MINNESOTA 4-H STEM PROGRAM

Electrical Engineering and the 4-H Engineering Design Challenge Level 2

One of the exciting aspects of building the 4-H Engineering Design Challenge Level 2 machine is learning about the various categories of machine construction. This information addresses the Electrical element.

WHAT IS ELECTRICITY?

At its most basic, electricity is the presence and flow of electrical charges. Since all atoms have charges, electricity is all around us. While certain aspects of electricity had been observed for centuries, like lightning and static electricity, it wasn't until the 1600s that people tried to harness this energy.

Today electricity is used for a lot more than powering appliances and lighting your home. All home devices communicate with each other using electrical impulses. Home stereo speakers are connected to TV with cables, audio visual cables each carry an electrical signal which allows televisions to communicate with different peripherals. None of that would be possible without electricity.

ELECTRICITY AND OHM'S LAW

Georg Ohm found that, at a constant temperature, the electrical current flowing through a fixed linear resistance is directly proportional to the voltage applied across it and inversely proportional to the resistance. This relationship between the Voltage, Current and Resistance forms the basis of Ohm's **Law**.

Ohm's Law Relationship

$$Current,(I) = \frac{Voltage,(V)}{Resistance,(R)} \; in \; Amperes,(A)$$

By knowing any two values of the Voltage, Current or Resistance quantities we can use Ohm's Law to find the third missing value. Ohm's Law is used extensively in electronics formulas and calculations and can provide some insight into how electricity may be involved in your machine.

To find the Voltage, (V)

[V = I x R] V (volts) = I (amps) x R

(Ω) To find the Current, (I)

[I = V ÷ R] I (amps) = V (volts) ÷ R

(Ω) To find the Resistance, (R)

[R = V ÷ I] R (Ω) = V (volts) ÷ I (amps)

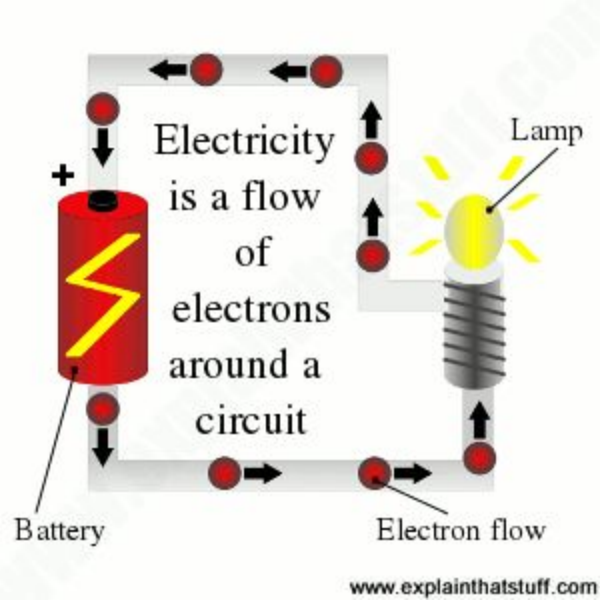
ELECTRICITY IN THE 4-H ENGINEER DESIGN CHALLENGE LEVEL 2 MACHINES

For the Engineering Design Challenge, electricity needs to be a part of the machine. Teams are encouraged to use any type of power (with the exception of wall outlets), switches, pulleys, circuits and controls using electricity. Use your innovative skills to design your machine.

HOW ELECTRICITY MOVES IN A CIRCUIT

Materials such as copper metal that conduct electricity (allow it to flow freely) are called **conductors. Insulators** are materials that do not allow electricity to pass through them so readily, such as rubber and plastic. What makes copper a conductor and rubber an insulator?

A current of electricity is a steady flow of electrons. When electrons move from one place to another, round a circuit, they carry electrical energy from place to place like marching ants carrying leaves. Instead of carrying leaves, electrons carry a tiny amount of electric charge.



Electricity can travel through something when its structure allows electrons to move through it easily. Metals like copper have "free" electrons that are not bound tightly to their parent atoms. These electrons flow freely throughout the structure of copper and this is what enables an electric current to flow. In rubber, the electrons are more tightly bound. There are no "free" electrons and, as a result, electricity does not really flow through rubber at all. Conductors that let electricity flow freely have a high conductance and a low resistance; insulators that do not allow electricity to flow are the opposite: they have a low conductance and a high resistance.

ELECTRICAL SAFETY

Water is an excellent conductor. You can become electricity's path to the ground if you are touching water that touches electricity. Electricity would travel through the water and through you to the ground.

This is why it is important to keep all electrical appliances away from water, and to make sure your hands are dry and you are not standing in water when you touch anything electrical. It is the reason no one should ever use water on an electrical fire, but should use a multipurpose fire extinguisher instead.

What CAN and CANNOT be used for electrical equipment in a machine

Items teams **CAN** use:

- Up to four batteries (nothing larger than a 6 volt or 12 amp sealed dry cell battery)
- Light bulbs
- Power switches
- Wire
- Or any other item that will help you with completing this

step Items teams **CANNOT** use:

- Wall outlets
- Air compressor
- More than two power strips
- Broken, taped (repaired) and or modified power cords
- Any dry cell batteries larger than a 6 volt.
- Any cords connected to a wall outlet

WHERE DO TEAMS OBTAIN SUPPLIES FOR ELECTRICITY?

Teams are responsible for purchasing their own electrical supplies for their 4-H Engineering Design Challenge machine. For equipping your team with electrical supplies try going to a local electrician who might provide you with extra supplies they are not using. Another option would be to talk with a hardware store or a store who sells electrical equipment and maybe they would donate electrical supplies.

LEARN MORE ABOUT ELECTRICITY

Electricity Handout
http://www.cleanlineenergy.com/sites/cleanline/media/resources/students/electricity/Electricity_Infobook-High_School.pdf

Series and Parallel Circuits
http://tryengineering.org/sites/default/files/lessons/serpar_0.pdf

Electricity Connect: Materials for Students and Teachers
https://sewelldirect.com/learning-center/electricity

Introduction to Electricity
https://www.youtube.com/watch?v=EJeAuQ7pkpc

Explaining an Electrical Circuit
https://www.youtube.com/watch?v=VnnpLaKsqGU

Introduction to Circuits
https://www.youtube.com/watch?v=UkP-f88aTm4

ACKNOWLEDGMENTS:

Electronic Tutorials
http://www.electronics-tutorials.ws/dccircuits/dcp_2.html

FOR MORE INFORMATION, CONTACT:

Brian McNeill, Extension Educator

University of Minnesota Extension Center for Youth Development Email: mcnei006@umn.edu
Phone: (320) 589-1711, ext. 2131

Content compiled by Brian McNeill, Extension Educator, Center for Youth Development February 2018