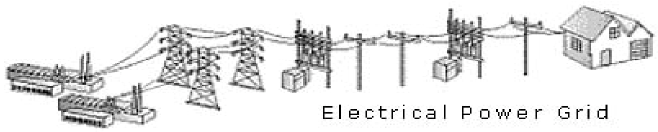
Topic 7 - Electricity in the Home

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.



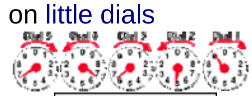
A *step-up transformer* increases voltage at the generating plant prior to distribution to the power grid over high voltage transmission lines, whereas, a *step-down transformer* reduces voltage just before entering your home.

From the Grid into Your Home

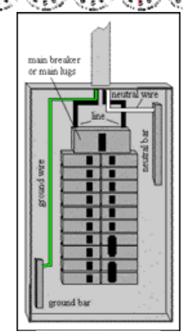
Coming in contact with a power transmission line can prove to be deadly. By touching it, a short circuit can occur, because the electricity is trying to find a path to the ground - you can complete the circuit, and it may be fatal. Power needs to enter your home safely.

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.

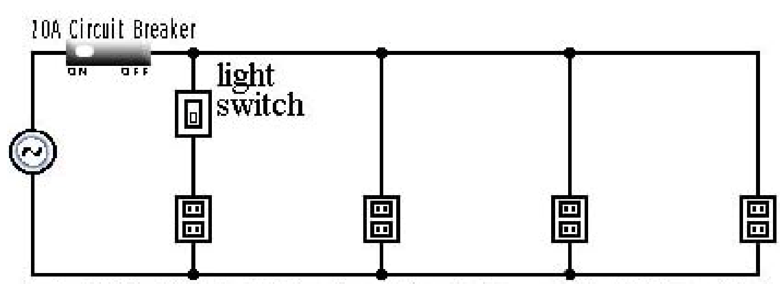
Each branch circuit is connected in parallel to wall plugs, lights and wall switches within a particular area of the house.

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**.

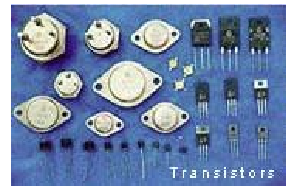


Typical 120V - 20A Parallel Circuit with 4 wallplugs - one of which is switched.

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.



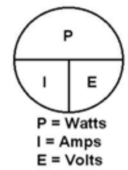
Measuring Electric Power

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:

POWER = CURRENT X VOLTAGE

CURRENT = POWER / VOLTAGE

VOLTAGE = POWER / CURRENT

Model Problem

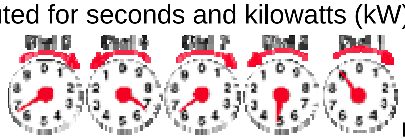
http://www.cix.co.uk/~hdh/power/power.htm
Do your own model problems online and get immediate results. (Good for homework questions as well.)
* Try doing the **Practice Problems** (p. 324) with the Java Script on the site above.

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)

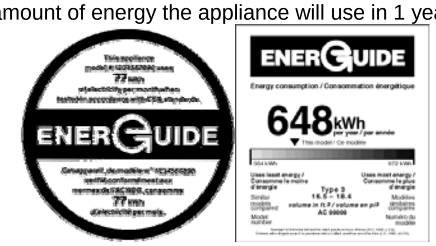
Power Rating

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.

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

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

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

How efficient is the kettle?

Solution: 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 CSA 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

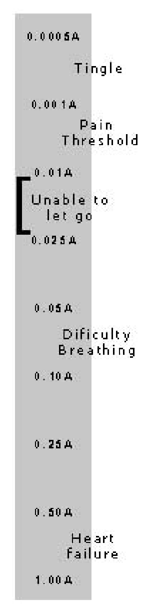
The third prong of a 3 prong plug is a ground wire, connected to the ground wire of the building, in case of a short circuit. Fuses and circuit breakers interrupt a circuit when there is too much current flowing through it. Fuses contain a thin piece of metal designed to melt if the current is too high. 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.