# STEM: Electronics
# Curriculum Map & Standards

## Time: 45 Days

### Lesson 6.1 What is Electricity? (16 days)

**Concepts**

1. As engineers design electrical systems, they must understand a material's tendency toward being a conductor or insulator.
2. Electron flow is created as electrons are transferred between atoms.
3. Current, voltage, and resistance are measurable quantities that are used to explain electron flow in an electrical system.
4. Generators are used to convert mechanical energy into electrical energy, while motors convert electrical energy into mechanical energy.
5. Magnets play an important role in creating electromotive force which is used to make and convert electricity.

**Performance Objectives**

*It is expected that students will:*

- Identify the roles of protons, neutrons, and electrons in an atom.
- Identify an element based on the atomic number.
- Identify metals, metalloids, and non-metals on the periodic table.
- Judge whether a material is a conductor, insulator, or semiconductor based upon its number of valance electrons and its position on the periodic table.
- Explain how the Law of Charges holds an atom together.
- Explain how electrons transfer from one atom to another to create electron flow.
- Define current, voltage, and resistance.
- Measure voltage and current using a multimeter.
- Understand the properties of a magnet.
- Build an electromagnet to demonstrate its characteristics and functions.
- Build a DC motor to identify the primary parts and demonstrate how it functions.
- Build a generator to identify the primary parts and demonstrate how it functions.
- Understand the role of an electromagnet in the function of a DC motor and generator.
- Compare the characteristics of a basic motor and generator.

### Lesson 6.2 Electronics (17 days)

**Concepts**

1. An electrical circuit is a system made up of conductors and electrical components that form a complete path for electrical current.
2. Engineers use circuit diagrams to communicate components and functions of electrical circuits.
3. A variety of electronic components are incorporated into electrical circuits by engineers to achieve specific functions.
4. When building or diagnosing circuits, it is important to be able to measure voltage, current, and resistance.
5. Ohm's Law explains the mathematical relationship between voltage, current, and resistance.
6. The transistor is an important electronic device because it allows a small amount of current to control a larger amount of current.
7. Engineers, designers, and engineering technologists are needed in high demand for the development of future technology to meet societal needs and wants.

**Performance Objectives**

*It is expected that students will:*

- Build series, parallel, and combination electrical circuits.
- Create circuit diagrams using standardized schematic symbols.
- Build and test physical electrical circuits based upon circuit diagrams.
- Integrate DC sources, lamps, switches, diodes, light emitting diodes, resistors, and capacitors into electrical circuits to achieve specific functions.
- Distinguish between the functions and operations of fixed resistors, variable resistors, and photo resistors.
- Determine the value of a fixed resistor based upon the color codes on those resistors.
- Measure voltage, current, and resistance using a multimeter.
- Mathematically calculate voltage, current, and resistance using Ohm's law.
- Create a circuit that uses a transistor as a switch.

## Lesson 6.3 Digital Electronics (12 days)

**Concepts**

1. Computer processors are the key component of electronic devices and function based on logic.
2. Digital wave forms that communicate binary digits are the means of communication within and among digital electronic devices.
3. Engineers decide upon inputs, outputs, and the logic necessary for an electronic device.
4. Engineers must decide on the necessary constraints and trade-offs in control systems.

**Performance Objectives**

*It is expected that students will:*

- Interpret logic scenarios to determine outputs based upon possible conditions within those scenarios.
- Distinguish between the functions of NOT, AND, OR, NAND, NOR, and XOR gates.
- Create truth tables for logic scenarios and match those gates to truth tables.
- Convert binary numbers to Base-10.
- Convert ACII characters to binary.
- Create a digital wave form and graph it for a binary sequence.
- Communicate using electronic circuit diagrams.
- Use transistors as switches to create circuits that function as AND and OR gates.
- Determine the logic, sensors, gates, outputs, and other components needed to emulate existing electronic devices that utilize logic.
- Design, construct, and test device solutions for emulating common electronic devices that utilize logic.

# Next Generation Science Standards

## Lesson 6.1 - What is Electricity?

**Middle School**

Matter and Its Interactions

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. (MS.PS1.1)

Motion and Stability: Forces and Interactions

MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. (MS.PS2.3)
MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. (MS.PS2.5)

## Lesson 6.2 - Electronics

**Middle School**

Waves and their Applications in Technologies for Information Transfer

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (MS.PS4.2)
MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. (MS.PS4.3)

Engineering Design

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS.ETS1.1)

## Lesson 6.3 - Digital Electronics

**Middle School**

Waves and their Applications in Technologies for Information Transfer

MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. (MS.PS4.3)

Engineering Design

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS.ETS1.1)
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS.ETS1.2)
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS.ETS1.3)
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS.ETS1.4)



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# Common Core State Standards for Mathematical Practice (6-8)

## Lesson 6.1 - What is Electricity?

**Grade 7**

The Number System

-Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.
1.a. Describe situations in which opposite quantities combine to make 0. For example, a hydrogen atom has 0 charge because its two constituents are oppositely charged. (7.NS.A.1a)

Geometry

-Draw, construct, and describe geometrical figures and describe the relationships between them.
1. Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. (7.G.A.1)

**Grade 8**

Expressions and Equations

-Work with radicals and integer exponents.
4. Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. (8.EE.A.4)

# Lesson 6.2 - Electronics

**Grade 6**

The Number System

-Compute fluently with multi-digit numbers and find common factors and multiples.

2. Fluently divide multi-digit numbers using the standard algorithm. (6.NS.B.2)

3. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. (6.NS.B.3)

Expressions and Equations

-Apply and extend previous understandings of arithmetic to algebraic expressions.

1. Write and evaluate numerical expressions involving whole-number exponents. (6.EE.A.1)

2. Write, read, and evaluate expressions in which letters stand for numbers. (6.EE.A.2)

2.c. Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations). For example, use the formulas $V = s^3$ and $A = 6s^2$ to find the volume and surface area of a cube with sides of length s = 1/2. (6.EE.A.2c)

-Reason about and solve one-variable equations and inequalities.

6. Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (6.EE.B.6)

7. Solve real-world and mathematical problems by writing and solving equations of the form x + p = q and px = q for cases in which p, q and x are all nonnegative rational numbers. (6.EE.B.7)

**Grade 7**

The Number System

-Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.

2. Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers. (7.NS.A.2)

2.c. Apply properties of operations as strategies to multiply and divide rational numbers. (7.NS.A.2c)

3. Solve real-world and mathematical problems involving the four operations with rational numbers. (7.NS.A.3)

Expressions and Equations

-Solve real-life and mathematical problems using numerical and algebraic expressions and equations.

4. Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (7.EE.B.4)

**Grade 8**

Expressions and Equations

-Work with radicals and integer exponents.

4. Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. (8.EE.A.4)

-Analyze and solve linear equations and pairs of simultaneous linear equations.

7. Solve linear equations in one variable. (8.EE.C.7)

## Lesson 6.3 - Digital Electronics

**Grade 6**

The Number System

-Apply and extend previous understandings of numbers to the system of rational numbers.

7. Understand ordering and absolute value of rational numbers. (6.NS.C.7)

**Grade 8**

Expressions and Equations

-Work with radicals and integer exponents.

4. Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. (8.EE.A.4)

Functions

-Use functions to model relationships between quantities.

5. Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. (8.F.B.5)



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# Common Core State Standards for English Language Arts

## Lesson 6.1 - What is Electricity?

**Reading**

Comprehension and Collaboration

4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)

Conventions of Standard English

1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. (AS.L.1)

2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. (AS.L.2)

6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

## Lesson 6.2 - Electronics

**Reading**

Comprehension and Collaboration

4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)

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## Lesson 6.3 - Digital Electronics

**Reading**
Comprehension and Collaboration

4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (AS.SL.4)

Conventions of Standard English

1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. (AS.L.1)
2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. (AS.L.2)
6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression. (AS.L.6)

http://www.corestandards.org/



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# Standards for Technological Literacy

## Lesson 6.1 - What is Electricity?

**Students will develop an understanding of the characteristics and scope of technology.**
6-8

H. Technology is closely linked to creativity, which has resulted in innovation. (1.6-8.H)

**Students will develop an understanding of the core concepts of technology.**
6-8

P. Technological systems can be connected to one another. (2.6-8.P)

9-12

AA. Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. (2.9-12.AA)

**Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.**
9-12

H. Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. (3.9-12.H)

**Students will develop an understanding of the effects of technology on the environment.**
9-12

J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. (5.9-12.J)

**Students will develop an understanding of the attributes of design.**
6-8

E. Design is a creative planning process that leads to useful products and systems. (8.6-8.E)
G. Requirements for design are made up of criteria and constraints. (8.6-8.G)

**Students will develop an understanding of engineering design.**
6-8

F. Design involves a set of steps, which can be performed in different sequences and repeated as needed. (9.6-8.F)
G. Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. (9.6-8.G)
H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. (9.6-8.H)

9-12

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. (9.9-12.K)

**Students will develop the abilities to apply the design process.**
6-8

J. Make two-dimensional and three-dimensional representations of the designed solution. (11.6-8.J)
K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. (11.6-8.K)
L. Make a product or system and document the solution. (11.6-8.L)

9-12

N. Identify criteria and constraints and determine how these will affect the design process. (11.9-12.N)
Q. Develop and produce a product or system using a design process. (11.9-12.Q)

# Lesson 6.2 - Electronics

**Students will develop an understanding of the characteristics and scope of technology.**
6-8

F. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. (1.6-8.F)

**Students will develop an understanding of the core concepts of technology.**
6-8

M. Technologies systems include input, processes, output, and at times, feedback. (2.6-8.M)
N. Systems thinking involves considering how every part relates to others. (2.6-8.N)
P. Technological systems can be connected to one another. (2.6-8.P)

9-12

CC. New technologies create new processes. (2.9-12.CC)

**Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.**
6-8

D. Technological systems often interact with one another. (3.6-8.D)

9-12

G. Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. (3.9-12.G)

**Students will develop an understanding of the role of society in the development and use of technology.**
6-8

D. Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. (6.6-8.D)
E. The use of inventions and innovations has led to changes in society and the creation of new needs and wants. (6.6-8.E)

**Students will develop an understanding of the attributes of design.**
6-8

E. Design is a creative planning process that leads to useful products and systems. (8.6-8.E)
F. There is no perfect design. (8.6-8.F)
G. Requirements for design are made up of criteria and constraints. (8.6-8.G)

9-12

H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype. (8.9-12.H)
I. Design problems are seldom presented in a clearly defined form. (8.9-12.I)
J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. (8.9-12.J)
K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8.9-12.K)

**Students will develop an understanding of engineering design.**
6-8

H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. (9.6-8.H)

9-12

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. (9.9-12.K)

**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.**
6-8

F. Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. (10.6-8.F)

**Students will develop an understanding of and be able to select and use energy and power technologies.**
9-12

N. Power systems must have a source of energy, a process, and loads. (16.9-12.N)

**Students will develop an understanding of and be able to select and use information and communication technologies.**
9-12

P. There are many ways to communicate information, such as graphic and electronic means. (17.9-12.P)
Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. (17.9-12.Q)

## Lesson 6.3 - Digital Electronics

**Students will develop an understanding of the characteristics and scope of technology.**
6-8

F. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. (1.6-8.F)
H. Technology is closely linked to creativity, which has resulted in innovation. (1.6-8.H)

**Students will develop an understanding of the core concepts of technology.**
9-12

W. Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. (2.9-12.W)
X. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. (2.9-12.X)
Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. (2.9-12.Y)
AA. Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. (2.9-12.AA)

**Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.**
9-12

G. Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. (3.9-12.G)

**Students will develop an understanding of the effects of technology on the environment.**
9-12

I. With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. (5.9-12.I)

**Students will develop an understanding of the role of society in the development and use of technology.**
6-8

D. Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. (6.6-8.D)

**Students will develop an understanding of the attributes of design.**
9-12

H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype. (8.9-12.H)
I. Design problems are seldom presented in a clearly defined form. (8.9-12.I)
J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. (8.9-12.J)
K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. (8.9-12.K)

**Students will develop an understanding of engineering design.**
9-12

J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. (9.9-12.J)
K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. (9.9-12.K)

**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.**
6-8

F. Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. (10.6-8.F)

**Students will develop the abilities to apply the design process.**
9-12

N. Identify criteria and constraints and determine how these will affect the design process. (11.9-12.N)
O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. (11.9-12.O)
Q. Develop and produce a product or system using a design process. (11.9-12.Q)

**Students will develop an understanding of and be able to select and use information and communication technologies.**
6-8

K. The use of symbols, measurements, and drawings promotes a clear communication by providing a common language to express ideas. (17.6-8.K)

9-12

L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. (17.9-12.L)
M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. (17.9-12.M)
P. There are many ways to communicate information, such as graphic and electronic means. (17.9-12.P)
Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. (17.9-12.Q)