of the cell, through the device, which uses the electricity, and back to the positive terminal of the cell. The chemical reactions within the cell determine the potential difference (voltage) that the cell can create. Several cells connected in series produces a higher voltage, and is commonly referred to as a battery, which is a sealed case with only two terminals.

A *primary cell* is one in which the reactions will not continue after the reactants are used up.

Wet cells use a liquid electrolyte. Wet cells are 'wet', because the electrolyte is a liquid (usually an acid). Each electrode (zinc and copper) reacts differently in the electrolyte. The acidic electrolyte eats away the zinc electrode, leaving behind electrons that give it a negative charge. The copper electrode is positive, but it is not eaten away. Electrons travel from the negative terminal (attached to the zinc electrode) through the device and on to the positive terminal (attached to the copper electrode).



*Dry cells –*the electricity-producing cells, referred to as 'batteries', are called dry cells, because the chemicals used in them are a paste. The dry cell is made up of two different metals, called electrodes in an electrolyte. An electrolyte is a paste or liquid that conducts electricity because it contains chemicals that form ions. An ion is an atom or group of atoms that has become electrically charged through the loss or gain of electrons from one atom to another. The electrolyte reacts with the electrodes, making one electrode positive and the other negative. These electrodes are connected to the terminals.



A *secondary cell* uses chemical reactions, which can be reversed. These are referred to as rechargeable batteries.

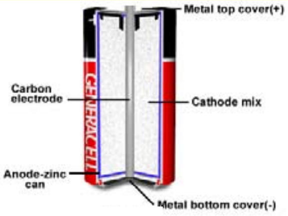
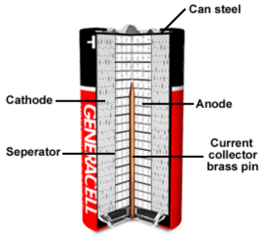
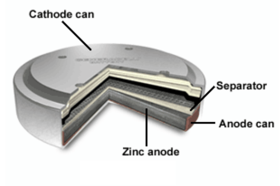
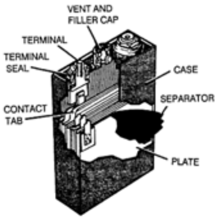
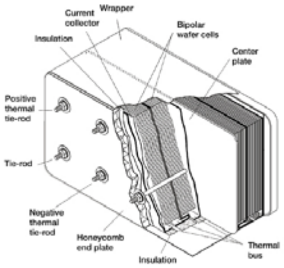
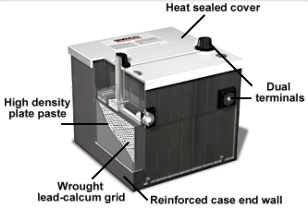
Rechargeable cells use an external electrical source to rejuvenate the cell. The reversed flow of electrons restores the reactants in the cell. The most common reactions that are efficient enough to be used for these types of cells are Nickel Oxide and Cadmium (Ni-Cad). The reactants are restored, but the electrodes will eventually wear out over time.

The tiny cells in a pacemaker can last from 5-12 years

Fuel Cells

Fuel cells combine hydrogen and oxygen without combustion. Electricity, heat and pure water are the only by-products of the fuel cell's reaction. They are 50-85% efficient.
World leader in fuel cell technology is a Canadian company Ballard Power Systems, in Burnaby, B.C. http://www.ballard.com/

Types of ‘dry’ cells

<table>
<tr><th colspan="4">Primary Dry Cells</th></tr>
<tr><th>Name</th><th>Diagram</th><th>Uses</th><th>Pros and Cons</th></tr>
<tr><td>zinc-carbon</td><td>
</td><td>Flashlights, portable stereos, CD players, walkmans</td><td>Not efficient at low temperatures</td></tr>
<tr><td>alkaline</td><td>
</td><td>Flashlights, portable stereos, CD players, walkmans</td><td>Last longer than zinc carbon, but more expensive</td></tr>
<tr><td>zinc-air</td><td>
</td><td>Calculators, hearing aids, watches</td><td>Highest energy per unit mass, but discharge rapidly</td></tr>
<tr><th colspan="4">Secondary (rechargeable) Dry Cells</th></tr>
<tr><td>nickel-cadmium</td><td>
</td><td>Electric shavers, laptops, power tools, portable TV’s</td><td>Rechargeable hundreds of times</td></tr>
<tr><td>nickel-metal hydride</td><td>
</td><td>Cameras, laptops, cell phones, hand tools, toys</td><td>Less toxic than NiCad – 40% more energy density than NiCad, rechargeable, no memory effect, lose charge when stored</td></tr>
<tr><th colspan="4">Secondary (rechargeable) Wet Cell</th></tr>
<tr><td>lead acid</td><td>
</td><td>Cars, motorbikes, snowmobiles, golf carts</td><td>Dependable, but heavy and has a corrosive liquid</td></tr>
</table>

Topic 6 - Generators and Motors

A device that converts mechanical energy (energy of motion – windmills, turbines, nuclear power, falling water, or tides) into electrical energy is called an *electric generator*. The operation of a generator depends on the relationship between electricity and magnetism.

Electricity to Magnetism

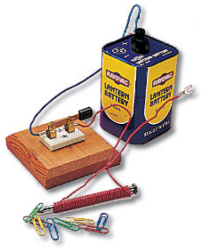
Deflection of a compass needle using electrical current showed that there is a relationship between electricity and magnetism. Hans Christian Oersted found that the current created a magnetic field around the wire. The amount of needle deflection depended on how much electric current was flowing in the wire. When the current was reversed, the needle moved in the opposite direction.

Electromagnets

When a soft iron core is inserted into a coil of wire and a current is passed through the wire, a very strong temporary magnet is produced, called an electromagnet.

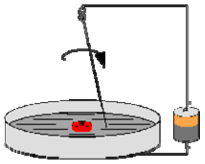
The strength of an electromagnet is affected by the …

- type and size of core
- strength of current
- number of coils



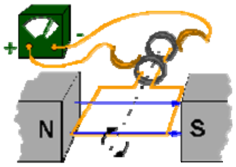
Magnetism to Electricity

Electric effects can also be created using a magnet. Michael Faraday (and Joseph Henry) discovered *electromagnetic induction* in 1831. They demonstrated that moving a conducting wire through a magnetic field by moving it back and forth through the field, Faraday created the first electricity-producing generator, which could generate electrical current. They also found that moving the magnet worked as well.



Faraday introduced terms such as 'ion', 'electrode', 'cathode', and 'anode' to science and invented the lines of magnetic force. The farad, a unit for measuring stored electric charge, was named after him.

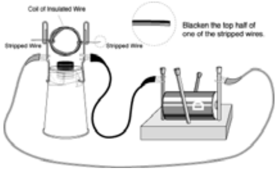
What's in a Generator?



An AC generator – the most common type – has a coil of wire rotating inside a stationary field magnet. The central axle of an AC generator has a loop of wire attached to two slip rings. The current is switched as the loops move up and down alternatively through the magnetic field. The slip rings conduct the alternating current to the circuit through the brushes (the brush and ring assembly allows the whole loop to spin freely).

The electricity produced by this type of generator is called *alternating current* because it changes direction (in North America it changes direction 120 times per second – giving 60 Hertz or complete waves each second. In large AC generators many loops of wire are wrapped around an large iron core. Massive coils of wire rotating in huge generators can produce enough electricity to power an entire city.

DC Generators

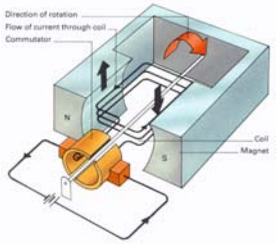


A DC generator is much the same as a DC motor, and is often called a dynamo. The spinning armature produces the electricity (if electricity is passed through a DC generator, it will spin like a motor). The armature is connected to a split ring commutator which enables this type of generator to send current through a circuit in only one direction. The DC generator's pulsating electricity is produced in one direction - referred to as *direct current* - and coincides with the spinning of the generator.

The St. Louis motor was designed to teach how a DC motor works

Electric Motors: Electric to Mechanical Energy

An electric motor is constructed in exactly the same way as a generator. Instead of producing electricity, it uses electrical energy to make a wire coil spins between the poles of a magnet. Current flowing through the coils makes it an electromagnet, which is then affected by the laws of magnetic forces when it is in proximity to the field magnet. *Opposite poles attract and like poles repel*. All electric motors operate on this principle.



Some motors run on direct current (*DC*). It is 'direct', because the electricity flows in only one direction. Alternating current (*AC*) flows back and forth 60 times per second

DC Motors

Faraday constructed the first motor. By coiling (copper) wire around a (iron) metal core a strong electromagnet can be made. When attached to an electrical source it will produce a strong magnetic field. To keep this electromagnet spinning in a magnetic field, the direction that the current is traveling through the coil must be switched. This is accomplished by with a gap, which allows the polarity of the electromagnet change just before it aligns with the permanent magnet.

DC motors use a commutator (a split ring that breaks the flow of electricity for a moment and then reverses the flow in the coil, when the contact is broken, so is the magnetic field) and brushes (contact points with the commutator) to reverse the flow of electricity through the magnetic field. The armature (the rotating shaft with the coil wrapped around it) continues to spin because of momentum, allowing the brushes to come into contact once again with the commutator.

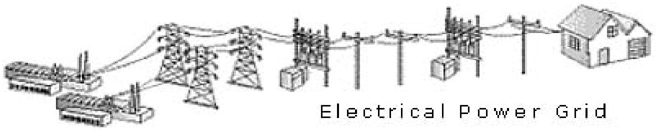
AC Motors

AC motors have a rotating core, or rotor, made up of a ring of non-magnetic conducting wires connected at the ends and held in a laminated steel cylinder. Surrounding the rotor is a stationary component called a stator. The stator is a two-pole electromagnet. When the motor is turned on, the attraction and repulsion between the poles of the stator and the rotor cause the rotor to spin.

Topic 7 - Electricity in the Home

Transmission of Electricity through the Power Grid

Transformers are used to change the amount of voltage with hardly any energy loss. Voltage change is necessary because the most efficient way to transmit current over long distances is at high voltage and then reduced when it reaches its destination, where it will be used.


Electrical Power Grid

A *step-up transformer* increases voltage at the generating plant prior to distribution to the power grid over high voltage transmission lines, whereas, a *step-down transformer* reduces voltage just before entering your home.

From the Grid into Your Home

Coming in contact with a power transmission line can prove to be deadly. By touching it, a short circuit can occur, because the electricity is trying to find a path to the ground - you can complete the circuit, and it may be fatal. Power needs to enter your home safely.

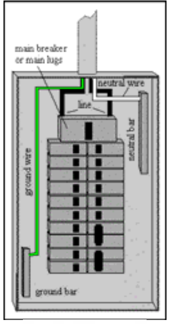
Electrical power enters a meter on the side of your house where electrical usage is recorded

on little dials

Power is then routed into the service panel *(usually in the basement).*

The main circuit breaker shuts off all the power in the house at once, in case of an overload. The individual circuit breakers in the service panel control the branch circuits, located throughout the entire house.

Each branch circuit is connected in parallel to wall plugs, lights and wall switches within a particular area of the house.

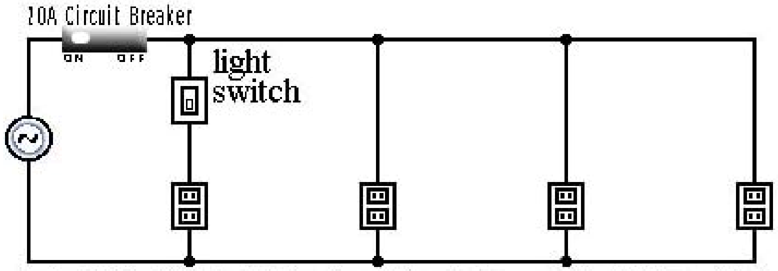


Each branch circuit is a series of 14 gauge electrical cables that contain:

2 *'live'* insulated wires (white – neutral; and black – hot);
And, a *'ground'* wire (bare copper wire, or insulated green).

Home Wiring

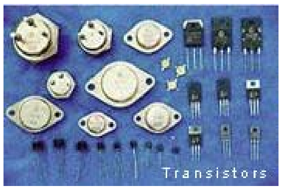
To install or change electrical wiring in your home a *permit* is necessary and all work done must meet a set of standards called the **electrical code**.



Typical 120V - 20A Parallel Circuit with 4 wallplugs - one of which is switched.

Digital Devices

The four basic elements of a circuit are present in a microcircuit, as well as a normal electrical circuit, although they may be in different forms. Conductors are thin traces of copper, instead of wires. Resistors and lamps are similar, but the **switches** are very different.
To process the digital information switches in microcircuits use 'binary code' – 0 and 1 - for on and off.
These ***electronic digital switches are transistors*** – solid state components that are controlled by electronic signals. The transistors can then control other signals.



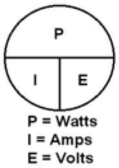
Measuring Electric Power

Power is defined as energy per unit time. Electric power describes the amount of electric energy that is converted into other forms of energy (heat, light, sound, or motion) every second. The formula that is used is:

Power (watts) = Energy (joules) / Time (seconds)

A *kilowatt* is 1000 watts.

Electrical power measures *voltage* and *current* and the formula is as follows:



The electrical power formula can be manipulated as follows to determine Power, Current or Voltage use:

$$\text{POWER} = \text{CURRENT} \times \text{VOLTAGE}$$

$$\text{CURRENT} = \frac{\text{POWER}}{\text{VOLTAGE}}$$

$$\text{VOLTAGE} = \frac{\text{POWER}}{\text{CURRENT}}$$

Model Problem

http://www.cix.co.uk/~hdh/power/power.htm

Do your own model problems online and get immediate results. (Good for homework questions as well.)

* Try doing the **Practice Problems** (p. 324) with the Java Script on the site above.

Paying For Electrical Energy

The power rating of a device can be used to determine the amount of energy the device uses. Multiply the power rating by the time the device is operating.

(E) Energy in joules (P) Power in watts (J/s) (t) time in seconds

$$E = P \times t \qquad P = E / t \qquad t = E / P$$

Kilowatt Hours is used as a unit for energy. The energy calculation is the same, except that hours are substituted for seconds and kilowatts (kW) are substituted for watts.

Electricity meters  measure the energy used in kilowatt hours and then bills you for every kilowatt hour used.

Model Problem

Do Practice Problems (p. 325)

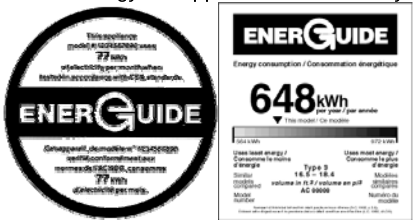
Power Rating

The power rating on an energy using device tells you how many joules of energy (1 W = 1J/s) the device uses every second it is on.

ENERGUIDE labels help consumers make comparisons of energy use, when purchasing large appliances.

Measuring energy inputs and energy outputs allows you to calculate the efficiency of devices and systems.

The large number indicates the approximate amount of energy the appliance will use in 1 year.



Electric Devices and Efficiency

Energy is neither created nor destroyed. It doesn't appear and then disappear, but is transformed from one form to another. Most of the energy transformed in a light bulb is wasted as heat. Known as the *Law of Conservation of Energy*, *no device is able to be 100% efficient in transforming energy*. Most often, the energy is lost, or dissipated as heat. Mechanical systems also dissipate energy to their surroundings, but not as obvious as the heat loss. Much of the dissipated energy is sound.

The efficiency of a device is the ratio of the useful energy that comes out of a device to the total energy that went in. The more input energy converted to output energy, the more efficient the device is.

$$\text{Efficiency (\%)} = \frac{\text{useful energy output (J)}}{\text{total input energy (J)}} \times 100\%$$

Comparing efficiencies of devices by their energy cost and their environmental impact can be an important decision that can affect sustainability of our resources, by helping us to make better consumer choices.

Incandescent light bulbs (5% is light energy, while 95% is heat)

Halogen lights (filled with high-pressure gas, with traces of iodine) (15%).

Florescent lights (20%) are even more efficient

Toyota Prius hybrid gas-electric car

Hybrid gasoline-electric vehicles are more efficient than gas-powered vehicles.

Model Problem

Calculate the efficiency of an 1000W kettle that takes 4 min to boil water. To heat the water to boiling point, it takes 196,000 J of energy. What is the **efficiency** of the kettle?

Show your work

Given: P = 1000 W Efficiency
t = 4.00 min

Useful energy output (E_{output})= 1.96×10^5 J

t = 4.00 X 60s/min = 240s

E_{input} = Pt 1000W x 240s = 2.40×10^5 J

Formula: $\text{efficiency} = \frac{\text{Useful energy output}}{\text{Total energy input}} \times 100\%$

How efficient is the kettle?

Solution: $\text{Efficiency} = \frac{1.96 \times 10^5\ \text{J}}{2.40 \times 10^5\ \text{J}} \times 100\%$

Efficiency = **81.7%**

The kettle is about 81.7% efficient.

Try the Practice Problems on p. 329

Home Electric Safety

Protect yourself from electrical shock by using only SA approved electrical devices.
The Canadian Standards Council issues labels to identify the amount of voltage required to operate electrical devices and the maximum current they use.

Electrical Safety Pointers...

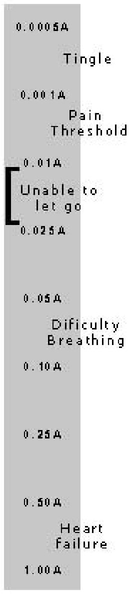
- Cover electrical outlets with child-proof covers if they are within reach of small children
- Don't use devices that have a frayed or exposed power cord
- Always unplug an electrical device before disassembling it
- Don't put anything into an electrical outlet - except a proper plug for an electrical device
- Don't overload an electrical circuit, by trying to operate too many devices at once
- Don’t bypass safety precautions when you are in a hurry
- Pull on the plug, not the wire
- Never remove the third prong from a 3 prong plug

The third prong of a 3 prong plug is a ground wire, connected to the ground wire of the building, in case of a short circuit. Fuses and circuit breakers interrupt a circuit when there is too much current flowing through it. Fuses contain a thin piece of metal designed to melt if the current is too high. Circuit breakers, on the other hand, trip a spring mechanism, which shuts off the flow of electricity through the circuit, when there is too much current. It can be reused over and over (provided the cause of the increased flow is corrected).

- Never handle electrical devices if you are wet or near water

Electric Safety Outdoors

A lightning strike can have 30,000A - more than enough to kill you. Avoid being the target of a lightning strike, by staying low to the ground (horizon) and away from trees. Lightning can also do a lot of damage to a building. Metal lightning rods connected to the ground with a grounding wire are fixed on the roof of many buildings to prevent damage to the building during an electrical storm.



High voltage power lines carry 50,000V of electricity. However, amperage is more important to consider. 0.001A will likely not be felt at all, 0.015A to 0.020A will cause a painful shock and loss of muscle control (which means you will not be able to let go of the line). A current can be fatal as low as 0.1A.

Electrical dangers vary, depending on the situation. When the current can flow easily, it is more dangerous. Insulators (such as wood, rubber and air) hamper the flow of electricity. Moisture is a good conductor of electricity, so avoid water when working with electricity.

- Never allow yourself to come into contact with anything that is touching live electrical wires.
- Never use ungrounded or frayed 2 prong electrical cords outdoors
- Do not operate electrical equipments outdoors in the rain
- Check before you dig – you could end up digging into electrical cables or wires for communication causing injury and disruption.

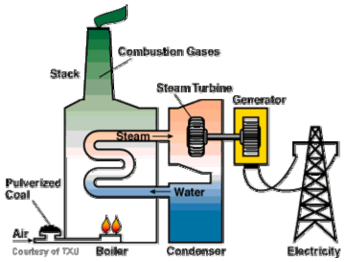
Topic 8 - Electricity Production and the Environment

Electrical energy consumption in Canada is 2 X 10^{18} J every year. To generate this amount of electricity is a massive undertaking and can effect the environment.

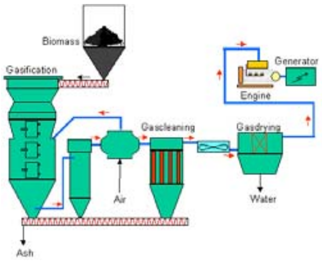
Energy from Burning Fuels

Fuel oil, natural gas, and coal are used in large thermo-electric generating plants to produce roughly 25% of Canada's electrical energy needs.

Coal is mined, crushed into a powder, blown into a combustion chamber and burned to release heat. This heat boils water and superheats the resulting steam to a high temperature and pressure, which then turns a turbine. The turbine shaft rotates large electromagnetic coils in the generator to produce electricity.



These fossil fuels are non-renewable resources – eventually they will be gone.



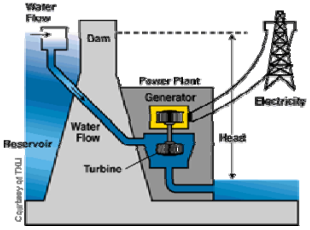
Biomass, solid material from living things, is also burned to power these thermo-electric generators.

Biomass is a renewable resource.

Fossil Fuels Affect Land and Air

Coal is mined in Alberta in open pits, which are an eyesore, and disturb topsoil and vegetation. Underground mines produce 'tailings' which accumulate near the mine. Water seeps through these tailings and becomes acidic and contaminated. Fossil fuel reserves are decreasing, but with less reliance on these fuels we will be able to see a decrease in pollution. The burning of these fuels creates contaminants such as visible particles and invisible gases (SO_2 is one such gas). Electrostatic precipitators can remove most of the solid particles, but not the gases. Sulfur dioxide can be reduced by using scrubbers – which spray a water solution through the gas, making sulfuric acid, which is then collected and sold. Another gas produced is carbon dioxide CO_2 which is a greenhouse gas. Producing more of this naturally occurring gas helps the atmosphere trap more heat, leading to global warming. Some generating plants are switching to natural gas which burns a little cleaner. Finding ways to lower our dependence on fossil fuels and finding alternative fuel sources is a decision that will determine much of what our future environment will be like.

Electric Energy from Flowing Rivers

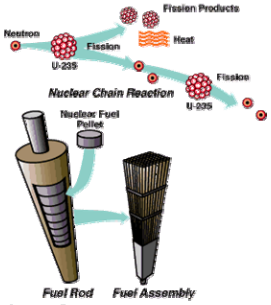


Hydro-electric plants use falling water (gravity), and pressure to generate electricity. Large dams raise the water above the power plant (which is usually built inside the dam), near the base.

A channel, called a penstock, directs the water (at high pressure) to a turbine. The turbine then converts mechanical energy to electrical energy.

Although these hydro-electric plants appear to be doing no harm to the environment, the reservoir they have to create behind the dam, destroys habitat and displaces whoever lived in the area prior to the reservoir being created. When the submerged vegetation is decomposed, bacteria take up the oxygen supply in the water, methane gas can be produced, and aquatic species – such as fish, are affected when the oxygen levels drop. Other species take over and a new ecosystem can be created.

Energy from Atomic Reactions



Courtesy of TXU

Bombarding uranium atoms with tiny particles, called neutrons cause the uranium to split into two smaller atoms.

This is called nuclear fission.

The process creates a huge amount of energy which is used to generate electricity in a thermonuclear plant.

Heating the Environment

All thermonuclear and thermo-electric-generating plants release thermal energy into the environment. 43% of the water used in the cooling process enters the environment. Thermal pollution occurs when this heated water is not cooled before it re-enters the water system. This overheated water can upset the life cycles of organisms in the water and be fatal because they cannot tolerate the sudden temperature change. The heated water also contains less oxygen. To reduce this type of pollution, plants are required to have holding ponds or towers which hold the water until it returns to normal levels.

Cogeneration

Cogeneration is the dual generation of electrical and thermal energy. The cogeneration systems usually are associated with industries, or commercial complexes. The cogeneration plant (like Poplar Creek Power Plant in Fort McMurray) provides electricity and heat or steam to the industry and may even sell excess electricity to the provincial power grid.

Alternative Energy Sources


Wind - this energy is harnessed by large propeller-type blades, which turn a shaft - connected to a generator.


Sunlight - Solar cells (made from silicon) enable the energy from the sun to be transformed (photoelectric effect) into electricity.


Geothermal - Heat from the Earth's core can also be used to generate electricity. This geothermal energy (hot water and steam) is channeled through pipes to drive turbines - connected to generators, which produce the electricity.


Tides - moving water can power turbines, which then run generators. When the tide comes in, the water is trapped in large reservoirs and then allowed to flow out past turbines.

Renewable resources like these alternative sources of energy can be replenished over and over again. Tree harvesting can also be renewed, but it takes a much longer period of time to renew this resource. They can also negatively affect the environment: Dams, wind farms and solar cell arrays can destroy large areas of ecological habitat; Tidal power plants can disrupt the habitat of fish and other marine life.