Electricity is no longer a luxury but a necessity we can't survive without. However, some of us are not aware of what electricity is and what it is made of. In this reviewer, I'll help you learn more about electricity and give you a glimpse of magnetism.

Part I. Electricity.

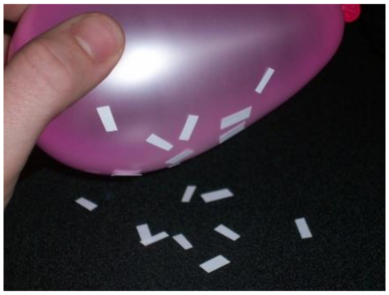
Have you ever wondered why your hair gets attracted to a comb when you comb your hair continuously? That is because of the electric charge! In studying **electricity**, it is important to understand the charges first.

A. Electric charge.

When we studied chemistry, we were first introduced to the concept of atoms. An **atom** makes up everything in this world, and each atom consists of a **proton, electron, and neutron**. In studying electricity, we are going to concentrate on protons and electrons because they possess an electric charge.

An electric charge can be generated when electrons are transferred to materials. Each electron carries a fundamental charge of **$1.6x10^{-19}$ C**. The magnitude of this is negative for electrons and positive for protons. All substances have a charge that is multiple of this value, hence, electric charge is quantized.

In our example, the combing of hair results in gaining electric charges in the comb. When you comb your hair continuously, the comb becomes negatively charged because the electrons from your hair are transferred to the comb, leaving your hair positively charged. **When two charges are unlike or not the same, they will attract or pull toward each other**. That is the reason why your hair seems to move towards the comb.



On the other hand, **when they are the same, they will repel or push away from each other**. This can be demonstrated when your hair tries to move away from each other by standing up and away from all the other strands. This example perfectly demonstrates ***static electricity***. Rubbing of materials like comb and hair, or even balloon and hair, can transfer electric charge.

Materials can be distinguished based on their ability to transfer electric charge. When materials can easily transfer electric charge and electrical current like metal, these are called **conductors**. On the other hand, materials that do not transfer electric charge like rubber, plastics, and wood are called **insulators**. Insulators are usually used to protect us from the dangers of electricity since they conduct electricity poorly.

B. Coulomb's Law.

The hair-comb example has shown that like charges repel and opposite charges attract. This is due to the electric force between the two materials. It can easily be described in **Coulomb's law**, which states that the magnitude of the electric force between two objects is directly proportional to the product of two charges and inversely proportional to the square of the distance between them.

Mathematically,

$$F = k\frac{q_1 q_2}{r^2}$$

where $k = 9\text{x}10^9\ N \cdot m^2/C^2$. In case there are more than two charges, vector analysis must be done to find out the force upon the object.

Sample Problem.

Find and describe the force between the two charges that are 4 meters apart if:

- $q_1 = +2.3\text{x}10^4$ C; and
- $q_2 = -5.1\text{x}10^{-6}$ C.

Solution.

We know that $F = k\frac{q_1 q_2}{r^2}$. Substituting the given values to the formula, we will get

$$F = (9 \times 10^9 N \cdot \frac{m^2}{C^2})\ \frac{(+2.3\times10^{-4}\ C)\ (-5.1\times10^{-5}\ C)}{(4\ m)^2}$$

$$F = (9 \times 10^9 N \cdot \frac{m^2}{C^2})\ \frac{-1.173 \times 10^{-8}\ C^2}{16\ m^2}$$

F = -6.6 N

A force of -6.6 N acts between the two charges. Since they have opposite charges, the force that acts between them is attractive.

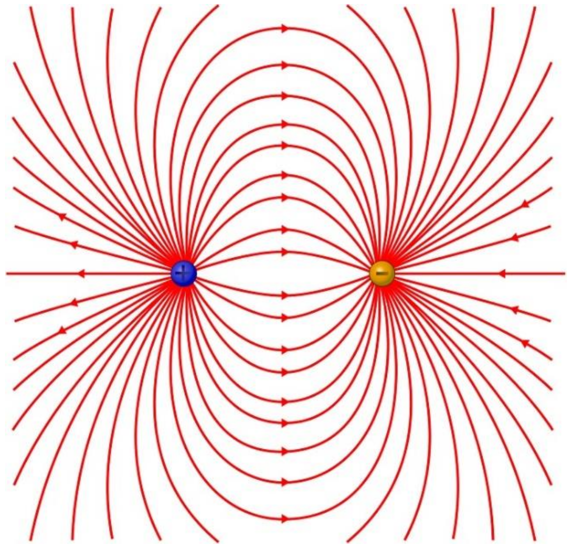
C. Electric field.

The electric force forms an electric field which allows it to propagate. Any stationary object that has a charge creates an electric field around itself. If another charged object enters this electric field, interactions will occur.

The electric field strength generated by a point charge can be calculated using the formula

$$E = \frac{kq}{r^2}$$

We use electric field lines to depict the electric field ideally. These lines point towards the negative charges and away from the positive charge. The more densely packed the field lines are, the greater the electric field strength.



D. Electric Potential, Current, and Resistance.

In the previous reviewer, we have learned that objects have gravitational potential energy by virtue of their location and work must be applied to move massive objects against the Earth's gravitational field.

The same case can be applied to charged objects since these also have **electric potential energy** by virtue of their position in an electric field and work must be exerted to the charged particles against the charged objects' electric field.

We can also relate an object's electric potential energy to its **unit charge**. Charged particles tend to experience a change in electric potential energy as they move within an electric field. The more charged a particle is, the more the electric potential energy it possesses. This concept is called **electric potential**, which is expressed as

$$\Delta V = \Delta PE_{electric}/q$$

This is measured in **volts (V)** which is equal to 1 J/C. Hence, we can say that a battery that contains 1.5 V has an energy of 1.5 J for every 1 C of charge.

When charges move, it is not only the electric potential energy that can be described but the flow itself. The flow of electric charge is known as the **electric current**, and it is measured in **amperes (A)** which is equal to 1 coulomb of charge per second.

Current can be generated by positively charged and negatively charged particles and its direction is always opposite to the movement of electrons.

The motion of charges can also be opposed, depending on the property of the material and its dimension. This ability is called **resistance** which is the ratio of electric potential to current. This is measured in **ohms (Ω)**.

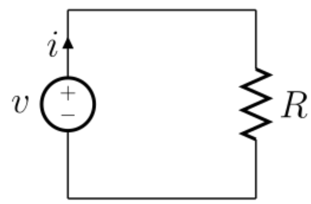
Part II. Circuits.

Everything that needs electricity, from the light in your house to the gadgets that allow you to study this reviewer, is powered by a circuit.

A ***circuit*** is a series of electrical components such as batteries, bulbs, switches, resistors, and others that are connected in a complete loop.

To study a circuit, we must first understand its features such as current, resistance, and voltage.

- ***Current* (I)** refers to the amount of charge flowing through a circuit per unit of time. It is measured in amperes (amps). The faster the current flows, the greater the amount of electrical energy is being transferred to the electrical components.
- ***Resistance* (R)** describes the amount of opposition to the current flowing in a circuit. It is measured in ohms (Ω). The higher the resistance, the lesser the current flow.
- ***Voltage* (V)** refers to the amount of potential energy between two points in a circuit, hence, it is also known as the *potential difference*. It is measured in volts (V).



These three features are related to one another. This relationship is summarized in ***Ohm's Law*,** which states that the current is directly proportional to the voltage across the circuit and inversely proportional to the resistance.

Mathematically,

$$I = V/R$$

Types of Circuits.

Electrical components can be connected along a circuit in two ways - in series and in parallel.

Series circuits connect devices in a single pathway for electron movement while **parallel circuits** connect devices in branched pathways to allow electrons to flow in different directions.

The table below summarizes how voltage, current, and resistance are described in the circuits.

	Series	Parallel
Voltage	$V_T = V_1 + V_2 + \ldots + V_{N-1} + V_N$	$V_T = V_1 = V_2 = \ldots = V_{N-1} = V_N$
Current	$I_T = I_1 = I_2 = \ldots = I_{N-1} = I_N$	$I_T = I_1 + I_2 + \ldots + I_{N-1} + I_N$
Resistance	$R_T = R_1 + R_2 + \ldots + R_{N-1} + R_N$	$R_T = 1/(1/R_1 + 1/R_2 + \ldots + 1/R_{N-1} + 1/R_N)$

In a series circuit, we can see that the total current is just the same through any component since there is only a single pathway available for the current to flow. Meanwhile, the total voltage, as well as the total resistance, is just equal to the sum of its individual components.

On the other hand, parallel circuits seem to be more complicated. The total current is equal to the sum of individual currents since there are multiple branches for the current to flow. Unlike the total voltage in a series circuit, the total voltage in a parallel circuit is just the same through any component. The total resistance in a parallel circuit is equal to the reciprocal of the sum of the inverse of each individual resistances.

Part III. Magnetism.

We have been familiar with **magnets** since we were young, but have you ever thought about how they work?

Thousands of years ago, magnets were first discovered in the form of **magnetite** - a naturally magnetic iron oxide mineral commonly found in various kinds of rocks. From that moment until the present day, magnets have been used for different purposes.

We know what magnets look like and how it can attract metals like iron. They usually look like this:

A magnet has two ends that we call ***poles***. One end is called a ***north* pole** (north-seeking pole) since it points towards the Earth's north pole while the other end is known as the ***south* pole** (south-seeking pole) because it points towards the Earth's south pole. This is because Earth acts as a gigantic magnet due to the number of magnetic materials it contains.

When you place two magnets together, the north pole of the first magnet repels the north pole of the second magnet and attracts its south pole. Hence, **like poles repel and opposite poles attract**.

Magnets can also be cut and when it is cut, it will form a new, smaller magnet with its own set of poles.

Magnetic field.

Say you have a magnet and iron filings on a table. As you place the magnet near the iron fillings slowly, there will come a point when the iron filings stick to the magnet. That is because magnets create an invisible area of magnetism around it called a *magnetic field.*

A **magnetic field** is produced by all moving charged particles. Magnetic fields can be depicted using magnetic field lines, just like the electric field. These field lines will occur as a closed loop that continues to the magnet itself.