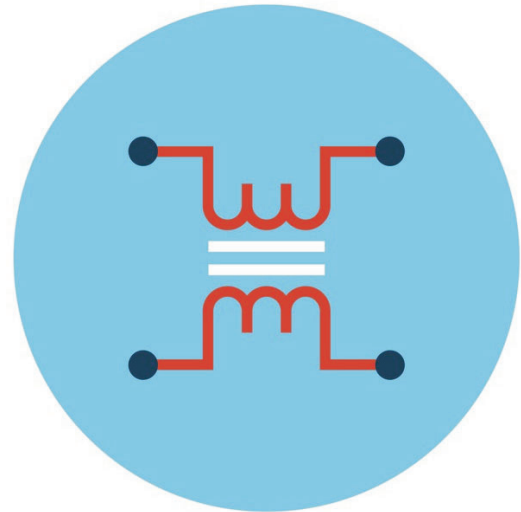


Electrical and Electronic Technology

ELECTRICAL TECHNOLOGY produces and distributes electrical power. Electronic technology works with small electronic circuits, and electricity relies on the basic laws of physics. Technicians and engineers use numerous science and mathematics concepts in their daily work. As consumers, electrical and electronic technologies are the way we store, retrieve, process, and communicate information or data. Career paths include electrician, building and code compliance inspector, electrical contractor, telecommunication technician, product engineer, electrical engineer, quality control, and electronics engineer.



Objective:



Explain how electrical and electronic technologies are used and the math and science all the careers require.

Key Terms:



alternating current (AC)	electrical technology	Ohm's law
circuit	electricity	potentiometer
Common Core State Standards (CCSS)	electronic technology	power
conduction	electronics	resistance
conductor	electrons	semiconductor
current	equation	silicon
derivative	graphical analysis	static electricity
direct current (DC)	magnetism	voltage
dynamic electricity	measurement	
electrical engineering	Next Generation Science Standards (NGSS)	

Understanding Electrical and Electronic Technology Applications

The common methods of power transmission are mechanical, fluid power, and electrical. In general, the difference between electrical technology and electronic technology is that electrical technology careers work with the production and distribution of electrical power and electronic technology careers work with small electronic circuits.

ELECTRICAL TECHNOLOGY vs. ELECTRONIC TECHNOLOGY

Electricity

Electricity is a form of energy that results from charged particles: statically (static) or dynamically (dynamic) as a charged current. **Electrons** are the charged particles that carry a negative charge and create electricity.

Static Electricity

Static electricity is a stationary charge. It does not move. An example of static electricity is if you rub a balloon on your hair, the balloon will then stick to a wall because the static electricity stays on the balloon.

Dynamic Electricity

Dynamic electricity is the movement of an electrical charge as a current. For instance, a television's plug transmits power (electricity) from the street and delivers it to your television via a current.

Electrical Technology

Electrical technology is the harnessing of electricity to transform it into another form of energy. This form of technology tends to be moved through conductors. A **conductor** is a material containing many free electrons that move through the material easily. Copper is a good example of a material that conducts electricity. It is used as the material in plugs and outlets.

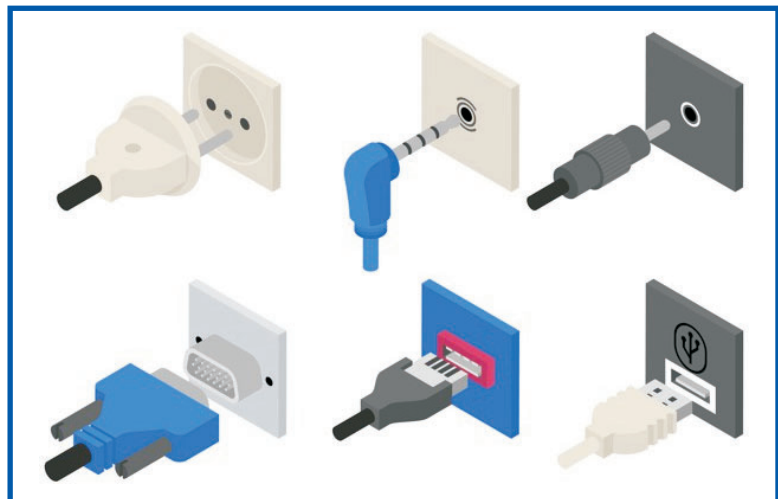


FIGURE 1. After electricity is transferred from a power plant, it is usable by way of various electrical plugs and outlets.

Uses

Electrical technology uses include:

- ◆ A toaster oven harnesses electricity and turns it into heat, and bread becomes toast.
- ◆ A vacuum cleaner converts electricity into suction by powering a motor inside the machine.

Applications

Electrical technology applications include:

- ◆ Power plant generator
- ◆ Flashlight
- ◆ Microwave
- ◆ Smartphone and headphones
- ◆ Electric heater
- ◆ Hair dryer
- ◆ Tablet and computer

Educational Requirements

Careers in electrical technology require a strong background in mathematics and science—especially physics—and include two-, four-, and six-year degrees.

- ◆ Associate's degree programs include electrician, electrical project manager, building code compliance inspector, electrical contractor, etc.
- ◆ Bachelor's degree programs include electrical product design and development, technical services and facilities management, high frequency and microwave technology, electrical engineering, etc.
- ◆ One master's degree program is Master of Science in Electrical Engineering. A more advanced graduate degree is a Doctor of Philosophy in Electrical Engineering. **Electrical engineering** is a branch of engineering that focuses on the study and application of electricity, electromagnetism, and electronics.

Electronics and Electronics Technology

Electronics is the science of controlling electrical energy—energy in which electrons have a fundamental role. Electronics also studies how electrons behave and their effects in vacuums, gases, and semiconductors. To control electricity, there must be a device that carries, selects, steers, switches, stores, manipulates, and/or uses the electron.

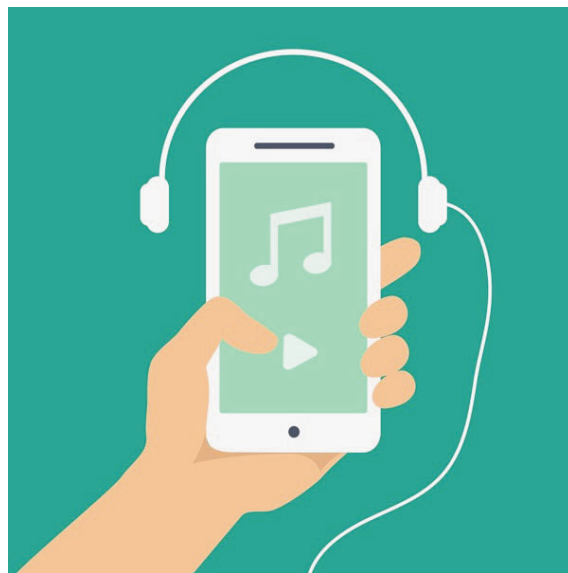


FIGURE 2. The capacity of smartphones and other devices to store and transmit musical sounds is only possible with electronic technology.

Electronic technology is the study of a controlled, manipulated flow of electricity as it powers a useful device: motor, generator, heater, radio wave, converter, or control system. This technology is typically distributed through the devices using semiconductors. A **semi-conductor** is a material whose electrical conductivity can be precisely altered by manufacturing processes.

Examples

Examples of electronic technologies include:

- ◆ A toaster may have a semiconductor inside that regulates the power transferred to the heating element so the toast does not burn.
- ◆ A vacuum cleaner may have a semiconductor that stops the motor when a large item is mistakenly sucked into the vacuum.

Applications

Electronic technology applications include:

- ◆ Thermostat
- ◆ Metal detector
- ◆ Smartphone and cellphone
- ◆ Cellphone camera
- ◆ Graphing calculator
- ◆ Tablet, laptop, watch, and FitBit®
- ◆ Gaming consoles
- ◆ Television

Educational Requirements

Careers in electronic technology require a strong background in mathematics and science, especially physics. Degree programs may require an investment of two, four, or six years.

- ◆ Associate's degree programs include electronics technician, medical equipment assembler, telecommunication technician, industrial electronics technician, and service technician.
- ◆ Bachelor's degree programs include product engineer (design computers and devices), engineering consultant, project manager, quality control (diagnostics), and electrical engineer.
- ◆ Master's degree programs (e.g., Master of Science in Electronic Engineering, Master of Science in Computer Engineering, Master of Science in Project Management Engineering, and Master of Science in Software Engineering)

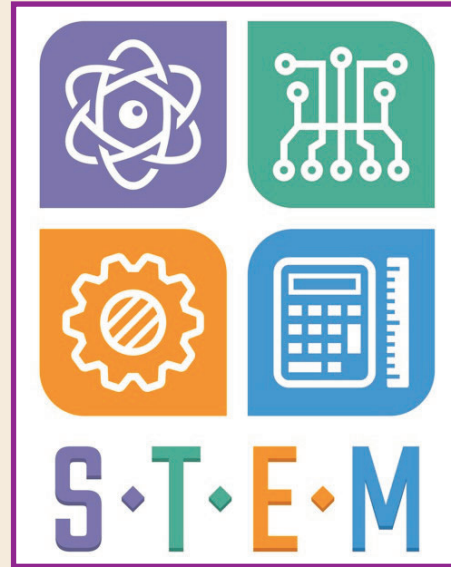


FURTHER EXPLORATION...

ONLINE CONNECTION: NGSS for Students

As a student, you can review the High School Engineering Design framework that the NGSS provides at <http://www.nextgenscience.org/topic-arrangement/hsengineering-design>. You can review the desired outcome of your learning process throughout this lesson and any other engineering or technology lesson.

Then take it a step farther and identify the standards that you need to master to achieve your desired career. List them, and include the NGSS coding (e.g., HS-ETS1-1) so you can frequently refer back to them and gauge your level of progress. Then find out more about STEM: science, technology, engineering, and mathematics.



STEM is an acronym for science, technology, engineering, and mathematics and a course that includes content typically taught in separate classrooms. STEM focuses on finding a solution to a real-world problem.

SCIENCE AND MATHEMATICAL CONCEPTS IN ELECTRICAL SYSTEMS

Next Generation Science Standards

The **Next Generation Science Standards (NGSS)** are K-12 science content standards used as benchmarks for student expectations in science content. Teachers work with these standards to design classwork and projects that improve science education for all students. Science, engineering, and computer teachers use the NGSS as a resource when creating lessons.

Science Concepts

All technology studies and careers require the application of many science and mathematics concepts. The electrical math and science concepts are often developed and applied through the laws of physics. Electrical and electronic technologies use a range of concepts to understand what electricity is, how it moves, and how it works.

Resistance

Resistance is the opposition to the flow of electrical charge. Everything that electricity travels through provides resistance to that electrical current. For example, air provides resis-

tance to a lightning bolt shooting through the sky. In addition, copper provides resistance to the electrical current running to an appliance from the electrical source.

Conduction

Conduction is the transmission of heat, sound, or electricity through matter. A pan on an electric stove is heated by conduction. The hot electric stovetop coil heats the bottom of the pan as the energy moves from the hotter object to the cooler object, eventually bringing the bottom of the pan to the same temperature as the hot coil.

- ◆ A conductor is a material containing many free electrons that move through the material easily. Copper is a great conductor because it provides little resistance to the electrical current moving through it. In contrast, air is a poor conductor because it provides great resistance to electrical currents.
- ◆ A semiconductor is a material whose electrical conductivity can be precisely altered by manufacturing processes. Silicon is a prime example of a semiconductor. **Silicon** is a nonmetal chemical element used in making electronic circuits. It is used in the production of computer processor chips as they receive and transmit electrical signals throughout the computer.

Current

Current is the total amount of electrons flowing through a circuit per unit of time. When the ignition of a car is started, it sends a current from the battery to start the engine and motors in the vehicle. A **circuit** is a complete path of electric current, including the source of electrical energy. A car's battery begins a circuit as it provides electricity to operate the radio, and the



FURTHER EXPLORATION...

ONLINE CONNECTION: How Electricity Works

Electricity has changed our lives dramatically. Its applications and uses are endless. Its production, distribution, use, and final result range from how we cook and heat our homes to how we communicate. Electrical technology and electronic technology are developing fields because of consumer needs.

The website <http://www.HowStuffWorks.com> is a fantastic way to learn about science and how it works. You can read about many science concepts, from electricity to solar cells, and learn how and why Thomas Edison electrocuted an elephant at

<http://science.howstuffworks.com/electricity.htm>



Login to the "HowStuffWorks" website to learn how these handheld devices and how WiFi work.

electricity is returned to the battery through the car's metal body. Electric circuits provide a means of transferring and using electrical energy to produce heat, light, and sound as well as chemical changes.

- ◆ **Alternating current (AC)** is electrons flowing in both directions along the conductor and reversing at regular intervals. Anything that plugs into a wall is using alternating current. The appliances in homes all use alternating current.
- ◆ **Direct current (DC)** is electrons flowing in one direction from the power source. Anything that uses a battery is using direct current. Cellphones, car batteries, and flashlights are a few examples.

Voltage

Voltage is the force that moves electrons. It exists when two points have different charges. The difference in charge is referred to as the voltage. Batteries provide voltage as they have two oppositely charged ends. When a battery is placed into its device, the top of the battery transfers voltage through the device, and the energy is returned to the bottom of the battery (or from one side to the other side).

Power

Power is the rate of doing work or the rate of transferring energy. Overhead or buried electrical cables transfer power from the source to the point of distribution.

Magnetism

Magnetism is the property of some materials to attract or repel others. Electrons with positive and negative charges attract or repel each other. This basic principle allows us to use and create electricity.

Ohm's Law

Ohm's law is the linear relationship between voltage and current through an electrical device. A battery placed into a cordless device (e.g., a remote control) only works with a specific size battery. For instance, you

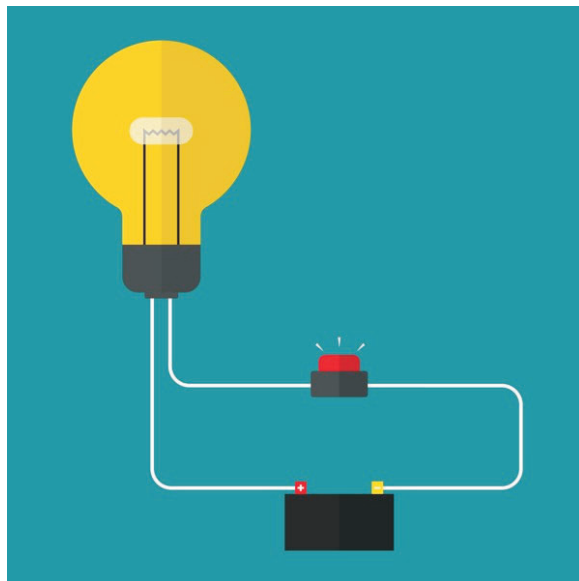


FIGURE 3. A circuit is a complete path of electric current, including the source of electrical energy (e.g., this power switch to light a bulb). Electric circuits provide a means of transferring and using electrical energy to produce heat, light, and sound as well as chemical changes.

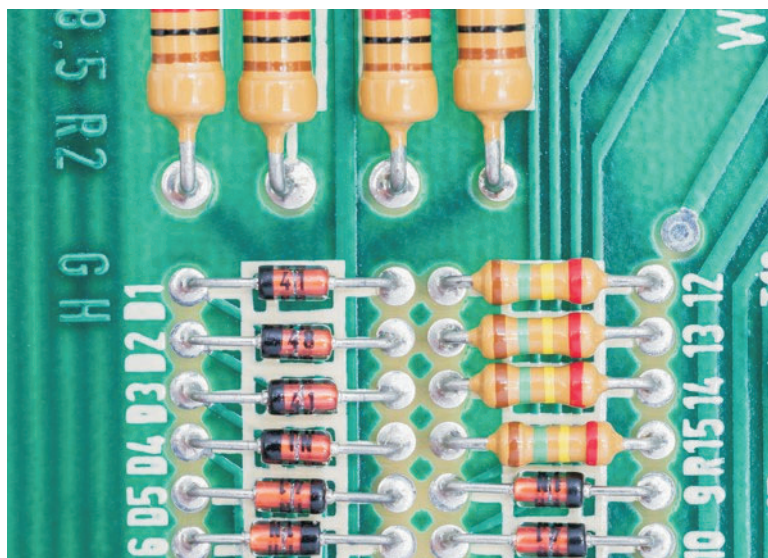


FIGURE 4. Power resistors are found in most electronic equipment. Resistors control and regulate the flow of electricity.

cannot use AA batteries if the remote calls for AAA batteries. The device would not function properly because it was created with a certain level of resistance measured in Ohms. Named after Georg Ohm (1787 to 1854), a German physicist, its mathematical equation is $I = V/R$. [I = Current, V = Voltage, and R = Resistance]

Mathematics Concepts

The **Common Core State Standards (CCSS)** is the set of learning standards that focuses on developing the critical thinking, problem solving, and analytical skills you will need to be successful. The state-led effort to develop the CCSS was launched in 2009 by state leaders, including governors and state commissioners of education from 48 states, two territories and the District of Columbia, through their membership in the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO). The CCSS provide clear and direct guidelines for what every student needs to know from kindergarten through 12th grade for mathematics and English language arts. CCSS mathematics for high school are:

Algebra

You should be able to see structure in expressions; complete arithmetic in polynomials; create equations; and reason with equations and inequalities. Algebra is used in electrical and electronic technology whenever expressions are being used to solve for load, Ohms, voltage, etc.

Geometry

You must be familiar with congruence, similarity, right triangles, trigonometry, circles, expressing geometric properties with equations, geometric measurement and dimensioning, and modeling with geometry. Geometry is used in electrical and electronic technology whenever blueprints are created for a project.

Numbers and Quantities

You must be able to handle the real number system, quantitative reasoning, the complex number system, and vector and matrix quantities. Numbers and quantities are used in electrical and electronic technology whenever a calculation or measurement is made.

Functions

You need to be able to interpret functions; build functions; create linear quadratic and exponential models; and use trigonometric functions. Functions are used in electrical and electronic technology when solving mathematical questions involving the functions listed.

Statistics and Probability

You should be able to interpret categorical and quantitative data; make inferences and justify conclusions; utilize conditional probability and the rules of probability; and use probability to make decisions. Statistics and probability are used in electrical and electronic technology when

decisions or predictions are required to complete projects. These are not just good guesses; probability relies on data (statistics) and experience.

CCSS Mathematical Practices

The eight CCSS Mathematical Practices are:

- ◆ Math Practice 1: Make sense of problems and persevere in solving them.
- ◆ Math Practice 2: Reason abstractly and quantitatively.
- ◆ Math Practice 3: Construct viable arguments and critique the reasoning of others.
- ◆ Math Practice 4: Model with mathematics.
- ◆ Math Practice 5: Use appropriate tools strategically.
- ◆ Math Practice 6: Attend to precision.
- ◆ Math Practice 7: Look for and make use of structure.
- ◆ Math Practice 8: Look for and express regularity in repeated reasoning.

Graphical Analysis

Graphical analysis is the process of investigating phenomena in a systematic way using diagrams and graphs. For example: In plotting the amount of energy used in a household over the course of a month, electrical engineers examine a column chart based on an x-y axis table.

- ◆ The y-axis contains the energy used (kWh).
- ◆ The x-axis contains the days of the month.

Equation

An **equation** is a mathematical statement that shows two things are equal; the statement has an equals sign “=.” Ohm’s law is an example. It uses common electric variables in an equation, such as P = Power (watts, W, J/s), V = Voltage (volts, V), I = Current (amperes, A), R = Resistance (ohms, Ω).

Electrical potential:

- ◆ $V = RI$
- ◆ $V = P \div I$
- ◆ $V = (PR)^{1/2}$

Measurement

Measurement is a number that shows the size or amount of something (e.g., weight, meters, inches, or yards). **Derivative** is the rate of change. It is a term with roots in calculus. The easiest concept to illustrate a derivative is change in time. If a person created a function that illustrated the amount of money in a savings account represented by “S” and let “t” equal

time, knowing that “d” is typically used for labeling change or derivative, he or she would create a formula like this: $dS \div dt$. For example:

- ◆ If you had \$12,000 in savings and spent \$3,000 per year, how many years would it take to deplete (drain) your savings account? It is an easy answer. Divide \$12,000 by \$3,000 = 4 years.
- ◆ What is a little more challenging is if you label this correctly, \$3,000 should be a negative number because in relation to the savings account we are taking money out of it, and 4 years should be negative because time is passing.

Potentiometer

Electrical engineers use a **potentiometer**, which is a device that measures the position of a machine part in terms of a voltage. It is typically used on robotic arms through an assembly line process. If a potentiometer is connected to a differentiator circuit, you can measure the angular velocity of the robotic arm using the derivative equation from above.

- ◆ Velocity: $V = dx \div dt$ (where V = Velocity, x = position, and t = time)
- ◆ The change of the angular position of the robotic arm is measured as the arm’s end point moves over time.

Summary:



Electrical technology is based on the general application and knowledge of how electric works and can be used to perform certain tasks as an energy source. Electronic technology is focused specifically on controlling small amounts of electric in computer chips or transistors. Smartphones, laptops, and tablets are all examples of electronic technology.

Electrical technology uses a range of science and mathematical concepts to understand how electricity moves and works, how it is used, and how it can be controlled. The concepts relate to how much electricity is there, its frequency, and how it moves through specific materials. Too much electricity results in your tablet getting fried. Too little electricity results in the screen not being visible. With this knowledge, we can control how much electricity is required and administered.

Checking Your Knowledge:



1. What is electrical technology?
2. What is electronic technology?
3. Compare and contrast alternating current (AC) and direct current (DC).

4. How is a resistor different from a conductor?
5. How do derivatives help us explain electric current?

Expanding Your Knowledge:



You can create your own direct circuit of electricity and experiment how well it moves through different materials. Ask your teacher to supply you with various batteries and low-voltage light bulbs. Add the required amount of volts through the batteries in a series to power the appropriate lights. Research how to set up a basic direct current. Then experiment with it. Choose different objects, and attempt to pass the current through the objects. Record your findings. Draw conclusions on which were better conductors and which were strong resistors. Ask your classmates if they came to the same conclusions.

Web Links:



Electricity

<https://learn.sparkfun.com/tutorials/what-is-electricity>

How Electricity Works

<http://www.easyapplianceparts.com/resources/How-Does-Electricity-Work.aspx>

Electronics Applications

<http://www.ansys.com/Solutions/Solutions-by-Application/Electronics>