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STUDY GUIDE:

ELECTRICITY + MAGNETISM

ELECTRICITY

An atom is made of three parts: protons, electrons, and neutrons. The protons and neutrons are located within the nucleus of the atom, and the electrons move around the outside of the nucleus in shells or energy levels. Protons have a positive charge. Neutrons have no charge, and electrons have a negative charge. **ELECTRICITY IS THE MOVEMENT OF ELECTRONS FROM ONE PLACE TO ANOTHER.** Most often, the electrons move through wires or other conductors. Sometimes the electrons move from one object to another without continuing their movement. This type of electricity is called **STATIC ELECTRICITY.**

Some materials allow electrons to pass easily through them. They are called **CONDUCTORS.** Examples: most metals (especially copper), and salt water. Materials that do not allow electrons to pass through them are called **INSULATORS.** Examples: wood, rubber, plastic, cloth, glass, and rock.

As the electrons travel through the conductor, there is opposition to their flow, caused partially by friction within the wire and partly between collisions of the moving electrons. This opposition to the flow of the current is called **RESISTANCE.** Materials in which there is very little resistance are said to be **SUPERCONDUCTORS.**

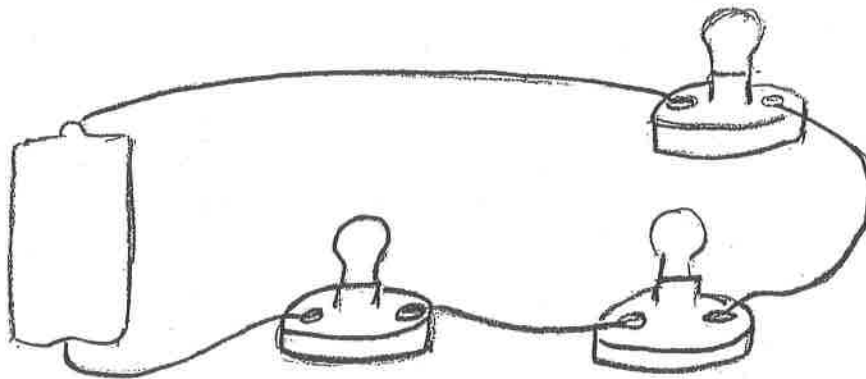
The flow of electrons through the wire or conductor is called **CURRENT.** The path that the electrons follow is the **CIRCUIT.**

An electric circuit consists of 4 parts:

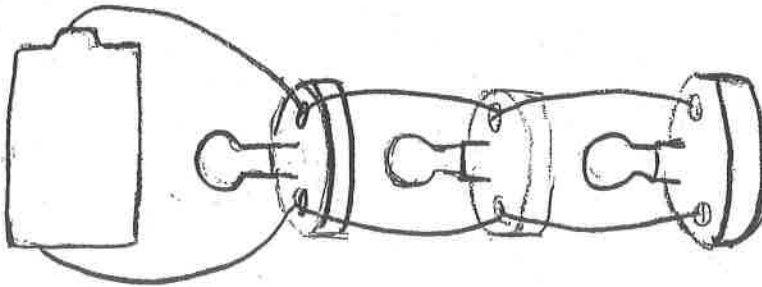
1. A **LOAD (or RESISTANCE)**-- This is the device that uses the electrical energy. It might be the light bulb, an appliance, or a motor.
2. **SOURCE OF ENERGY**--Examples: a battery, electric generator, etc.
3. **WIRES**
4. **SWITCH**--This opens and closes the circuit.

There are two types of electrical circuits, depending upon how all the parts of the circuit are connected. These are **SERIES CIRCUITS** and **PARALLEL CIRCUITS**.

In a series circuit, there is only one path for the electrons to take. If there is a break anywhere in the circuit, the flow of electrons is stopped and the load will not operate.



In a parallel circuit, the different parts of the circuit are on separate branches. Each branch of a parallel circuit can be switched off without affecting the other branches. Our houses are wired in parallel circuits.



When a circuit is created by using a battery, the electrons all flow in the same direction. They leave the negative terminal of the battery, flow through the wires and the resistance, and enter the battery at the positive terminal. This is called **DIRECT CURRENT (DC)**. In DC current, electrons always flow in one direction.

The electrical energy that is supplied by machines in power stations **DOES NOT** flow in only one direction. It changes directions many times a second. This type of current is called **ALTERNATING CURRENT**, or AC.

Dry cells have potential energy inside them. The amount of potential energy available in them is called the VOLTAGE. We measure VOLTAGE in units called VOLTS. A 6 volt battery has more potential energy than a 1.5 volt battery, and is capable of doing more work. It pushes the electrons harder. We measure voltage with an instrument called a VOLTMETER.

An AMPERE (or AMP for short) is a unit used to measure the amount of electrical current that flows past a particular point in a circuit in one second. The greater the voltage, the more current that will be pushed through the circuit. The amount of RESISTANCE in the wire and in the load help to determine how many amps of current will flow around the circuit. Remember, RESISTANCE is the opposition to the flow of the current. Thin wires create more resistance than fatter wires. Five light bulbs would create more resistance than two light bulbs. Resistance is measured in a unit called OHMS.

OHM'S LAW STATES THE RELATIONSHIP BETWEEN CURRENT, VOLTAGE, AND RESISTANCE.

OHM'S LAW: The current in a wire (I) is equal to the voltage (V) divided by the resistance (R).

Stated in other words: current = voltage divided by resistance

$$I = V/R \qquad \text{Amperes} = \text{Volts divided by Ohms}$$

$$V = IR$$

$$R = V/I$$

Ohm's Law is named after Georg Ohm, a German high school teacher and physicist, who first discovered this electrical relationship. By using these equations, we can calculate the current, voltage, or resistance. For example: What is the resistance of an appliance if it has a 4 ampere current when 120 volts are used?

Remember that $R = V/I$. If $V = 120$ and $I = 4$, 120 divided by 4 is 30 . Since resistance is measured in ohms, our answer is 30 ohms.

What is the voltage needed to operate an automatic dishwasher that has a resistance of 14 ohms and uses 15 amperes of current?

$V = IR$ If $I = 15$ and $R = 14$, then $15 \times 14 = 210$. Voltage is measured in volts, so our final answer is 210 volts.

SWITCHES are devices that are put into circuits to stop the flow of the electrons.

FUSES are safety devices that are put into a circuit to prevent electrical overloading and fires. Inside each fuse is a metal strip. When too many electrons are pushed through the circuit, the metal strip melts and breaks apart, causing an open circuit. Once a fuse burns out, it must be replaced.

CIRCUIT BREAKERS are also emergency switches. When a circuit becomes overloaded, a switch flips open, thus breaking the circuit. Once the problem has been corrected, the flip can be switched back to reset it.

POWER is the rate at which electricity does work. POWER IS MEASURED IN WATTS. Watts help us measure how much electrical energy is used. A 100 watt light bulb uses more energy than a 60 watt light bulb. Power can be expressed as an equation:

$$\text{Power} = \text{Voltage} \times \text{Current}$$

$$P = V \times I \quad (\text{The letter "I" always stand for current in an electrical equation.})$$

Since power is measured in watts, voltage is measured in volts, and current is measured in amperes, we could also say:

$$\text{watts} = \text{volts} \times \text{amperes}$$

The total amount of energy that is used depends upon the amount of power that's used by the electrical appliances, and the amount of time that they are used.

$$\text{Energy} = \text{Power} \times \text{Time}$$

Energy is measured in kilowatt-hours. One kilowatt is equal to 1,000 watts.

MAGNETS AND MAGNETISM

Most magnets are made from iron. The regions where the magnetic force are the strongest on a magnet are called the poles of the magnet. On a bar magnet, these poles are at the ends. One of the poles is called the North Pole, and the other pole is called the South Pole. If two north poles are brought toward each other, they will repel. If a north pole and a south pole are brought together they will attract. The LAW OF MAGNETIC POLES states:

LIKE POLES OF A MAGNET REPEL EACH OTHER AND UNLIKE POLES ATTRACT EACH OTHER.

Not all metals are attracted to a magnet. The three main metals that are attracted to a magnet are IRON, NICKEL, and COBALT. These three metals can also be magnetized themselves by stroking a magnet across them several times in the same direction. This process is called INDUCED MAGNETISM. Induced magnetism is a temporary condition. If you magnetize your screwdriver, it will eventually lose its magnetic charge.

The area around a magnet in which the magnetic force is found, is called the MAGNETIC FIELD.

Hans Oersted, a Danish physicist, noticed that a compass needle that had been placed near an electric wire deflected, or moved as the current flowed through the wire. Therefore, the current in the wire was producing a magnetic field around the wire. He decided that a wire that was wound around in loops would probably produce a magnetic field that was stronger than a straight wire. He wound a wire into loops and passed an electrical current through it. He created a SOLENOID, which was a much stronger magnet than a regular wire.

To further increase the strength of the wires, he placed an iron core inside the loops or coils. He changed the SOLENOID into an ELECTROMAGNET.

An ELECTROMAGNET is a temporary magnet that can be created by wrapping a wire around an iron core (such as a large nail), and connecting the ends of the wire to an electrical energy source (such as a battery).

Electromagnets can be made stronger by:

1. Increasing the number of coils that are wound around the core.
2. Using a larger iron core.
3. Increasing the amount of voltage.

An ELECTRIC MOTOR is an object that changes electrical energy into mechanical (moving) energy. It contains an electromagnet and an armature.

A GALVANOMETER is an instrument that detects small currents. It is simply a coil of wire that is connected to an electric circuit and attached to a needle. Current flowing through the wire exerts a force on the needle and causes it to move.

A GENERATOR is a device that changes mechanical (moving) energy to electrical energy. Electric generators in power plants supply about 99 percent of the electricity used in our country today. Spinning turbines provide the mechanical energy that is needed to turn the wire coils in the magnetic field. When the coils turn in the magnetic field, they cause alternating current to flow into the wires.

Power plants are often located long distances from the homes and businesses that they serve. Thus, the voltage sent out through the main power lines is very high. This voltage must be reduced to a lower voltage before it can be sent into homes or offices. TRANSFORMERS LOWER THE VOLTAGE FOR USE IN HOMES. This electricity that is supplied to homes is ALTERNATING CURRENT, and the wires that bring the electricity into the home are connected in PARALLEL CIRCUITS.

TRANSFORMERS can also increase, or step-up, the voltage of a current.