Voltage

OBJECTIVES

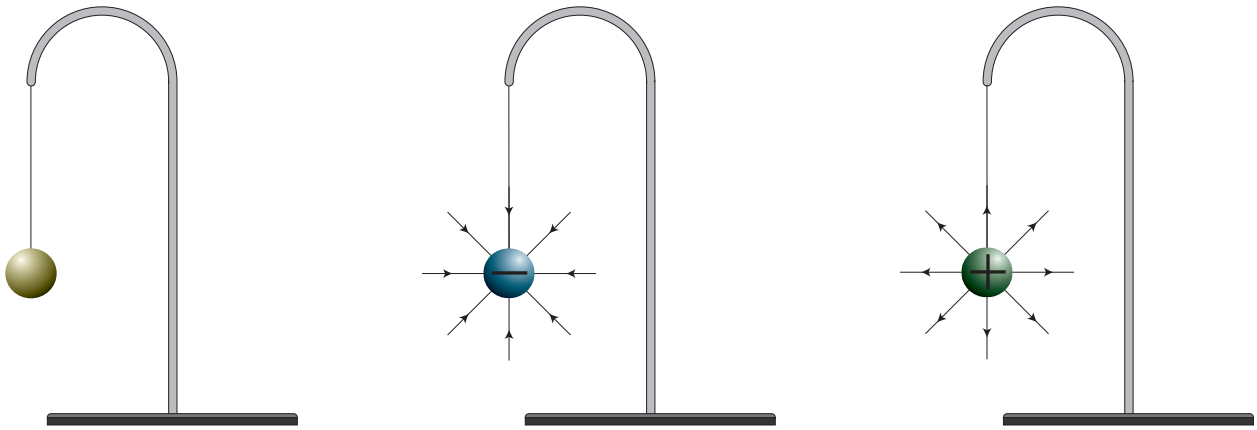
- Describe Voltage as “Difference of Potential”
- Define the Unit of measure for Voltage
- Explain six sources of Voltage

INTRODUCTION

In this section we will look at Voltage, one of the four basic properties of electricity. The other three are Current, Resistance, and Power, each of these properties will be discussed in detail in there own sections. Voltage is the electrical pressure in electrical circuits. Without Voltage, Current would not flow and work in an electrical circuit could not be performed. We will also look at six ways Voltage can be produced.

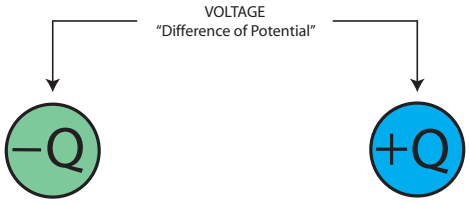
Voltage

From the Charge section of this course we said that another name for charge was POTENTIAL. You can have a single charged object, but with only one reference charge work cannot be accomplished. Look at what happens when we charge a pith ball electroscope (either positive or negative) and we take the rods away and leave the pith ball by itself. It just hangs straight down. You don’t see a difference between a non-charged ball, a negatively charged ball or and positively charged ball.

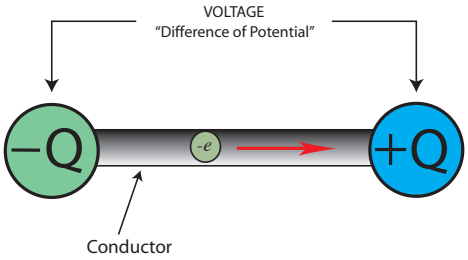


Notice that the Pith Ball hangs straight down on all the electroscope.

It is not until you bring objects with different charges (potentials) close together that you can perform work. It is this difference between two charged objects or areas that allows work to be performed. It is this difference between two charges (potentials) that we call Voltage. That is why Voltage is sometimes referred to as the “Difference of Potential”. Another name for Voltage is Electromotive Force or EMF. Whichever term you use Voltage is the push or pull force that moves electrons through a material.



When a material such as a conductor is placed between two charged objects or areas, electrons will flow from the negatively charged object toward the positively charged object. This flow of electrons will continue until there is no difference of potential or Voltage. (Or the path for the electron is removed.)



Symbol for Voltage: V or E

The symbol used to describe Voltage or "Difference of Potential" is V or E for Electromotive Force. In the study of electronics you will see both depending on which text book you read.

Unit of Measure for Voltage: Volt

The unit of measure for Voltage is named after the Italian physicist Alexander Volta. Volta was given this honor for the creation of the "Voltaic Pile", the first battery cell. As with everything so far we need to quantify what exactly a volt is. One volt is equal to one Joule per Coulomb or how many Joules are needed to move a Coulomb of charge to a particular point in space.

1 Volt = 1 Joule/ 1 Coulomb

Sources for Voltage

Friction - We have been looking at static electricity so far in our study of basic electricity. These electrical fields have been produced by friction. We have seen that rubbing select materials together can create a static electric field produced by the transfer of electrons. Although this method is the least important of the six methods of producing electricity we will discuss, it still has some important uses.

Static electric fields are used:

- To remove carbon and most other solids from manufacturing smoke stacks, thus helping to clean our air.
- In the reproduction process of copier machines.
- In high volume paint applications so that the paint will cover irregular surfaces evenly.

Pressure - Voltage produced by pressure is called piezoelectricity. Many crystalline materials such as Quartz, Rochelle salts, and Tourmaline exhibit what is called the PIEZOELECTRIC EFFECT.

The piezoelectric effect works in two ways:

- If you apply mechanical pressure or force to the afore mentioned crystals a voltage will be developed. Many microphones work in this manner when acoustical pressure is applied to the crystal and the voltage created is amplified and recorded. Old phonographs had their needles mounted so that the movement of the needle in the

groove caused varying pressures on the crystal and hence varying voltages that could be amplified and fed to a speaker for listening.

- If a voltage is applied to the afore mentioned crystals, the crystals will distort. This distortion can be coupled to a diaphragm and create audio sound waves. Small speakers can be made in this fashion. Oscillators can also be produced in this manner and we will be describing these in later sections of this course.

Heat - When most metals (such as copper) are heated at one end, electrons will move from the heated side toward the cooler side.

A few metals (iron is one) have the opposite effect. When you heat one end, electrons will move from the cooler side toward the heated side.

Take two wires made of these materials and twist them together to form a junction. If that junction is heated electrons will flow toward the heat in the iron wire and away from the heat in the copper wire. This causes less electrons in the iron wire (positive charge) and more electrons in the copper wire (negative charge). Remember the difference between two charges is VOLTAGE. The higher the temperature difference between the junction and the other sides of the wires the higher the voltage. It should be stated that if this junction is cooled the opposite voltage is produced.

Heat is used to create Voltage in the following:

- Thermocouple - When the two different metal wires are welded together the junction becomes more efficient and can be used to measure temperature. Thermocouples are often used as an automotive engine temperature indicator.
- Thermopile or thermoelectric generator - Many thermocouples can be used together to increase the small amount of voltage they produce. These "thermopiles" are used to measure much higher temperatures in home pilot light fail-safe devices or even industrial blast furnaces.

  One problem with thermocouples is their limited amount of power production, even in large sizes they are not very efficient. Modern semiconductor materials are being used to increase the power capabilities and are starting to replace batteries in some military applications. The advantage being that the power can be delivered as long as a heat source is available.

Light - The release of electrons from materials caused by light is called the PHOTOELECTRIC EFFECT. Materials that exhibit the photoelectric effect include potassium, sodium, germanium, cadmium, cesium, selenium, and silicon.

Commonly used photoelectric effects:

- Photoconductive effect - Light can cause some materials to change their ability to allow electrons to flow through them. Light sensors (sensor that detect the presence of light) are the main devices that use the photoconductive effect.
- Photovoltaic effect - Also known as solar cells produce the flow of electrons directly. The amount of electrical energy is small for an individual photovoltaic cell but by making the cells large and using many of them useful electrical energy can be made.

Chemical - Batteries are by far the most common source of electrical energy from chemical processes. We will discuss batteries in detail later in this section, but the basics are as follows. Two different metals (let's say zinc and copper) are submerged in a sulfuric acid and water solution (this is called a wet cell, a dry cell would use a paste form of an acid solution.) The zinc will dissolve in the acid leaving behind electrons on the undissolved zinc (negative terminal.) By a similar process the copper

will give up electrons to merge with the hydrogen atoms in the sulfuric acid to form neutral hydrogen (positive terminal.) Between the negative charged zinc terminal and the positively charged copper terminal a voltage would be present.

Another type of chemical device used to generate electricity is the fuel cell. Fuel cells have the advantage of being lighter and lasting longer than batteries. The disadvantage of a fuel cell is their cost, at this time they are extremely expensive. In a fuel cell, gases like hydrogen (fuel) and oxygen (oxidant) are combined directly to form water and energy. These react in the presence of an electrolyte. As long as the fuel flow is maintained, fuel cells will produce electricity. This differs from batteries that just store electric energy chemically in a closed system.

Magnetism - The most common way of producing electricity in modern times is with magnetism. Almost all of the electricity we use with the exception of the emergency and portable equipment powered by batteries comes from a generator at a commercial power plant.

These generators are driven (turned) from many sources:

- Water flow
- Steam turbine from the heating of coal, oil, gas, or atomic power
- Internal combustion engine

Magnetism is such a vital source of both electrical power (good) and also electrical noise (bad). We will discuss noise in detail in a section of its own later.