Electricity

Electric Circuits

link™
CPO Science

Real Investigations in
Science and Engineering

Overview Chart for Investigations–Electric Circuits

	Investigation	Key Question	Summary	Learning Goals	Vocabulary
A1	**What Is a Circuit?** Pages 1–8 50 minutes	What is an electric circuit?	Students build and analyze a circuit with a bulb, battery, wires, and switch. They also learn to draw and understand diagrams of electric circuits using standard electric symbols. Students discover what is needed in order for the bulb to light.	• Build and diagram a simple circuit. • Explain how a switch works. • Identify open and closed circuits. • Test and identify conductors and insulators.	circuit diagram closed circuit conductor electric circuit electrical symbol electricity insulator open circuit
A2	**Voltage and Current** Pages 9–14 50 minutes	How are voltage and current measured in a circuit?	Students build a circuit with a bulb, a battery, and wires. They use an electric meter to measure the voltage of the battery when it is outside of its holder, and then when it is in the circuit lighting the bulb. A comparison is made between the voltages. Students then use the meter to measure the current in the circuit.	• Measure voltage of a battery both in and out of a circuit. • Measure the current in a circuit.	ammeter ampere coulomb current multimeter volt voltage voltmeter
A3	**Types of Circuits** Pages 15–20 50 minutes	What kinds of electric circuits can you build?	Students compare how two kinds of circuits work by building and observing series and parallel circuits. They explore an application of these circuits by wiring two switches in series and in parallel.	• Build, describe, and identify a series circuit. • Build, describe, and identify a parallel circuit. • Build, describe, and identify AND and OR circuits.	AND circuit OR circuit parallel circuit series circuit
A4	**Analyzing Circuits** Pages 21–26 50 minutes	Why are the bulbs in a 2-bulb parallel circuit brighter than the ones in a 2-bulb series circuit?	Students measure voltage and current of a series circuit and a parallel circuit and develop an explanation for why the parallel bulbs are brighter.	• Build series and parallel circuits. • Measure the voltage and current at different places in series and parallel circuits. • Explain why the bulbs wired in parallel are brighter than the bulbs wired in series.	ampere current parallel circuit series circuit volt voltage
A5	**Electromagnets** Pages 27–32 50 minutes	How are electricity and magnetism related?	Students study the magnetic force created by a permanent magnet and an electromagnet. They observe the interaction between the two types of magnets, and between the two magnets and a compass needle. Using a potentiometer, they see that the strength of an electromagnet can be altered.	• Use a compass to detect magnetic force. • Recognize that permanent magnets and electromagnets both can exert magnetic force. • Build a circuit to control the strength of an electromagnet.	electromagnet permanent magnet right-hand rule

Overview Chart for Investigations–Electric Circuits

	Investigation	Key Question	Summary	Learning Goals	Vocabulary
A6	**Electric Circuit Game** Pages 33–38 50–100 minutes	How can the engineering cycle be used to build a game?	Students use the engineering design cycle to create an electric circuit game. They identify criteria and constraints, brainstorm a solution, test it, and make refinements until a final design is reached.	• Describe the steps of the engineering design cycle. • Identify the criteria and constraints for building a game. • Follow the steps of the engineering cycle to build a working electric circuits game.	constraint criteria engineering cycle prototype trade-off
B1	**Voltage** Pages 39–44 50 minutes	What makes current flow through a circuit?	Students learn how to use a digital multimeter to measure voltage, and observe how a change in voltage affects a light bulb. They also observe what happens when batteries are connected incorrectly in a circuit.	• Measure voltage with a digital multimeter. • Describe the role of a battery in a circuit. • Calculate the total voltage of several batteries in series. • Describe the transfer of energy in a circuit.	multimeter volt (V) voltage voltmeter
B2	**Current** Pages 45–52 50 minutes	How does current move through a circuit?	Students learn about current and how to measure current at different points in a circuit. Students also describe the relationship between current and bulb brightness by comparing circuits with one bulb and two bulbs. They discuss their ideas about why current decreases when a second bulb is added.	• Define current and explain its role in an electric circuit. • Measure current with a digital multimeter.	ammeter ampere (A) electric current multimeter
B3	**Resistance** Pages 53–58 50 minutes	What is resistance and how is it measured?	Students learn about resistance and use a multimeter to measure the resistance of fixed resistors. Students build simple circuits with different fixed resistors to observe the effect of resistance on the circuit's current.	• Explain the role of resistance in an electric circuit. • Measure resistance with a digital multimeter. • Predict and describe what happens when resistors are added in series to a light bulb circuit.	fixed resistor ohm (Ω) resistance resistor variable resistor
B4	**Ohm's Law** Pages 59–64 100 minutes	How are voltage, current, and resistance related?	Students build circuits and analyze them with a digital multimeter to see how changing resistance and voltage affects electric current. From their data analysis, students determine the mathematical relationship between voltage, current, and resistance in a circuit.	• Describe how current changes when resistance is increased. • Describe how current changes when voltage is increased. • Describe how voltage, current, and resistance are related. • Explain why resistors are used in a circuit.	Ohm's law potentiometer resisistor

Overview Chart for Investigations–Electric Circuits

	Investigation	Key Question	Summary	Learning Goals	Vocabulary
B5	**Series Circuits** Pages 65–70 100 minutes	How do you use Ohm's law in series circuits?	Students find out how to add resistance in a series circuit. They will also build a light bulb circuit with a dimmer switch and use this circuit to graph the resistance of a light bulb at different levels of current.	• Calculate the total resistance of a series circuit. • Analyze series circuits using Ohm's law. • Determine the relationship between a bulb's resistance and the current passing through it.	Ohm's law series circuit
B6	**Parallel Circuits** Pages 71–76 100 minutes	How do parallel circuits work?	Students analyze how a parallel circuit works by measuring voltage and current in different parts of the circuit. They apply their understanding of parallel circuits to design a battery voltage tester circuit.	• Build circuits with fixed and variable resistors. • Compare current and voltage in series and parallel circuits. • Design a battery voltage tester circuit.	Kirchhoff's current law parallel circuit
B7	**Compound Circuits** Pages 77–84 100 minutes	How do you analyze compound circuits?	Students build compound circuits. They apply what they learned about series and parallel circuits in the previous investigation to analyze more complicated designs. Current and voltage are measured at various locations and compared with the predicted results. Resistors are changed and added to illustrate the relationship between current, voltage, and resistance.	• Calculate the total resistance of a compound circuit. • Calculate the current at various locations in a compound circuit. • Determine the voltage across each resistor in a compound circuit. • Measure the current and voltage in a compound circuit.	compound circuit Kirchhoff's current law Kirchhoff's voltage law
B8	**Electricity and Magnetism** Pages 85–90 50 minutes	How are electricity and magnetism related?	Students study the magnetic force created by a permanent magnet and an electromagnet. They observe the interaction between a permanent magnet and electromagnet, and between the two magnets and a compass needle. Using a potentiometer, they see that the strength of an electromagnet can be altered.	• Use a compass to detect magnetic force. • Recognize that permanent magnets and electromagnets both can exert magnetic force. • Build a circuit to control the strength of an electromagnet. • Observe the effect of adding a steel core to an electromagnet.	electromagnet permanent magnet right-hand rule

Overview Chart for Investigations–Electric Circuits

	Investigation	Key Question	Summary	Learning Goals	Vocabulary
C1	**Capacitors** Pages 91–98 100 minutes	How does a capacitor work?	Students study the charging and discharging rates of a capacitor and use the data to construct graphs. They discover that the relationship between voltage and time is not linear. Students then compare the charging rates when different resistors are used in the charging circuit.	• Discuss how the voltage across a capacitor varies with time as it charges and discharges. • Explain how the current in a circuit with a capacitor changes with time as it charges and discharges. • Describe the relationship between the circuit resistance and the charging rate of a capacitor.	capacitance (C) capacitor charge electric current farad (F) voltage
C2	**Semiconductors** Pages 99–104 100 minutes	What are some useful properties of semiconductors?	Students build an electric circuit and construct a current versus voltage curve for a diode in both the forward bias and reverse bias directions. They observe that a diode allows current to flow only in one direction and only when the voltage is greater than a minimum value. The same experiment is repeated for a LED.	• Describe the electrical behavior of a diode. • Explain how a diode is different from a resistor in terms of its current and voltage characteristics.	bias voltage diode forward biased LED reverse biased semiconductor

Next Generation Science Standards Correlation

CPO Science *Link* investigations are designed for successful implementation of the Next Generation Science Standards. The following chart shows the NGSS Performance Expectations and dimensions that align to the investigations in this title.

NGSS Performance Expectations	Electric Circuits Investigations
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.	A6
MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.	A1, A2, A3, A4, A5
HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	B8
HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.	C1, C2
HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	B1, B2, B3, B4, B5, B6, B7

Next Generation Science Standards Correlation (cont'd)

NGSS Science and Engineering Practices	Electric Circuits Investigations
Asking Questions and Defining Problems	A1, A2, A3, A4, A5, A6
Developing and Using Models	B1, B2, B3, B4, B5, B6, B7
Obtaining, Evaluating, and Communicating Information	C1, C2
Planning and Carrying Out Investigations	B8

NGSS Disciplinary Core Ideas	Electric Circuits Investigations
PS2.B: Types of Interactions	A1, A2, A3, A4, A5, B8, C1, C2
PS3.A: Definitions of Energy	B8
PS3.C: Relationship Between Energy and Forces	B1, B2, B3, B4, B5, B6, B7
ETS1.A: Defining and Delimiting Engineering Problems	A6

NGSS Crosscutting Concepts	Electric Circuits Investigations
Cause and Effect	A1, A2, A3, A4, A5, B1, B2, B3, B4, B5, B6, B7, B8
Influence of Science, Engineering, and Technology on Society and the Natural World	A6
Structure and Function	C1, C2

Common Core State Standards Correlation

CCSS-Mathematics		Electric Circuits Investigations
MP.2	Reason abstractly and quantitatively.	A1, A2, A3, A4, A5, A6, B1, B2, B3, B4, B5, B6, B7
MP.4	Model with mathematics.	B1, B2, B3, B4, B5, B6, B7
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.	B8, C1, C2
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.	B8, C1, C2
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	B5, B6, B7, B8, C1, C2

CCSS-English Language Arts & Literacy		Electric Circuits Investigations
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.	A6
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	C1, C2
WHST.6-8.8	Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.	A6
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	C1, C2
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	B1, B2, B3, B4, B5, B6, B7
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.	B1, B2, B3, B4, B5, B6, B7, B8