<u>Grade 11 Notes June 15-19, 2020</u>

This week we are continuing our last unit on Electromagnetism. It is important that you download the notes for Grade 12 as we will be expecting you to be familiar with the information.

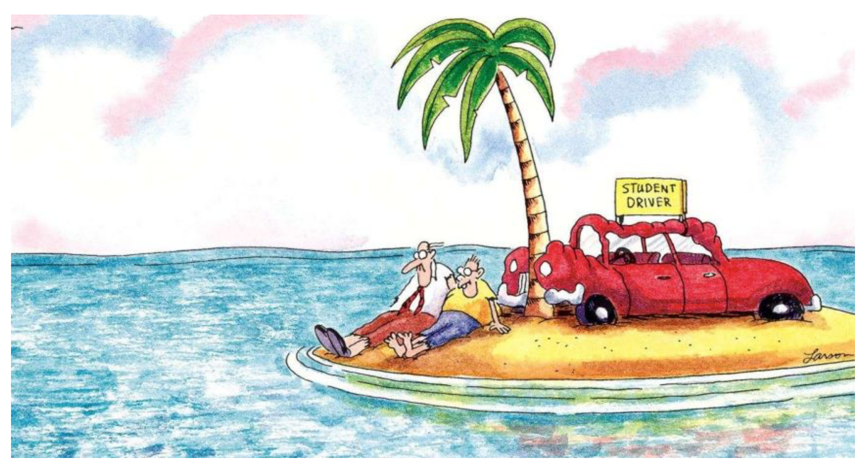
This week we are going to investigate electricity with the following notes

1. **Current Electricity and Circuits**
2. **Current**
3. **Voltage**
4. **Resistance, Ohm's Law and Kirchhoff's Laws**

Remember there is no assignment due this week. This does not mean you can stop doing work, I will be putting out notes till the last week to finish the course. Still cover the material presented.

Have a good week.

Miss Takken



1. <u>Electrical Circuits</u>

Every time you use an electronic device you are using current electricity which is the flow of electric charges through a set path. This is different then static electricity because static electricity only sits on an object. Current electricity, however, flows.

Recall: All substances are composed of atoms.

Atom have a heavy nucleus in the centre containing protons (+ charges) and neutrons (neutral charges). Electrons (- charges) orbit the nucleus and can transfer to other atoms. This transfer of electrons (if all in the same direction and a large amount) results in electricity or electron flow.

When wires conduct electrical current, the electrons in the wire get pushed through the wires by jumping from atom to atom in the wire. Electrical current becomes useful when it is controlled in an electrical circuit.

An electrical circuit is an arrangement of components that transforms electrical energy into another form of energy (for example light, heat, sound, movement) in an electric device.

For a circuit to work properly you need the following **Circuit Components**

1. Source ~ the source of the electricity. Can be a plug, battery, generator etc.

2. Conductors ~ the path the electricity travels along. Usually wires.

3. Load ~ the device that converts the electricity to another type of energy. Can be a light, motor, resistor (heater) or anything else that uses electricity.

4. Control (optional) ~ a device that turns the circuit on and off, or up and down. For example a switch or rheostat (dimmer switch). You actually don't need this in a circuit but it is nice to have control.

If a circuit has a source, conductors and possibly a control but no load this is known as a **short circuit.** These are very dangerous because you are making the electricity flow back into the source which causes the battery or generator to overheat and possible start on fire.   Do not try this at home.

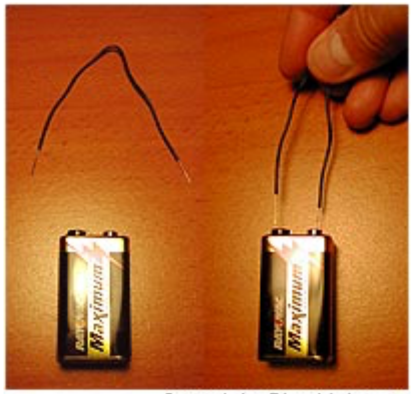
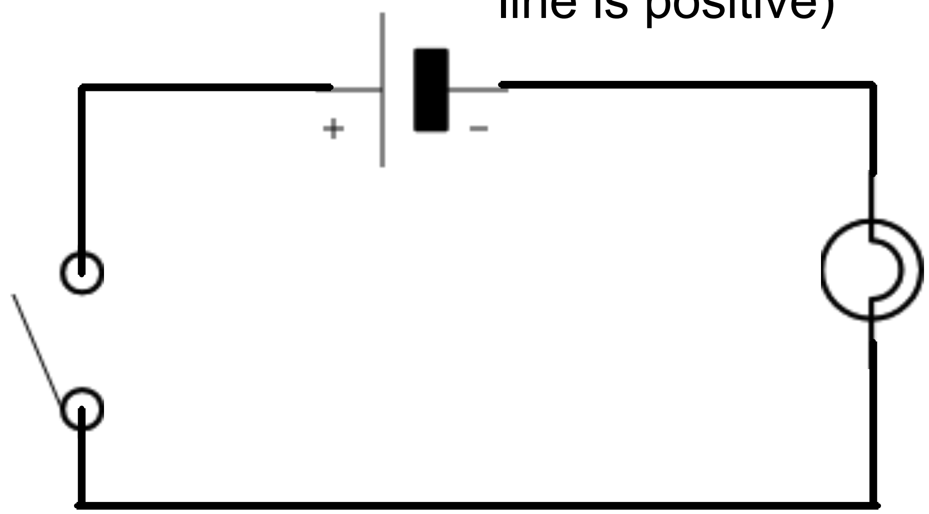


Image: The simplest example of a 'Short Circuit'. All you need is a battery and a piece of wire. If you do this in dark you may notice faint sparking when you connect + to - of the battery.

When you have an **open circuit** the **switch is open** and the electrical current **does not flow.** When you have a **closed circuit** the **switch is closed** and the current **does flow**; there is a complete path.

Drawing Circuits

source (in this case a single battery cell. Notice the short side is negative and the long line is positive)



control (this is an open circuit)

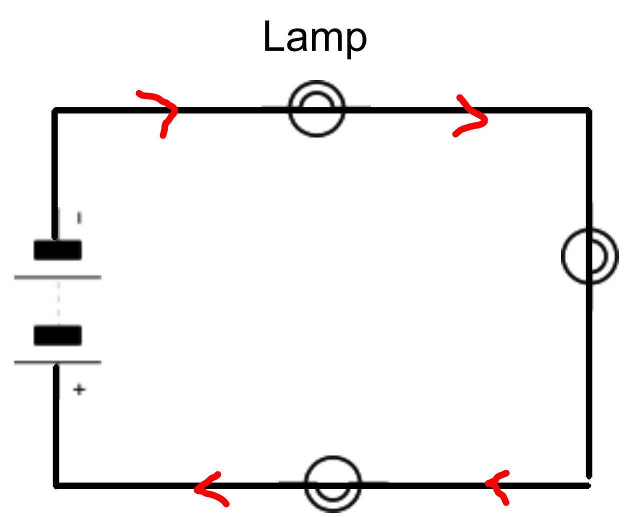
load (in this case a lamp)

conductors

Rules: Always use straight lines and 90^o corners.

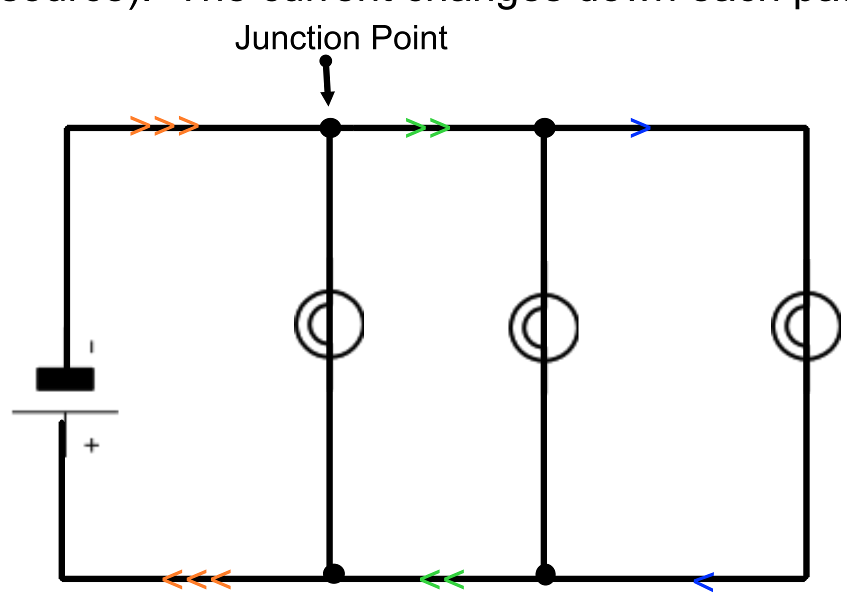
Circuit Types. There are three types of circuits; series, parallel and combination (which is just series and parallel mixed together)

<u>Series Circuit</u> is a circuit where the electrons pass through one load and on to the next. The current is the same in all parts of the circuit. The voltage, however, is highest at the first load and decreases with each additional component.



This is a diagram of a series circuit with a two cell battery and three lamps. No control is present. Notice that electricity travels from the negative terminal towards the positive terminal. Negative to positive. This type of circuit, though useful, is not very functional. If any of the lamps burns out the entire circuit will be off. As well, since they need to share the voltage each light will be dim.

<u>Parallel Circuit</u> is a circuit in which the electrons have a choice of several paths to take. Every electron goes through just one of the circuit's loads before returning to the source. Thus, each load gets the same voltage (the voltage of the source). The current changes down each path.



This is a diagram of a parallel circuit with a single cell battery source and three lamps. Each lamp has it's own path. This is a much more functional circuit as if one path is turned off or broken the other paths can continue to work. As well, since each path gets the same voltage the lights are all bright.

2. Current

There are three variables we need to consider when dealing with electricity; current, voltage and resistance. All three work together in circuits to transform electrical energy into another form of energy that is useful (light, heat, movement, sound etc.)

Current is the movement of electric charges from one place to another. We know that electrons can flow freely through conducting material. Thus, electric current is the amount of charge that moves past a given point in a conductor per second. Charges move due to repulsion from the next electron in line because they are both negative.

The symbol for current is I and it is measured in amperes (A). The formula for current is I = q/t where q = the amount of charge in coulombs and t is the time in seconds.

1 ampere is the electric current when 1 coulomb of charge (6.242×10^{18} electrons) moves past a point in a conductor in 1 second. Most AA batteries are 0.5 A. The sockets in your house are 15 A. That is a huge amount of electrons per second which is why you can get electrocuted.

Example: What is the current flowing if 30 C passes through a circuit in 10 s?

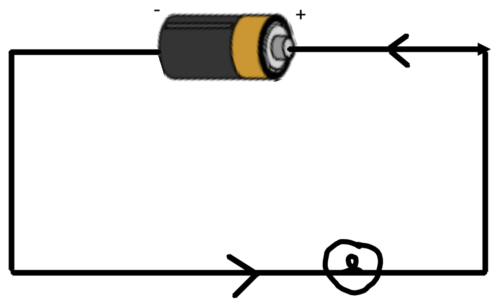
I = q/t

I = 30/10

I = 3 A

There are two types of current; direct (DC) and alternating (AC).

<u>Direct Current (DC)</u> is a flow of electric current which flows in one direction only. i.e. a battery produces direct current. The electrons cannot reverse their direction of flow. Positive and negative terminals are fixed.



<u>Alternating Current (AC)</u>

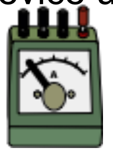
Electric Currents in which electrons change direction many times per second (60 times per second, 60 Hz in North America)

i.e. type of power supplied to homes and factories by power stations. It is easier to send alternating currents over long distances. The electrons move back and forth along the wire 60 times a second.

In other parts of the world the AC is 50 Hz. This is why we need adaptors when travelling (if we ever get to do that again) to boost the current to 60 Hz from 50 Hz so our electronic devices work properly.

To measure current we can use one of two devices; an ammeter or a galvanometer.

Ammeter is a device used to measure electric current. Must be placed in the stream of the current.



Galvanometer is another type of ammeter used to detect and measure a "small" electric current.

3. Voltage

The second variable we are concerned with when dealing with electrical circuits is voltage. Voltage (a.k.a. electrical potential difference) has the symbol **V** and is measure in **volts (V)**.

Electrical Potential Difference is the difference in electric potential energy between two points in a circuit. Also referred to as **voltage**. A battery gives electrons electric potential energy when it is hooked into a circuit.

The higher the potential difference in a circuit, the more potential energy there is per electron. The potential energy is converted to kinetic energy (E_k) when the electron is free to move.

Basically, voltage is the amount of energy each electron can carry from the source and drop off at the load. So the current is how many electrons travel the circuit but the voltage is the how much energy is attached to each electron as it travels. Current is good but voltage is the actual workhorse.

Some Common Electric Potential Differences (Voltages)

single dry cell 1.5 V
car battery 12 V
normal household outlet 110-120 V
heavy wiring 220-240 V (dryers, ovens)
electric street car 550 V
long distance transmission lines 50 000 V-758 000 V

Voltage is measured using a device called a voltmeter. It must be placed around a device in a circuit to get the difference between the energy going into the device and the energy coming out.

4. **Resistance, Ohm's Law and Kirchhoff's Laws**

The third variable is probably the most important, resistance. Current (the amount of electrons flowing in the circuit) and voltage (the amount of energy those electrons carry) are nothing if the load has no way of capturing that energy. This is where resistance comes into play.

Resistance is the degree to which a substance opposes the flow of electric current through it.

All substances resist the flow of electrons to some degree.
Resistance, symbol **R**, is measured in **Ohms** (greek symbol Ω) and is measured using an ohmmeter.

Resistance causes the flow electrons to decrease. Then the kinetic energy of the electrons is converted into another form of energy i.e. heat or radiant energy.

A **resistor** is any material that can slow the flow of electron current and cause the electrons to give up their energy. i.e. tungsten (filament in a light bulb), argon gas (in fluorescent light tubes), ceramic, glass etc.

Factors that affect resistance are length of the resistor, cross sectional area (thickness), type of material and temperature. Basically, the longer, thinner and more resistive the material you have the better the resistive device. Then when it's working the hotter it gets the better the resistance.

Ohm's Law

So how are voltage, current and resistance related? Well through Ohm's Law which states that the resistance of an electrical device is equal to the voltage divided by the current of that device.

$R = V/I$ where R is resistance in Ω, V is voltage in V and I is current in A.

Example: A current of 120 V is travelling on a current of 15 A, what is the resistance?

$R = V/I$

$R = 120/15$

$R = 8\ \Omega$

Conservation of Energy ~ as electrons move through an electric circuit they gain energy in sources and lose energy in loads. However, the total energy gained in one trip equals the total energy lost.

Conservation of Charge ~ Electric charge is neither created nor destroyed (lost) in an electric circuit nor does it accumulate at any point in the circuit.

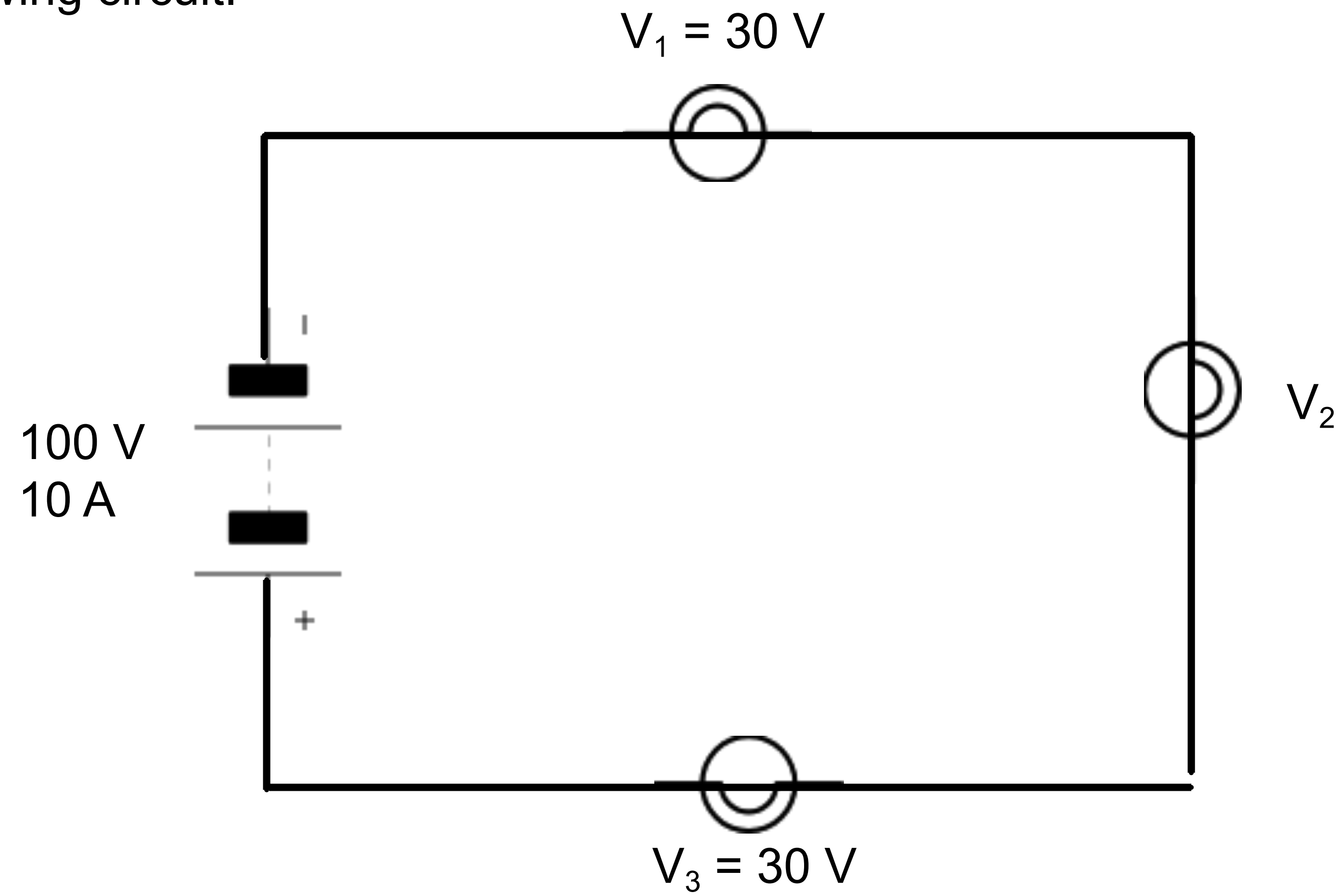
From these we can develop Kirchhoff's Laws of Electrical Circuits

Kirchhoff's Voltage Law (KVL) states that around any complete path through an electric circuit, the sum of increases in electric potential is equal to the sum of the decreases in electric potential.

Kirchhoff's Current Law (KCL) states that at any junction point in an electric circuit the total electric current into the junction is equal to the total electric current out of the junction.

Gustav Kirchhoff (1824-1887)

Example 1: Find the missing voltages and currents (V_2, I_1, I_2, and I_3) of the following circuit.



According to KCL the total current into a junction equals the total current out of a junction. Since this is a series circuit there are no junctions so

$I_1=I_2=I_3=I_{Total}$ = 10 A.

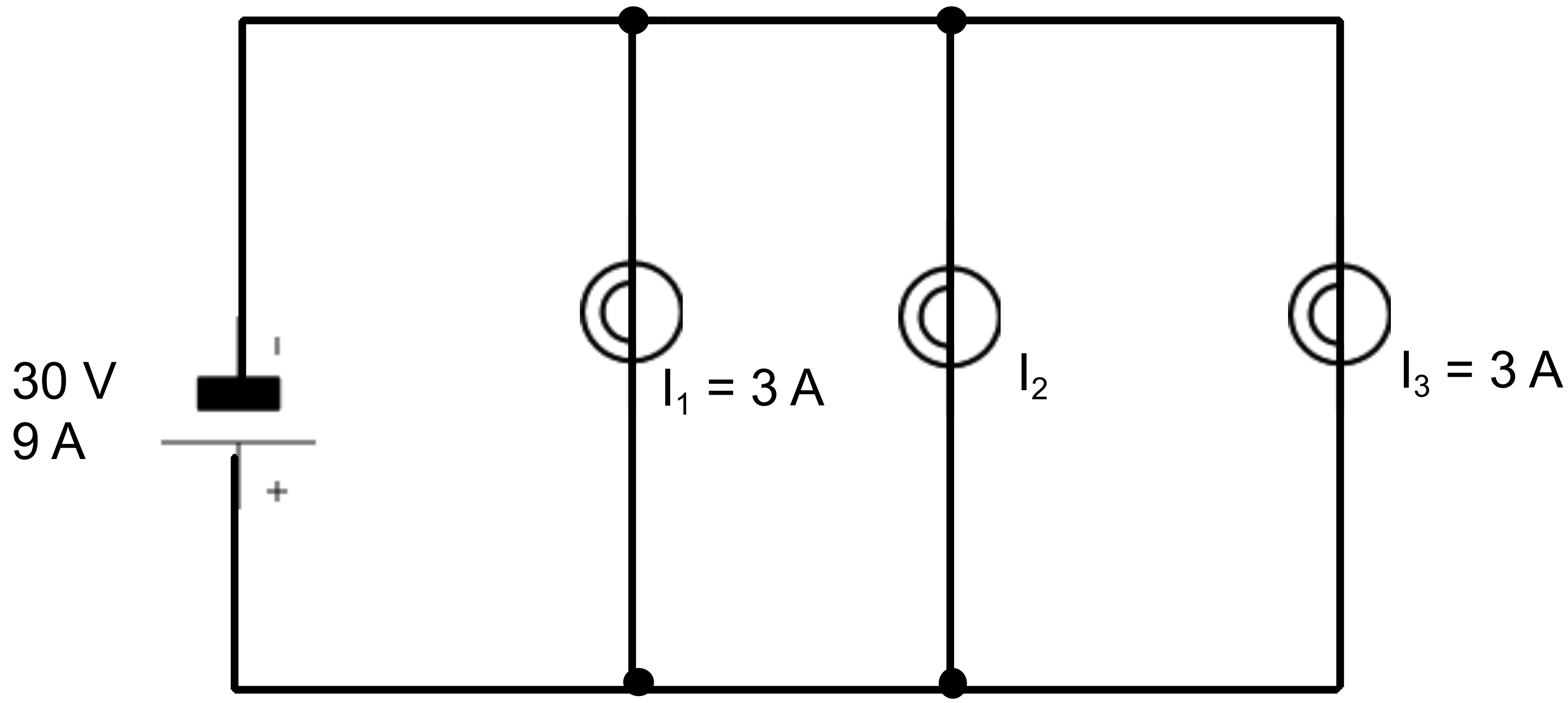
According to KVL the total increase in voltage at the source is equal to the total decrease in voltage at the loads around any complete path. Therefore

$V_{Total} = V_1+V_2+V_3$

$100 = 30 + V_2 + 30$

$V_2 = 40$ V

Example 2: Find the missing voltages and currents (V_1, V_2, V_3 and I_2).



According to KVL the voltage adds to the total around any complete loop in the circuit. So if the V_{Total} = 30 V that means each loop gets 30 V. So $V_1 = V_2 = V_3$ = 30 V

According to KCL at any junction point in an electric circuit the total electric current into the junction is equal to the total electric current out of the junction. So since I_1 and I_3 are 3 A and there is 9 A total that leaves 3 A for I_2.

Next week magnetism.