Notes – Electricity

- Anything that can cause a change to itself or the environment is said to have energy. As such, electricity (the movement of electrons) is a form of energy.

- In this section we are going to look at how we as scientists, can control this movement of electrons to do work for us.

- To have electrons do work for us, we need to have the electrons move. Electrons will only move from a source, like a dry cell or generator, if they have a path to leave and return to this source. In physics we call this a circuit.

- Circuits come in two forms:

1.) Series circuit – a circuit where there is only one path for the electrons to travel along.

Ex. –

2.) Parallel circuit – a circuit where there is one or more branches in the circuit allowing the electrons to flow along more than one path in returning to the source.

Ex. -

- In a circuit, the electrons are understood to flow from the positive end to the negative end of the source. This is called ______________________. THIS IS INCORRECT TO REAL LIFE. Electricity is the movement of electrons, so clearly the electrons must leave the source where there is extra electrons (negative end) and return to the deficient side of the source (positive end).

- In a circuit there are 3 important concepts to understand:

1.) ____________________(__) – is understood to be the "pushing" force that drives the electrons through the circuit. Voltage is measured in units of *Volts* (V), using a voltmeter. **Voltage is always measured parallel to the circuit**.

2.) Current (I) –

3.) Resistance (R) – is understood to be the force that opposes the movement of electrons (much like friction is to movement!). Resistance is measured in units called *Ohms* (Ω), using an Ohmmeter.

Ohm's Law

- To understand the connection between these variables, we use Ohm's law. Georg Ohm discovered that current is proportional to the voltage across the wires of a circuit.

- From this discovery he figured out the relationship we call Ohm's law:

or or

- Ex. 1 – A ceramic resistor attached to your led flashlight allows $1.0\ mA$ to flow through when $3.0\ V$ is applied to the end. What is the resistance of the resistor in $k\Omega$?

- Ex. 2 – If you plug your $10.0\ \Omega$ kettle into your $110\ V$ outlet on the counter, mow much current will it draw?

- Resistors are objects often made of carbon or ceramic that change electrical energy into heat. We use them to control current. They are commonly produced and look like this:

- Ex. 1 – Using your table of resistor colour codes, solve for the resistance of a brown, black, orange, gold resistor?

- Ex. 2 – Using your table of resistor colour codes, solve for the resistance of a yellow, violet, yellow resistor?

Joule's Law

- James Joule discovered that at a given resistance, the electrical energy converted to thermal energy (heat) per unit of time by the resistor, is proportional to the square of the current. Since the rate of energy released with respect to time is called power, below is the equation that describes this discovery;

$$P \propto I^2$$

- We know commonly relate the resistance to power in Joule's law and express it as such:

or or

- Ex. 1 – What is the resistance of a $75.0\ W$ fan, if the current in it is $1.5\ A$?

- Ex. 2 – When you pay for electricity in your home, you are charged not for the power, but for the energy used. The unit for measuring the energy used is the kilowatt·hour ($kW \cdot h$). How many $kW \cdot h$ of energy does a $900\ W$ toaster use in $4.5\ min$?

Series, Parallel, and Combination Circuits

- We've already discussed the two types of circuits. However, these to circuits cause differences in how we deal with voltage, current, and resistors. Firstly lets look at series circuits:
    1.) Voltage in Series – the total voltage put out from the cell(s) will decrease through each resistor to equal a total loss upon return to the cells. In other words . . . $V_s = V_1 + V_2 + V_3 + \ etc.$
    2.) Resistance in Series – the total resistance of the circuit will be the sum of each individual resistor in the circuit. In other words . . . $R_s = R_1 + R_2 + R_3 + \ etc.$
    3.) Current in Series – current doesn't change throughout the circuit.

Summary for Series Circuits

Parallel Circuits

- Circuits in parallel offer different challenges to understanding voltage, current, and resistance.

4.) Voltage in Parallel – the total voltage put out from the cell(s) will remain constant across each branch of the parallel circuit.

5.) Resistance in Parallel – the total resistance of the circuit will be the sum of the inverse of each individual resistor in the circuit. In other words . . . $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ etc.$

6.) Current in Parallel – current into a circuit branch must equal the amount coming out. As such, each branch may have **different** currents in each branch based on the resistance in that branch. Therefore, the sum of the currents in the branches will add to the total throughout the circuit. In other words . . . $I_p = I_1 + I_2 + I_3 + etc.$

Summary for Parallel Circuits

- Current (I) is the sum of the individual currents through the resistors of the branches.

$$I_p = I_1 + I_2 + I_3 + etc.$$

-
- Total resistance (Ω) is equal to the sum of the inverse of the individual resistors in a circuit.

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ etc.$$

- To solve circuits that combine both aspects of series and parallel circuits you will need to combine the rules you have just been shown.

The best way to start is to solve for the total current of the circuit and the total resistance of the circuit by condensing all the resistors into one total.

- Ex. – What is the voltage across the $6.0\ \Omega$ resistor in the circuit above?

Kirchoff's Laws

- Kirchoff's laws are really a restatement of the law of conservation of energy. He has two main postulates;

    1.) At any junction in a circuit, the sum of the currents entering equals the sum of all currents leaving the junction.

$$\sum I_{in} = \sum I_{out}$$

    2.) The sum of all the voltage changes in a circuit should equal zero. That is, the voltage from the cell(s) will decrease to zero before returning to the cell(s) in a circuit.

$$\sum V_{gains} = \sum V_{drops}$$