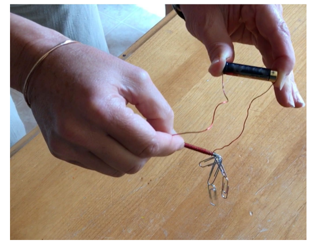

Electricity and Magnetism Unit Overview

Investigating the behavior and causes of electricity and magnetism requires studying the behavior of fields that are not directly observable. The required abstract thinking is supported in this unit through a series of investigations and demonstrations, each of which focuses on a particular aspect of the electromagnetic force. Through modeling and experimentation, students explore and communicate their ideas about complex scientific phenomena.

Explaining the cause of the Earth's magnetic field is used throughout the unit as the **anchor phenomenon**, to challenge students to apply their increasing understanding of electromagnetism to earth science. Students begin the unit by exploring the behavior of a compass and thinking about how it works. In the first 3 lessons, students explore with magnets. They learn that magnets, and the Earth, have dipole magnetic fields; and they are able to use this concept to explain various behaviors of magnets. They move from guided experiments to designing and running their own experiments.

Next students draw on prior knowledge to think about similarities and differences between magnetic and gravitational fields. In Lesson 4, they discuss the forces at work in both cases, and the potential energy stored in each type of system. Students complete a series of Magnetic Challenges in order to demonstrate their understanding, and to practice analyzing quantitative experimental results. In Lesson 5, they discuss the roles that modeling plays in science, and make and share their individual models of a magnetic field.

Students next investigate electricity, and begin to make connections between the causes of electricity and magnetism. Students expand their understanding of fields and how they behave by observing static electricity in Lesson 6, and applying their understanding to explain how lightning happens. They consider the interrelationship of electricity and magnetism in Lesson 7 by observing and explaining how temporary magnets are made, including the effect of electromagnetic induction on an iron nail.

Now familiar with the charged particles (electrons) that cause static electricity and allow for electrical circuits to work, students spend a few lessons exploring the behavior of electricity. They explore simple circuits in Lesson 8, gain an experimental understanding of some of the more complex behaviors of circuit components in Lesson 9, and are challenged to apply their understanding of the interrelatedness of electricity and magnetism to explain how an electromagnetic motor works in Lesson 10.

Students apply their understanding of electromagnetism in 3 different ways toward the end of the unit, through: (1) a multi-day Circuit Design Project, (2) creating new conceptual models of magnetic fields that include an understanding of electrical fields as well, and (3) returning to the **anchor phenomenon** to solve the puzzle of what is causing Earth's magnetic field, using their understanding of electromagnetism.

The circuit design lessons and project near the end of the unit are beyond the scope of the standards. We have included them for teachers who have the time and materials and want to give students some more experience with circuits. Electricity and electrical components can be mystifying for people who have not had a chance to explore how they work. Hands-on experiences and success with electrical circuits are very empowering and contribute to confidence and success with technology and engineering for all students. They also provide a nice opportunity for engineering design.

Image above, LM used by permission

Lessons

Lesson 1: What Is Magnetism?
Lesson 2: Exploring with Magnets
Lesson 3: Experimenting with Magnets (1–2 days)
Lesson 4: Magnetic Force and Potential Energy
Lesson 5: Modeling a Magnetic Field
Lesson 6: Static Electricity and Lightning
Lesson 7: Making a Temporary Magnet
Lesson 8: Exploring Simple Circuits
Lesson 9: Exploring Circuit Components
Lesson 10: Review and INTERIM ASSESSMENT (1–2 days)
Lesson 11: Conductors and Insulators
Lesson 12: How to Make an Electric Motor
Lesson 13: Circuit Project—Design
Lesson 14: Circuit Project—Build
Lesson 15: Circuit Project —Present and Evaluate (1–2 days)
Lesson 16: Electricity and Magnetism—Review
Lesson 17: The Mystery of the Earth's Magnetic Field
Review/Test

Next Generation Science Standards—Performance Expectations

MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

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-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

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.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Planning and Carrying Out Investigations Developing and Using Models	**PS2.B:** Types of Interactions **PS3.A:** Definitions of Energy **PS3.C:** Relationship Between Energy and Forces **ETS1.A:** Defining and Delimiting an Engineering Problem	Cause and Effect Systems and System Models ------------------------------------ *Connections to Engineering, Technology, and Applications of Science* Influence of Science, Engineering, and Technology on Society and the Natural World

California Common Core State Standards Connections:

ELA/Literacy –

RST.6–8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
RST.6–8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
RST.6–8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
RST.6–8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6–8.8	Gather relevant information from multiple print and digital sources (primary and secondary), using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
Mathematics –	
MP.2	Reason abstractly and quantitatively.
7.EE.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

Materials (for a breakdown of materials by lesson, see the Unit Planning Chart)

- ★ compasses
- ★ permanent marker or small stickers for teacher
- ★ periodic-table poster (recommended)
- ★ tape
- ★ string (2 lengths, ~1 meter each)
- ★ sandpaper, fine grain
- ★ 1 shoebox or other small or medium box per pair or group (Lesson 13)
- ★ poster paper, index cards and/or sticky notes for displays
- ★ graph paper

Per group:

- ★ balloons (2 per group)
- ★ ring magnets, 4–5 per group, at least
- ★ variety of other magnets* (shapes: round, horseshoe; magnets in plastic casing; optional)
- ★ small plastic propellers to fit on motor, or paper/cardstock for students to make their own blades

Labware

- ★ scales (a few per class)
- ★ 1 tablespoon of iron filings per pair and for Lesson 2 Opener
- ★ 1 metric ruler, per pair
- ★ *recommended:* trays for gathering and distributing supplies to groups
- ★ bar magnets
- ★ strong bar magnet (for teacher demo and groups)
- ★ iron nails (for teacher demo and groups)
- ★ copper wire (22 gauge, 40 cm length) 1 for teacher for electromagnet demo (Lesson 7)
- ★ ~3 m for teacher demo (recommended, Lesson 11)
- ★ electromagnet nail setup from Lesson 7 (re-used in Lessons 11 and 12)
- ★ electric motor setup from Lesson 12 (re-used in Lesson 16)
- ★ non-galvanized iron or steel nail (2 inch or longer)
- ★ conventional plug-in lamp with 2-prong plug (recommended, for demo)
- ★ optional: voltmeter/multimeter (for Extension) with instructions; simple inexpensive ones work best with these circuits
- ★ mini bulb holders to fit bulbs (optional) OR old string of holiday lights and wire cutter
- ★ wire strippers
- ★ large motor from an old clothes dryer or other appliance (optional, or show image provided in Lesson 12)
- ★ optional for Circuit Project (Lessons 13 and 14): mini solar panels, sliders, other available electrical components (Lesson 15)

- ★ batteries: variety of batteries to be used across multiple lessons(A, AA, AAA, C, D, 9 V, watch battery) for comparison (Lesson 9); multiple batteries per group (at least 2 AA, C, or D; 9 V; some extras)

<u>Per group:</u>

- ★ bare copper wire, coated copper wire, 2 copper wires with alligator clips (Lesson 12)
- ★ battery holder, at least 1 per pair (Lessons 9 and 11)
- ★ 3 wires per pair (*recommended*: with alligator clips)
- ★ 2 or 3 small light bulbs (flashlight lamps: 4.8 V / 0.5 A, or other bulbs with low voltage rating)
- ★ 1 or 2 small motors (1.5–3 V range or similar)
- ★ optional for Lesson 14: small hand-crank generators (as alternative to batteries, if available)
- ★ small plastic propellers to fit motors (optional, students can create own from paper)
- ★ resistors
- ★ small buzzers

Other Supplies

- ★ construction paper, or poster paper cut into quarters (optional)
- ★ scissors
- ★ paper
- ★ silk cloth
- ★ wool cloth
- ★ different objects or materials to test for conductivity (including rocks, if possible)
- ★ thick markers for wrapping wires around to create coils
- ★ optional for Circuit Project (Lessons 13 and 14): nails, screwdrivers, stainless steel spoons, butter knives
- ★ cardboard
- ★ metal thumbtacks, paper clips, and/or foil for making switches

<u>Per group:</u>

- ★ 1 clear plastic cup, with lid (taped closed, with iron filings inside)
- ★ paper clips, nails, or other metallic objects that are attracted to magnets
- ★ objects that are not attracted to magnets (optional, or students can experiment with what they have available at their desks)
- ★ 1 pencil (or thin rod that fits through the opening of the ring magnets)
- ★ recommended: colored pencils or markers for drawing models

Advance Preparation:

- ★ Lesson 3: *Optional:* If you chose to have students bring in approved materials from home to use in the magnetism investigation, check them from a safety standpoint. Decide where students will store those materials until they are needed.

★ Lessons 13–15: At the beginning of the unit, start collecting shoe boxes or other small boxes for students to use for the Home Electrical System design project. One box per small group of students will be needed.
★ Lesson 7: Save the electromagnet nail setup from L7, it will be used again (L11, L12)
★ Lesson 12: Save the electric motor setup from Lesson 12 to use again in Lesson 16
★ Lesson 17: Print and cut the 5 Earth's Magnetic Field cards to distribute to students. Color printouts are best. Laminate the cards for better durability. You will need a complete set for each group.

Tech option

★ Video recording device(s) to make video presentations (Lesson 15)

Vocabulary

magnet
magnetic field
dipole
attract/attraction
repel/repulsion
iteration
reproducibility
force (review)
potential energy (review)
scientific model (review)
charge
discharge
static electricity
field
electric field
polarized
potential energy (revised)
electromagnet
electric current
power source
circuit
system (review)
energy (review)
system (review)
component (review)
power
conductor
insulator
resistor