SAMPLER

Electromagnetic Force

INVESTIGATIONS GUIDE

FOSS Next Generation

Full Option Science System
Developed at the Lawrence Hall of Science, University of California, Berkeley
Published and Distributed by Delta Education

Science & Engineering PRACTICES
Disciplinary CORE IDEAS
CROSSCUTTING Concepts

Active investigation is at the heart of FOSS.

Every student deserves the benefits of science education—not just exposure to scientific phenomena, but the opportunity to make sense of them and authentically apply them to the real world. From its foundations, FOSS® is built to ensure access to all, regardless of background, culture, language, or ability.

The scholars at the Lawrence Hall of Science designed FOSS around the principle of collaborative, active investigation. FOSS effectively engages all students by leveraging their natural curiosity for observable phenomena, a teaching philosophy now considered best practice with the arrival of the Next Generation Science Standards (NGSS).

FOSS lessons help teachers reach all students through phenomena that are local and relevant. This student-centered approach ultimately enhances learning by ensuring that each individual has multiple opportunities to apply their prior knowledge and personal experiences to make sense of phenomena and solve problems. In this way, FOSS makes science accessible and equitable for every student in every classroom.

Comprehensive packages for complete learning.

FOSS® is more than just a science curriculum or science kit. Your investment in any FOSS course provides you with all the key student and teacher components to deliver world-class science education – no need to spend additional minutes or dollars searching for essential materials. Each element is thoughtfully designed with consideration for your money, space, and precious time.

"The hands-on group work is amazing. The kids get hands-on experience and can connect ideas about STEM to real-world experiences. The literacy component is great as well."

Arielle S., 4th Grade Teacher
Tell City, IN

Equipment Kit

Durable equipment and classroom tested materials, selected and designed expressly for FOSS, lead to successful investigations for all students. Kits include permanent equipment for classes of 32 students (8 groups) with enough consumables for five (5) uses at middle school.

Investigations Guide

This is the core instructional tool that supports the teacher in facilitating student investigations. Chapters include Overview, Framework and NGSS, Materials, Technology, Assessment, and each detailed Investigation. Available in print and digital.

FOSS Science Resources

FOSS student reading materials are in-depth articles that connect students' firsthand experiences to informational text, helping expand understanding from the concrete to the abstract. Available in print, eBook, and audiobook.

FOSS Technology

FOSSweb on ThinkLink™ offers simulations and virtual investigations. Online activities provide differentiating instruction. Student ebooks and streaming video are also included. Comprehensive teacher preparation videos and instructional slides support teachers.

Teacher Resources

Provided in print and available digitally, resources include grade-level chapters on sense-making and three-dimensional teaching and learning; connections to Common Core ELA and Math standards; taking FOSS outdoors; access and equity in science; science-centered language development; using science notebooks; and notebook, teacher, and assessment masters.

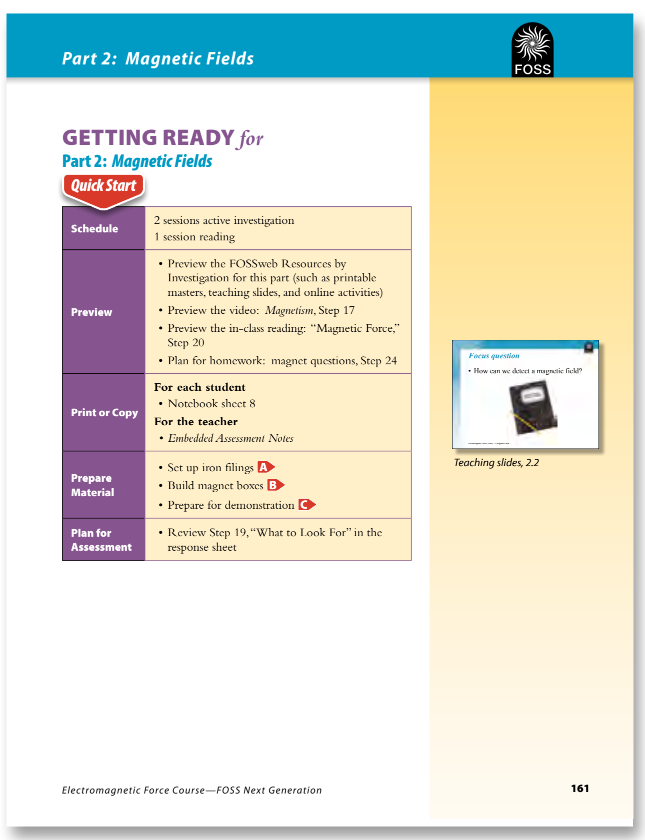
Spanish Resources

Spanish editions of *FOSS Science Resources* are offered both in print and eBook. FOSSweb on ThinkLInk provides audio files for *FOSS Science Resources*, as well as notebook, assessment, and teacher masters, module vocabulary and definitions, teaching slides, and Focus Questions.

Materials management made easy.

We believe that students learn science best by doing science. FOSS materials are field-tested to help you provide students with hands-on experiences that engage their minds and build their understanding. We've spent decades working in classrooms to provide comprehensive materials management support for teachers of all levels of experience.

- Investigations Guide with step-by-step instructions to help you through lesson preparation, facilitation, and assessment.
- Teacher preparation videos to provide visuals for important investigation setups.
- Efficient equipment kits, designed for middle schools—outfit your classroom with materials to complete each investigation with five classes of students.
- Handy refill kits replace consumables so you can make the most of your time teaching science.


Part 2: Magnetic Fields

GETTING READY *for*
Part 2: *Magnetic Fields*
Quick Start

Schedule	2 sessions active investigation 1 session reading
Preview	• Preview the FOSSweb Resources by Investigation for this part (such as printable masters, teaching slides, and online activities) • Preview the video: *Magnetism*, Step 17 • Preview the in-class reading: "Magnetic Force," Step 20 • Plan for homework: magnet questions, Step 24
Print or Copy	**For each student** • Notebook sheet 8 **For the teacher** • *Embedded Assessment Notes*
Prepare Material	• Set up iron filings A • Build magnet boxes B • Prepare for demonstration C
Plan for Assessment	• Review Step 19, "What to Look For" in the response sheet

Focus question
• How can we detect a magnetic field?

Teaching slides, 2.2

Electromagnetic Force Course—FOSS Next Generation 161

FOSS *Investigations Guides* include a streamlined Quick Start Guide for each part of every investigation that highlights exactly what needs to be printed, set up, or prepared in advance of the lesson.

New equipment options for middle schools

We listened to middle school teachers from across the country when developing FOSS Next Generation Middle School and now offer greater flexibility in equipping your FOSS classroom or lab. **Ask your Regional Sales Manager** which equipment option is the best fit for you.

	FULL KIT	LITE KIT
Consumable items (refill kits available)	X	X
Unique, program-specific permanent items	X	X
Common science lab items (beakers, graduated cylinders, etc.) or items found in multiple FOSS courses	X	

"I love teaching science, but many teachers do not feel confident. FOSS kits are laid out clearly so that a novice teacher can easily guide the investigations. Before FOSS, I had to gather materials myself. Now most materials are included in the kit."

Robin S., Teacher
Pennsylvania

Electromagnetic Force Grade 8 Course Phenomena Map

Anchor Phenomenon
COURSE DRIVING QUESTION(S): What is the relationship between magnetic and electric forces?
Students engage with the anchor phenomena of **magnetic and electric forces** by exploring their interactions and effects.

Firsthand Investigative Phenomena

INVESTIGATION 1: WHAT IS FORCE?	INVESTIGATION 2: THE FORCE OF MAGNETISM
Students explore motion and friction both qualitatively and quantitatively. **GUIDING QUESTION(S):** How are force and motion related? **FOCUS QUESTIONS FOR PHENOMENA:** **Part 1:** What makes things move? **Part 2:** How does friction affect the force needed to move an object? **Part 3:** How do multiple forces affect motion?	Students explore the phenomenon of magnetism by using materials as force detectors and developing a model for their attractive force. **GUIDING QUESTION(S):** How can we describe magnetic force? **FOCUS QUESTIONS FOR PHENOMENA:** **Part 1:** What happens when magnets interact? **Part 2:** How can we detect a magnetic field? **Part 3:** What factors affect the force of attraction between magnets?
INVESTIGATION 3: ELECTROMAGNETISM	**INVESTIGATION 4: ENERGY TRANSFER**
Students explore electromagnetism by building an electric circuit and engineering improvements to an electromagnet. **GUIDING QUESTION(S):** How are electricity and magnetism related? **FOCUS QUESTIONS FOR PHENOMENA:** **Part 1:** What is required to complete an electric circuit? **Part 2:** How does an electromagnet work? **Part 3:** Student-generated focus question: How does (student-chosen process) affect the strength of an electromagnet?	Students dissect a motor to explore its design and explain its energy transfers, then consider generators, solar panels, and human energy use. **GUIDING QUESTION(S):** How do human use energy? **FOCUS QUESTIONS FOR PHENOMENA:** **Part 1:** How does an electric motor work? **Part 2:** How can we generate electrical energy? **Part 3:** What is the relationship between magnetic and electrical forces?

Related Real-World Phenomena

INVESTIGATION 1 READING EXAMPLES	INVESTIGATION 2 READING EXAMPLES
Students explain skateboard motion in terms of interacting forces. Students explain hockey puck and skater forces by applying the work of Galileo and Newton.	Students consider Earth as a giant magnet and explore how a compass works.
INVESTIGATION 1 MULTIMEDIA EXAMPLES	**INVESTIGATION 2 MULTIMEDIA EXAMPLES**
Students view a tug of war between two vehicles and discuss balanced forces.	Students use an online activity to visualize magnetic fields and to test predictions when they add more magnets to a system.
INVESTIGATION 3 READING EXAMPLES	**INVESTIGATION 4 READING EXAMPLES**
Students explore static electricity and how batteries work. Students explain how a junkyard magnet, a maglev train, an induction stovetop, and a speaker use electromagnets.	Students explore electric car energy use and benefits. Students read about where energy comes from and consider alternative and sustainable energy choices.
INVESTIGATION 3 MULTIMEDIA EXAMPLES	**INVESTIGATION 4 MULTIMEDIA EXAMPLES**
Students explore common household appliances, such as a washer, dryer, or blender, to find those that use electromagnets.	Students virtually dissect a generator to compare its components and their functions to a motor.

The Full Option Science System• is developed at the Lawrence Hall of Science, University of California, Berkeley

Electromagnetic Force Alignment to Performance Expectations

Performance Expectations	FOSS	
	Investigation(s)	Benchmark Assessment
MS-PS2-2: Plan an Investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object	**Investigation 1**	• Investigation 1 Response Sheet • Investigation 1, Part 2 Performance Assessment • Investigation 1 I-Check • Survey/Posttest
MS-PS2-3: Ask questions about data to determine factors that affect the strength of electrical and magnetic forces.	**Investigation 2** **Investigation 3**	• Investigation 2 Response Sheet • Investigation 2, Part 3 Performance Assessment • Investigation 3, Part 3 Performance Assessment, (student-generated) • Investigations 2 and 3 I-Checks • Survey/Posttest
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 aren't in contact	**Investigation 2**	• Investigation 2 Response Sheet • Investigation 2, Part 3 Performance Assessment • Investigations 2 and 3 I-Checks • Survey/Posttest
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.	**Investigation 2**	• Investigation 2, Part 3 Performance Assessment • Investigations 2 and 3 I-Checks • Survey/Posttest
MS-PS3-5: Construct, use, and present arguments to support the claim that when kinetic energy of an object changes, energy is transferred to or from the object.	**Investigation 4**	• Investigation 4, Part 2 Performance Assessment • Investigation 4 I-Check • Survey/Posttest
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.	**Investigation 3**	• Investigation 3, Part 3 Performance Assessment, Student-generated
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**Investigation 3**	• Investigation 3, Part 3 Performance Assessment, Student-generated • Investigation 3 I-Check • Posttest
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.	**Investigation 3**	• Investigation 3, Part 3 Performance Assessment, Student-generated
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.	**Investigation 3**	• Investigation 3, Part 3 Performance Assessment, Student-generated

Electromagnetic Force Investigations

Investigation 1: What is force?

Part 1: Push and Pull
Part 2: Friction
Part 3: Forces in Action

Investigation 2: The Force of Magnetism

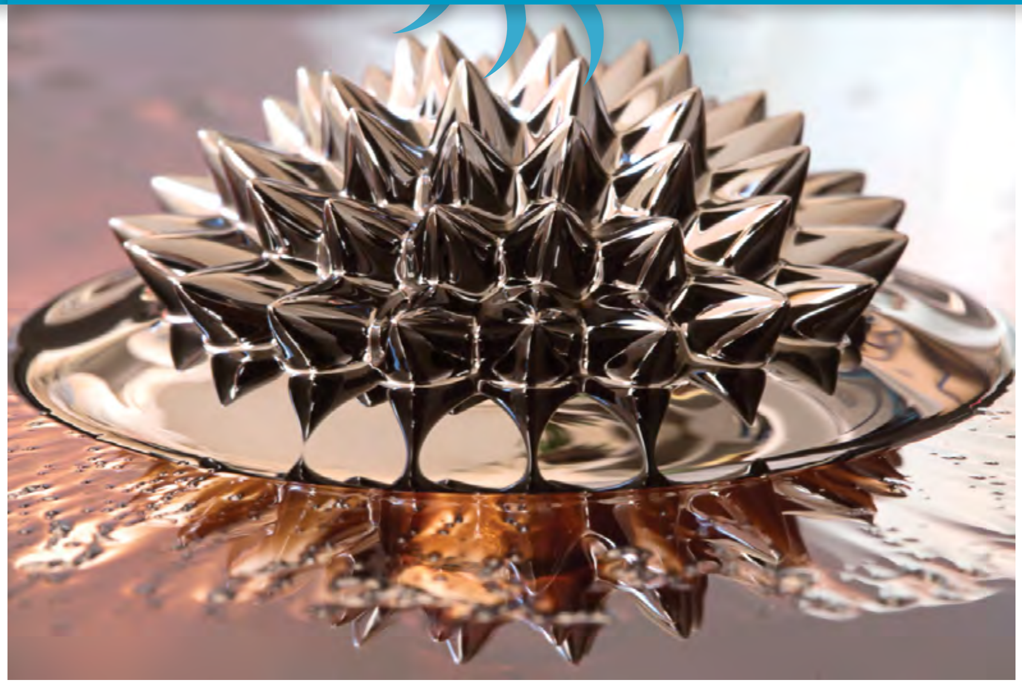
Part 1: Properties of Magnets
Part 2: Magnetic Fields
Part 3: Force over Distance

Investigation 3: Electromagnetism

Part 1: Building a Circuit
Part 2: Building an Electromagnet
Part 3: Improving the Design

Investigation 4: Energy Transfer

Part 1: Electric Motors
Part 2: Electric Generators
Part 3: Force and Energy



Start here to begin your review of the Grade 8 Electromagnetic Force Investigations Guide

INTRODUCTION

Electricity and magnetism are some of the most fascinating physics phenomena to study in a middle school classroom. Students will measure the force of invisible magnetic fields, learn to build a circuit, design an electromagnet, and explain the energy transfers that make it all possible. The anchor phenomena for this course are force interactions and effects. The driving question for the course is what is the relationship between magnetic and electric forces?

In the **FOSS Electromagnetic Force Course**, students manipulate equipment to collect data about magnetic fields and electricity. They construct explanations based on observable patterns and develop models that define the cause-and-effect relationships of the forces and interactions they are measuring.

The culmination of the course leads students to consider accessible energy sources and the reliance of modern lifestyles on access to this energy, as well as the consequences of such energy use. Students leave this course with an understanding of force and energy that forms a solid foundation for high school and college physics.

FOSS Electromagnetic Force is a 6-week course.

Contents

The NGSS Performance Expectations bundled in this course include:

Physical Sciences
MS-PS2-2
MS-PS2-3
MS-PS2-5
MS-PS3-2
MS-PS3-5

Earth and Space Sciences
MS-ESS3-4

Engineering Design
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4

	Investigation Summary	Time	Guiding and Focus Questions for Phenomena	Content and Disciplinary Core Ideas	Literacy/Technology	Assessment
Inv. 1	**What Is Force?** Students start their inquiry of force by using spring scales to push and pull objects, noting that some objects require more push or pull to put them into motion. Students are introduced to the idea of net force. They measure the force needed to move loads on different surfaces. Friction is developed as a force opposing motion, a force that changes depending on the two surfaces that are touching. Finally, students use net force to explain why force causes motion in some instances but not in others.	**Activities** **6 sessions *** **Assessment** **2–3 sessions**	***How are force and motion related?*** **Part 1** **Push and Pull**, 3 sessions **What makes things move?** **Part 2** **Friction**, 1 session **How does friction affect the force needed to move an object?** **Part 3** **Forces in Action**, 2 sessions **How do multiple forces affect motion?**	• A force is a push or a pull. • The metric unit for force is the newton (N). • Friction is a force that acts to oppose a force acting to put a mass in motion. • Net force is the sum of the forces acting on a mass.	**Science Resources Book** "The Force Is with You" "The Discovery of Friction" "Net Force" **Video** *Forces*	**Benchmark Assessment** *Entry-Level Survey* *Investigation 1 I-Check* **NGSS Performance Expectation** MS-PS2-2
Inv. 2	**The Force of Magnetism** Students conduct an investigation to determine if like or opposite poles attract. They work with magnets and other objects to discover that magnetism acts through certain materials. They also discover that bringing a magnet close to a piece of iron induces magnetism in the iron. Students learn that these effects are manifestations of the invisible magnetic field that surrounds every magnet. Students use a spring balance to measure the force of attraction between magnets. They determine that the force of attraction between magnets decreases as the distance between them increases and that magnetic fields can overlap and add their forces together.	**Activities** **7 sessions** **Assessment** **1–2 sessions**	***How can we describe magnetic force?*** **Part 1** **Properties of Magnets**, 1 session **What happens when magnets interact?** **Part 2** **Magnetic Fields**, 3 sessions **How can we detect a magnetic field?** **Part 3** **Force over Distance**, 3 sessions **What factors affect the force of attraction between magnets?**	• Magnets stick to (attract) objects that contain iron. • All magnets have two poles, a north pole on one side and a south pole on the other side. Like poles of magnets repel each other; opposite poles attract. • Magnets are surrounded by an invisible magnetic force field, which acts through space and through all nonmagnetic materials. • Magnetic materials may become temporary magnets when they interact with magnetic fields. • The magnitude of the magnetic force between two interacting magnetic fields decreases as the distance between them increases.	**Science Resources Book** "Magnetic Force" **Online Activity** "Adding Magnetic Fields" **Video** *Magnetism*	**Benchmark Assessment** *Investigation 2 I-Check* **NGSS Performance Expectations** MS-PS2-2 MS-PS2-3 MS-PS2-5 MS-PS3-2

* A class session is 45–50 minutes.

	Investigation Summary	Time	Guiding and Focus Questions for Phenomena	Content and Disciplinary Core Ideas	Literacy/Technology	Assessment
Inv. 3	**Electromagnetism** Students are introduced to electricity and energy. They discover how to make a complete circuit using a D-cell, wires, and a lightbulb. Students discuss the electricity's pathway in the circuit and the function of each of the system's components. Students discover that a steel core becomes a temporary magnet when current flows through an insulated wire wound around the steel core. They brainstorm different variables that might affect the strength of their electromagnet, and then test those variables. Working as a class, they combine their results to determine the best design for an electromagnet.	**Activities 8 sessions *** **Assessment 1–2 sessions**	***How are electricity and magnetism related?*** **Part 1 Building a Circuit**, 3 sessions **What is required to complete an electric circuit?** **Part 2 Building an Electromagnet**, 3 sessions **How does an electromagnet work?** **Part 3 Improving the Design**, 3 sessions **Student-generated question, e.g., How does (student-chosen process) affect the strength of an electromagnet?**	• Energy transfers through an electric circuit from a source to components. • A magnetic field surrounds a wire through which electric current is flowing. • The magnetic field produced by a current-carrying wire can induce magnetism in a piece of iron or steel. • An electromagnet is made by sending electric current through an insulated wire wrapped around an iron core. • The strength of magnetism induced in the core of an electromagnet increases with the number of winds of wire, the amount of electric current flowing in the wire, and the iron content of the core.	**Science Resources Book** "Parts of an Incandescent Bulb" "Circuitry and Lightbulbs" "What Is Electricity?" "Electromagnetism" "Engineering Design Process" "Electromagnetic Engineering" **Online Activities** "Lighting a Bulb" "Kitchen Magnets" "Virtual Electromagnet"	**Benchmark Assessment** *Investigation 3 I-Check* **NGSS Performance Expectations** MS-PS2-2 MS-PS2-3 MS-PS2-5 MS-PS3-2 MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4
Inv. 4	**Energy Transfer** Students operate an electric motor in a circuit, dissect a motor, and explain how it works after analyzing its components. They describe its design and function in terms of its components and energy transfers. They observe a generator and compare its components and function to a motor, explaining the interactions in terms of energy transfer. They consider energy sources for human electricity use and use solar cells to power an electric motor. Students read about human energy sources, including resource limitations and consequences. Finally, they consider key points from the entire course to prepare for the final benchmark assessment.	**Activities 6 sessions** **Assessment 2–3 sessions**	***How do humans use energy?*** **Part 1 Electric Motors**, 2 sessions **How does an electric motor work?** **Part 2 Electric Generators**, 3 sessions **How can we generate electrical energy?** **Part 3 Force and Energy**, 1 session **What is the relationship between magnetic and electrical forces?**	• An electric motor is designed with a commutator that acts as a switch turning on and off an electromagnet. • Electric generators transfer energy from kinetic energy to electrical energy. • Energy cannot be created or destroyed, only transferred. • Every energy use can be described as a sequence of energy transfers. • Energy sources can be categorized as renewable or nonrenewable.	**Science Resources Book** "Motor Dissection A" "Motor Dissection B" "Generator Dissection" "The Rebirth of Electric Cars" "Where We Get Energy" **Online Activity** "Kitchen Magnets" **Video** *Generator Dissection*	**Benchmark Assessment** *Investigation 4 I-Check* *Posttest* **NGSS Performance Expectations** MS-PS3-5 MS-ESS3-3 (foundational) MS-ESS3-4 (foundational)

* A class session is 45–50 minutes.

FOSS INSTRUCTIONAL DESIGN

FOSS is designed around active investigation that provides engagement with science concepts and science and engineering practices. Surrounding and supporting those firsthand investigations are a wide range of experiences that help build student understanding of core science concepts and deepen scientific habits of mind.

The Elements of the FOSS Instructional Design

Each FOSS investigation follows a similar design to provide multiple exposures to science concepts. The design includes these pedagogies.

- Active investigation in collaborative groups: firsthand experiences with phenomena in the natural and designed worlds
- Recording in science notebooks to answer a focus question dealing with the scientific phenomenon under investigation
- Informational reading in *FOSS Science Resources* books
- Online activities to acquire data or information or to elaborate and extend the investigation
- Opportunities to apply knowledge to solve problems through the engineering design process or to address regional ecological issues
- Assessment to monitor progress and motivate student learning

In practice, these components are seamlessly integrated into a curriculum designed to maximize every student's opportunity to learn.

A **learning cycle** employs an instructional model based on a constructivist perspective that calls on students to be actively involved in their own learning. The model systematically describes both teacher and learner behaviors in a systematic approach to science instruction.

The most recent model employs a series of five phases of intellectual involvement known as the 5Es: engage, explore, explain, elaborate, and evaluate. The body of foundational knowledge that informs contemporary learning-cycle thinking has been incorporated seamlessly and invisibly into the FOSS curriculum design.

Engagement with real-world **phenomena** is at the heart of FOSS. In every part of every investigation, the central phenomenon is referenced implicitly in the focus question that guides instruction and frames the intellectual work. The focus question is a prominent part of each lesson and is called out for the teacher and student. The investigation Scientific and Historical Background section is organized by focus question—the teacher has the opportunity to read and reflect on the phenomenon in each part before in preparing for the lesson. Students record the focus question in their science notebooks, and after exploring the phenomenon thoroughly, explain their thinking in words and drawings.

In science a phenomenon is a natural occurrence, circumstance, or structure that is perceptible by the senses—an observable reality. Scientific phenomena are not necessarily phenomenal (although they may be)—most of the time they are pretty mundane and well within the everyday experience. What FOSS does to enact an effective engagement with the NGSS is thoughtful selection of phenomena for students to investigate.

NOTE
The anchor phenomena establish the storyline for the module. The investigative phenomena guide each investigation part. Related examples of everyday phenomena are incorporated into the readings, videos, discussions, formative assessments, outdoor experiences, and extensions.

Active Investigation

Active investigation is a master pedagogy. Embedded within active learning are a number of pedagogical elements and practices that keep active investigation vigorous and productive. The enterprise of active investigation includes

- context: questioning and planning;
- activity: doing and observing;
- data management: recording, organizing, and processing;
- analysis: discussing and writing explanations.

Context: questioning and planning. Active investigation requires focus. The context of an inquiry can be established with a focus question about a phenomenon or challenge from you, or in some cases, from students—What is required to complete an electric circuit? At other times, students are asked to plan a method for investigation. This might include determining the important data to gather and the necessary tools. In either case, the field available for thought and interaction is limited. This clarification of context and purpose results in a more productive investigation.

Activity: doing and observing. In the practice of science, scientists put things together and take things apart, they observe systems and interactions, and they conduct experiments. This is the core of science—active, firsthand experience with objects, organisms, materials, and systems in the natural world. In FOSS, students engage in the same processes. Students often conduct investigations in collaborative groups of four, with each student taking a role to contribute to the effort.

The active investigations in FOSS are cohesive, and build on each other and the readings to lead students to a comprehensive understanding of concepts. Through the investigations, students gather meaningful data.

Online activities throughout the course provide students with opportunities to collect data, manipulate variables, and explore models and simulations beyond what can be done in the classroom. Seamless integration of the online activities forms an integral part of students' active investigations in FOSS.

Data management: recording, organizing, and processing. Data accrue from observation, both direct (through the senses) and indirect (mediated by instrumentation). Data are the raw material from which scientific knowledge and meaning are synthesized. During and after work with materials, students record data in their notebooks. Data recording is the first of several kinds of student writing.

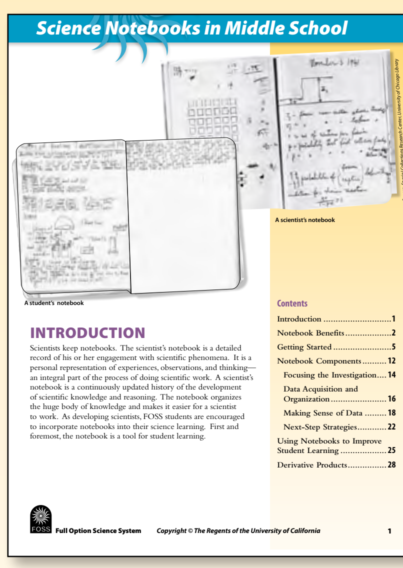
Students then organize data so that they will be easier to think about. Tables allow efficient comparison. Organizing data in a sequence (time) or series (size) can reveal patterns. Students process some data into graphs, providing visual display of numerical data. They also organize data and process them in the science notebook.

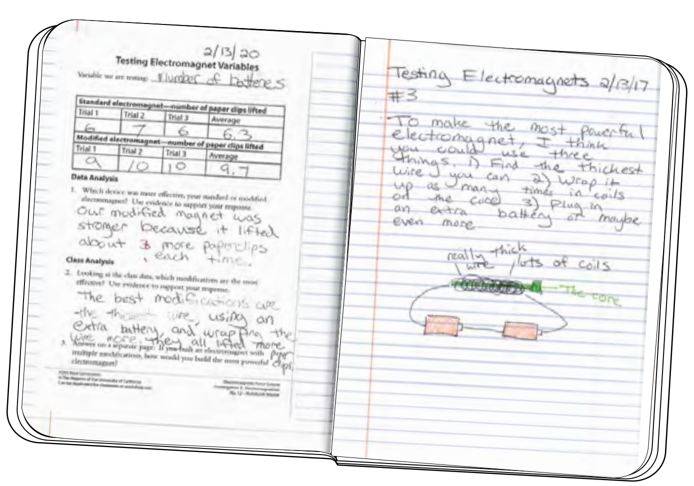
Analysis: discussing and writing explanations. The most important part of an active investigation is extracting its meaning. This constructive process involves logic, discourse, and existing knowledge. Students share their explanations for phenomena, using evidence generated during the investigation to support their ideas. They conclude the active investigation by writing in their notebooks a summary of their learning as well as questions raised during the activity.

Science Notebooks

Research and best practice have led us to place more emphasis on the student science notebook. Keeping a notebook helps students organize their observations and data, process their data, and maintain a record of their learning for future reference. The process of writing about their science experiences and communicating their thinking is a powerful learning device for students. And the student notebook entries stand as a credible and useful expression of learning. The artifacts in the notebooks form one of the core elements of the assessment system.

You will find the duplication masters for middle school presented in a notebook format. They are reduced in size (two copies to a standard sheet) for placement (glue or tape) in a bound composition book. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets. Full-sized masters that can be filled in electronically and are suitable for projection are available on FOSSweb. Look to the chapter in *Teacher Resources* called Science Notebooks in Middle School for more details on how to use notebooks with FOSS.





Electromagnetic Force Evaluation Checklist

When prescreening FOSS Next Generation Electromagnetic Force for the four criteria below, use the references and page numbers provided to locate evidence.

☐ **How does FOSS organize the learning around phenomenon and problems?**
FOSS Middle School courses are designed around culminating experiences and a driving question that support the progression of learning throughout the course. The driving question for this course is what is the relationship between magnetic and electric forces? The culmination of the course leads students to consider accessible energy sources and the reliance of modern lifestyles on access to this energy, as well as the consequences of such energy use.
- Electromagnetic Force Grade 8 Course Map, page 8
- Electromagnetic Force Overview, page 11

☐ **With FOSS, how are learning opportunities sequenced that enables students to make sense of the phenomenon or problems?**
FOSS investigations are grounded in storylines that are supported by a carefully designed progression of experiences. These experiences enable students to build on prior knowledge, ask questions, investigate, and make sense of core ideas over time.
- Electromagnetic Force Grade 8 Course Map, page 8
- Electromagnetic Force Overview Course Matrix, pages 12-15

☐ **What is the path of student thinking from their prior knowledge to the expected 3-dimensional learning outcomes when using FOSS?**
Students build on their prior knowledge through a multimodal learning cycle (see pages 16-17 of this booklet) that provides them with opportunities to learn new information, make sense of and integrate new learning, and reflect and communicate their new understanding.
- Investigate magnetism through materials (activate prior knowledge), pages 29-31, steps 1-7
- Investigate by making observations and collecting data, pages 31-32, steps 8-11
- Make sense of observations using data, pages 32-34, step 12-16
- Respond to the focus questions and construct an explanation, pages 34, step 19 and page 42, step 23

☐ **How does FOSS help students show/demonstrate their 3-dimensional understanding of the phenomenon?**
FOSS uses a reflective-assessment cycle of performance, formative, and summative assessments, with Next Step Strategies, interwoven into the instructional design.
- Develop and revise a model, page 30, step 5 and page 34, step 16
- Assess progress: Response sheet, page 34, Step 19
- Science Notebook entries, page 42, step 23
- Sample assessment item, pages 50-51

INVESTIGATION 2 — *The Force of Magnetism*

PURPOSE

In *The Force of Magnetism,* students explore the phenomenon of magnetism. They test properties of magnets to study their force. They develop a model of magnetic fields and use it to explain magnets' force over distance.

Content

- Magnets stick to (attract) objects that contain iron.
- All magnets have two poles, a north pole on one side and a south pole on the other side. Like poles of magnets repel each other; opposite poles attract.
- Magnets are surrounded by an invisible magnetic force field, which acts through space and through all nonmagnetic materials.
- Magnetic materials may become temporary magnets when they interact with magnetic fields.
- The magnitude of the magnetic force between two interacting magnetic fields decreases as the distance between them increases.

Practices

- Analyze and interpret data about magnetic force in a series of experiments looking at force over distance and force when more magnets are introduced.
- Develop and use models to construct explanations about magnetic fields and explain their properties and interactions.

Part 1
Properties of Magnets

Part 2
Magnetic Fields

Part 3
Force over Distance

Guiding question for phenomenon:
How can we describe magnetic force?

Science and Engineering Practices
- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Disciplinary Core Ideas

PS2: How can one explain and predict interactions between objects and with systems of objects?

PS2.A Forces and motion

PS2.B Types of interactions

PS3: How is energy transferred and conserved?

PS3.A Definitions of energy

PS3.C Relationship between energy and forces

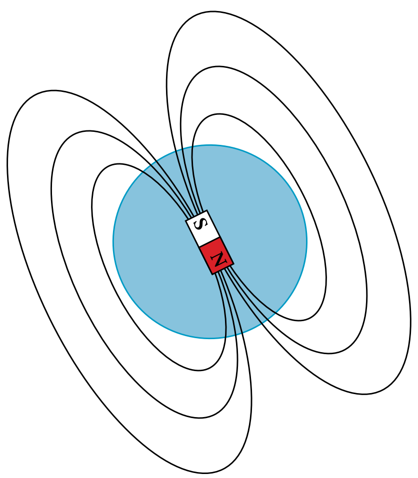
Crosscutting Concepts
- Patterns
- Cause and effect
- Systems and system models
- Energy and matter

FOSS **Full Option Science System**

FOSS

	Investigation Summary	Time	Focus Question for Phenomenon, Practices	Content Related to DCIs	Literacy/Technology	Assessment
PART 1	**Properties of Magnets** Students observe that the two sides (poles) of magnets are different, attracting or repelling one another, depending on orientation. While they conduct an investigation to determine if like or opposite poles attract, students learn the north/south convention for naming poles.	**Active Inv.** 1 Session*	**What happens when magnets interact?** **Practices** Planning and carrying out investigations Analyzing and interpreting data Constructing explanations	• All magnets have two poles, a north pole on one side and a south pole on the other side. Like poles of magnets repel each other; opposite poles attract. • Magnets stick to (attract) objects that contain iron.	**Science Notebook Entry** Answer the focus question	**Embedded Assessment** Science notebook entry
PART 2	**Magnetic Fields** Students work with magnets and other objects to discover that magnetism acts through certain materials including air, nonmagnetic metals, and nonmetals. They also discover that bringing a magnet close to a piece of iron induces magnetism in the iron. Students learn that these effects are manifestations of the invisible magnetic field that surrounds every magnet.	**Active Inv.** 2 Sessions **Reading** 1 Session	**How can we detect a magnetic field?** **Practices** Asking questions Developing and using models Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information	• Magnets are surrounded by an invisible magnetic force field, which acts through space and through all nonmagnetic materials. • Magnetic materials may become temporary magnets when they interact with magnetic fields.	**Science Notebook Entry** *Response Sheet—Investigation 2* **Science Resources Book** "Magnetic Force" **Video** *Magnetism*	**Embedded Assessment** Response sheet
PART 3	**Force over Distance** Students use a spring scale to measure the force of attraction between magnets. They increase the distance between the magnets and remeasure the force. Students learn that the force of attraction between magnets decreases as the distance between them increases. Next, they add additional magnets to a system to learn how magnetic fields overlap. Students then use an online activity to help visualize magnetic fields and to test further predictions.	**Active Inv.** 2 Sessions **Review** 1 Session **Assessment** 1–2 Sessions	**What factors affect the force of attraction between magnets?** **Practices** Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Obtaining, evaluating, and communicating information	• The magnitude of the magnetic force between two interacting magnetic fields decreases as the distance between them increases.	**Science Notebook Entry** *Adding Magnets* **Online Activity** "Adding Magnetic Fields"	**Embedded Assessment** Performance assessment **Benchmark Assessment** *Investigation 2 I-Check* **NGSS Performance Expectations addressed in this investigation** MS-PS2-2 MS-PS2-3 MS-PS2-5 MS-PS3-2

* A class session is 45–50 minutes.



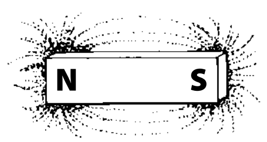
For historical reasons, and because Earth itself is a magnet, the "ends" of magnets are called **poles**, north pole and south pole. The pole on a permanent magnet that points north when allowed to pivot freely is the north pole of the magnet. When the north poles on two magnets are brought together, they repel.

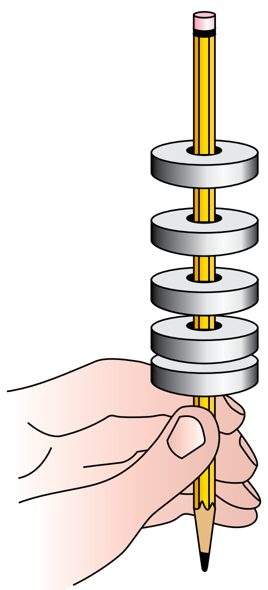
There is a contradiction in the conventional language associated with the poles of a magnet and the conceptual understanding of the behavior of magnets. The north pole of a magnet is attracted to Earth's northern magnetic pole. It would seem that similar poles attract.

The end of a magnet (compass needle) that points toward Earth's northern magnetic pole is, in fact, a north pole. Therefore, the magnetic pole up there near the North Pole in the Arctic is actually a south magnetic pole. This can be very confusing for students. The issue is dodged in some instances by referring to the north pole of the compass as the "north-seeking pole," but this is incorrect. Be very careful in the development of this concept.

How Can We Detect a Magnetic Field?

A magnet is surrounded by an invisible magnetic field that extends from the north pole of a permanent magnet and converges at the south pole. A field is a mathematical description of the magnetic force at each point in space surrounding the magnet. The field is often represented by a set of lines that runs through the magnet and loop from north pole to south pole in ever larger loops.





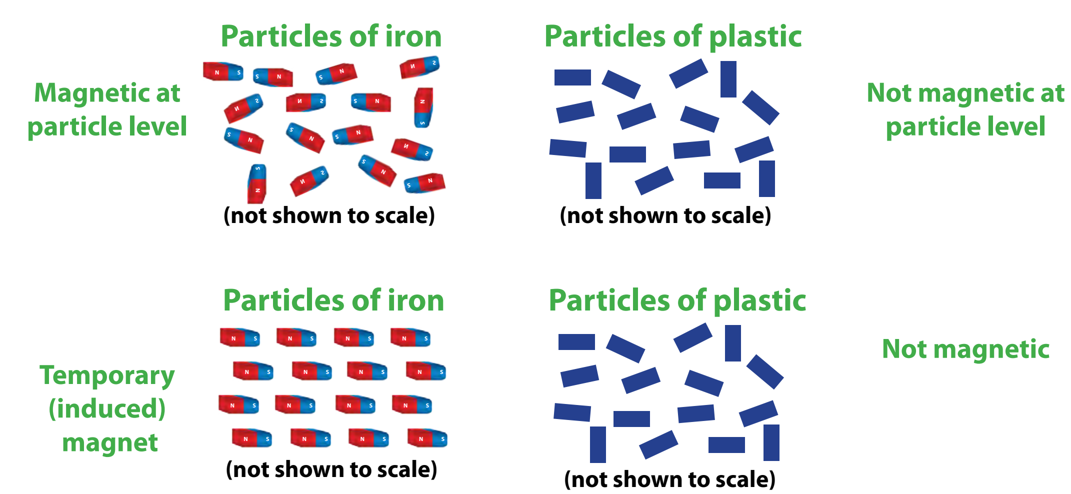
Magnetic fields act through air and the vacuum of outer space. They also act through water, plastic, wood, paper, cloth, and most metals. The magnetic field does not, however, act through iron. The field is transformed by the process of inducing magnetism in the iron.

You might want to try this magnetic stunt: Put four or five of the doughnut-shaped magnets on a pencil, oriented so that adjacent magnets repel each other. Hold the pencil straight up and down. Note the differential spacing of the magnets. This elegant, simple demonstration (which students will do during the investigation) shows the interaction between two of the four known forces in the universe—the electromagnetic force and the **gravitational force**. These forces, along with the strong and weak nuclear forces that hold atoms together and produce radioactivity, are the only physical forces that exist in the universe.

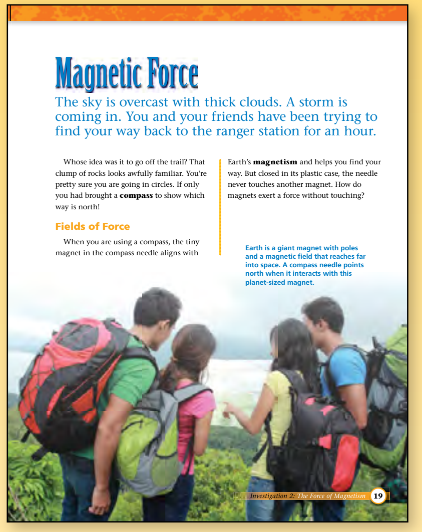
What Factors Affect the Force of Attraction between Magnets?

Technically, magnets don't stick to metals at all—they stick to other magnets. Iron, nickel, and cobalt, because of their chemical (atomic) properties, temporarily become magnets when they enter a magnetic field. This **induced magnetism** exists only as long as the metal is influenced by a magnetic field. As soon as the metal moves some distance from the field, the metal ceases to be a magnet. So when a magnet comes close to a piece of iron, cobalt, or nickel, the metal becomes a magnet, and the two magnets stick together. (Students may notice that an object that was stuck to a magnet for a while maintains a small amount of permanent magnetism even after they remove the magnet.)

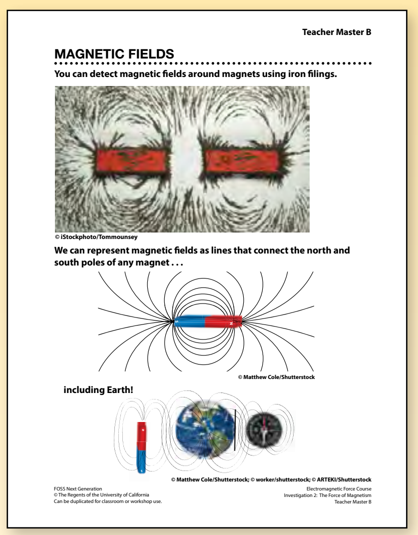
The magnetic field surrounding a permanent magnet is created by the orientation of microscopic associations of atoms called magnetic domains in the mass of metal. Domains have polarity; that is, they have a positive end and a negative end. When the domains in a piece of iron are all oriented in the same direction, the piece of iron is a magnet, and the magnet is surrounded by a magnetic field. When the domains are randomly oriented, the polar effect is neutralized, and the piece of iron is not a magnet and thus has no magnetic field. Nonmagnetic materials, such as plastic or aluminum, are unaffected when a magnetic field comes near.



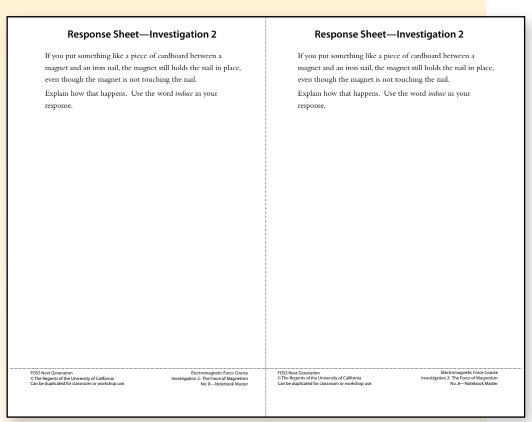
When the magnetic field of a permanent magnet comes near a piece of nonmagnetized iron, such as a steel nail, the magnetic field affects



FOSS Science Resources



Teacher Master B



No. 8—Notebook Master

MATERIALS *for*
Part 2: *Magnetic Fields*

Provided equipment

For each student

- 1 *FOSS Science Resources: Electromagnetic Force*
  - "Magnetic Force"

For each group

- 4 Magnets, doughnut-shaped
- 2 Magnets, bar-shaped
- 4 Paper clips
- 1 Compass
- 1 Cardboard box
- • Iron filings
- 1 Paper plate, small
- 1 Zip bag, 1 L
- • Masking tape

For the class

- 1 Magnet, doughnut-shaped
- 1 Paper clip
- 1 String, 20–30 cm

Teacher-supplied items

For the class

- Teaspoon, 1/4

FOSSweb resources

For each student

- 1 Notebook sheet 8, *Response Sheet—Investigation 2*

For the class

- Video, *Magnetism*

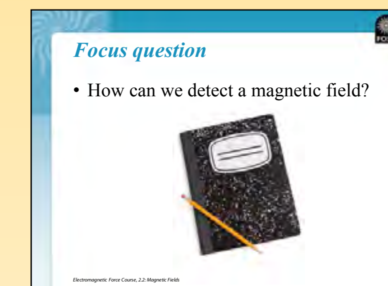
For the teacher

- Teacher master B, *Magnetic Fields*
- *Embedded Assessment Notes*
- Teaching slides, 2.2

GETTING READY *for*
Part 2: *Magnetic Fields*

Quick Start

Schedule	2 sessions active investigation 1 session reading
Preview	• Preview the FOSSweb Resources by Investigation for this part (such as printable masters, teaching slides, and online activities) • Preview the video: *Magnetism*, Step 17 • Preview the in-class reading: "Magnetic Force," Step 20 • Plan for homework: magnet questions, Step 24
Print or Copy	**For each student** • Notebook sheet 8 **For the teacher** • *Embedded Assessment Notes*
Prepare Material	• Set up iron filings A • Build magnet boxes B • Prepare for demonstration C
Plan for Assessment	• Review Step 19, "What to Look For" in the response sheet



Teaching slides, 2.2

Preparation Details

A Set up iron filings

Put about a quarter teaspoon of iron filings on a small paper plate. Seal the paper plate in a 1 L zip bag. Make eight bags of filings.

You can place the plate of filings on top of a magnet, then gently shake the plate to see filings fall in line with the magnetic field. Or you can move a magnet below the plate, to see how the filings line up. It's best to keep the plates horizontal. If filings accidentally fall off the plate into the bag, turn the bag with the plate upside down and then very quickly flip the plate over, so that the filings land on top of the horizontal plate.

B Build magnet boxes

The cardboard magnet boxes are flat when they originally arrive in the kit. If you are the first to use the kit, assemble the boxes. Fold in the rectangle edges and insert the small tabs. The flap with the round edges will form the lid of the box. Place a piece of masking tape on the edge of the lid that will be reused throughout the day. The tape will seal the box during the activity and indicate which end of the box students should pry open. Label the outside of the box lids with numbers 1–8.

Practice using a magnet box. Tape two magnets inside one of the boxes, close the lid, and practice detecting the magnet locations with the detecting tools: paper clip, magnet, compass, and iron filings. You might want to keep this magnet box assembled to use for a demonstration in Step 9.

C Prepare for demonstration

Tie a paper clip to one end of a 20–30 cm length of string. Practice demonstrating induced magnetism with the floating paper clip, described in Step 5.

GUIDING *the Investigation*

Part 2: *Magnetic Fields*

SESSION 1

Students will . . .

- Investigate magnetism through materials (Steps 1–4)
- Develop a model of a magnetic field (Steps 5–7)
- Record the focus question (Step 8)
- Use mystery boxes to detect magnets by their magnetic fields (Steps 9–13)

SESSION 2

Students will . . .

- Discuss mystery box findings and learn more about magnetic fields (Steps 14, 15)
- Improve their magnetic field models (Steps 16–19)

SESSION 3

Students will . . .

- Read about magnetic force (Steps 20, 21)
- Record vocabulary and answer the focus question (Steps 22, 23)
- Extend the investigation with homework and review notebook entries (Steps 24, 25)

FOCUS QUESTION

How can we detect a magnetic field?

SESSION 1 *45–50 minutes*

1. Investigate magnetism through materials

Suggest that students work again with their magnets and test objects to find out more about how magnets interact with materials. Introduce a challenge to students.

➤ *Can **magnetism** attract and repel through materials?*

2. Begin the exploration

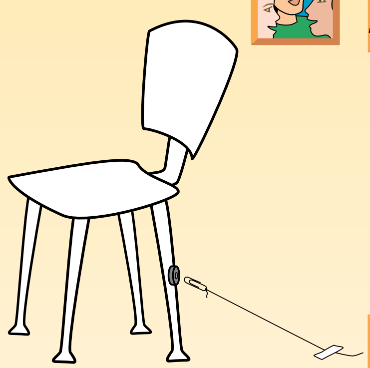
Ask Getters to get a doughnut-shaped magnet and a paper clip for each student. Inform students that paper clips are made of steel. Let students begin the investigation. Students may want to test magnetism through their books, desk, chair, shirt, and so on.

Visit students as they work, and ask questions like these.

➤ *Can magnets attract steel (paper clips) through all kinds of materials?*

➤ *Can a magnet attract a paper clip through a piece of cardboard, through a desk, or through cloth?*

➤ *Can a magnet attract a paper clip through the air?*



SCIENCE AND ENGINEERING PRACTICES

Developing and using models

Analyzing and interpreting data

Constructing explanations

TEACHING NOTE

Go to FOSSweb for Teacher Resources *and look for the* Science and Engineering Practices *chapter for details on how to engage students with the practice of developing and using models.*

3. Introduce magnetic chain

If nobody has discovered this yet, ask students to make a magnetic chain of paper clips. Working in their group, they can use one magnet to pick up one paper clip, use that paper clip to pick up another paper clip, and so on. How long a paper-clip chain can they make using one magnet?

Tell students,

When you make a paper-clip chain, you are ***inducing magnetism*** *in the steel paper clips. To* induce *means to make something happen. You have turned a paper clip into a* ***temporary magnet****.*

Students may want to use the temporary magnets (paper clips) to pick up other objects. Give them a few moments to explore the limitations in strength of these paper-clip magnets.

As students are working, visit groups and offer support by asking,

➤ *Does the paper clip need to be touching the magnet to be a temporary magnet?*

➤ *How long will the temporary magnetism last?*

4. Discuss results

Give groups a few minutes to discuss findings about whether magnetism can work through different materials. Ask a Reporter from each group to share an observation with the class. Students should discover that magnets can attract a piece of steel right through paper, cloth, a thin piece of cardboard, a book cover, and plastic, maybe even through a desk, as well as through air. Students may also report that if the material is too thick, the magnet will not attract the steel.

5. Develop a model

Show students your paper clip on a string. Tape the free end of the string to the surface of a desk. Carefully lift a chair with steel legs onto the desk and stick a magnet on the leg. Stick the paper clip on the magnet. Slowly move the chair away until the paper clip is suspended in air.

Ask students to talk in their groups to answer this question.

➤ *What keeps the paper clip suspended in air?*

Students should work individually to make a preliminary model in their notebooks to explain the phenomenon. Encourage them to include a diagram with labels. They should label the page "Chair Demonstration" for later reference.

Have students share their models with the rest of their group and revise their diagrams as needed. You may also choose to ask students to come up with a group model drawn on large paper.

6. Introduce *magnetic field*

As a class, discuss the behavior of the paper clip. The group models can be used as artifacts for the discussion of students' ideas for the behavior of the paper clip. Students will probably say the magnet attracts the paper clip through the air. At that point, introduce a new term.

Magnets can attract iron from a distance and through materials, because magnets are surrounded by an invisible ***magnetic field*** *that extends out from their poles. This force field is a region where the magnetic forces can be observed or detected. The magnet exerts a force that acts right through wood, paper, plastic, and air.*

7. Explain the demonstration

Ask,

➤ *How would you represent the magnetic field in your models?*

Give students a moment to discuss and add to their models. If necessary, add these ideas.

The paper clip on a string is suspended in the air close to a magnet. The magnetic field around the magnet interacts with the steel paper clip, turning the clip into a temporary magnet. The paper clip seems to hang in the air.

The force produced by gravity is pulling the paper clip down to Earth. The magnetic force acts to oppose the force of gravity. The net force keeps the clip in the air.

8. Focus question: How can we detect a magnetic field?

Tell students that today's activity will focus on the magnetic field. Introduce the focus question and write or project it on the board.

➤ *How can we detect a magnetic field?*

Have students record the focus question on the next page in their science notebooks.

9. Set up magnet detection challenge

Show students one of the magnet boxes. Tell them there are two small bar magnets taped someplace inside. Ask,

➤ *Can you figure out where magnets are taped in a box without looking inside?*

TEACHING NOTE

Students should use the two bar magnets in the box, and the doughnut-shaped magnet as a detector.

SCIENCE AND ENGINEERING PRACTICES

Planning and carrying out investigations

Analyzing and interpreting data

Engaging in argument from evidence

CROSSCUTTING CONCEPTS

Patterns

Cause and effect

10. Introduce detecting materials

Ask students to suggest materials that might be used as magnet detectors. Then show them the materials you have assembled: compasses, bags of iron filings, paper clips, and doughnut-shaped magnets.

Caution students to hold the bagged plate of iron filings horizontal to keep the iron filings on the plate. Show students how to replace the filings as needed by inverting the plate and then quickly flipping it over.

11. Describe preparation of the magnet boxes

Give construction instructions.

a. Each group will create a hidden arrangement of magnets, using
- the box with their group's number on it,
- two bar magnets, and
- masking tape.

b. Two team members will open the box and tape two magnets inside without letting the other team members see where the magnets are.

c. The other team members will use one or more detecting devices to find the magnets and figure out how they are oriented.

d. Remove tape carefully so the boxes are not damaged when it is time to open them and rearrange the magnets for the next test.

e. No drawing on the boxes! Recording will be done on paper.

12. Begin detecting

Have Getters get the box with their group's number and the other materials. Give groups 10–15 minutes to work. They should take turns setting up the box with hidden magnets and then using the different detecting materials to locate the magnets.

Instruct students to record diagrams in their notebooks to show what they think the mystery boxes look like inside. Encourage students to use each available tool (iron filings, paper clip, compass, doughnut-shaped magnet) to detect and to modify their map as they gather new evidence, and to record notes about these tools in their notebook.

13. Return detecting devices

When each pair of students has had a chance to detect at least once, have Getters return the detecting devices, boxes, and magnets to the materials station.

SESSION 2 *45–50 minutes*

14. Discuss magnet detectors

Ask students to take a few minutes with their groups to discuss which object or material was the best magnet detector and why. Encourage students to think of the detectors in terms of their strengths and limitations. Ask,

➤ *What were some strengths and limitations of each detector?* [Paper clips showed location of magnets, but not pole; filings showed the area and shape of magnets and some circles around the magnets; magnets could show location and pole of other magnets; compass could show location and pole of magnets (but could be hard to interpret if magnets were near to each other).]

Do you think the compass has iron in it? Why do you think so? [The needle must be made of iron, because it is affected by magnetic fields.]

Why do you think the filings made those interesting patterns? [They are made of iron so they are influenced by the magnetic field.]

15. Confirm magnetic fields

Ask students in more detail about their experience using the metal filings to detect magnets. Encourage them to describe the patterns that they saw that allowed them to detect magnets. They might describe lines, curves, or circles. Tell students,

Iron filings are very small pieces of iron, so they move very easily in response to magnetic forces. As a result, the patterns they form help us identify magnetic fields. A magnetic field is invisible, but we can make inferences about its characteristics by looking at the pattern of the iron filings.

Project teacher master B, *Magnetic Fields*. Point out the photograph at the top, which uses bar magnets like the ones they put in the boxes. Confirm that with a bar magnet, north is at one end of the bar and south is at the other.

Direct attention to the diagram just below the photo, which shows how physicists represent magnetic fields in drawings. Point out how the lines connect between the north and south poles in ever-larger circles. The lines that appear to stick out from the ends of the poles would also connect if the diagram were much larger.

Give students a moment to consider the three diagrams at the bottom of the page, and to consider Earth's magnetic field. Point out that the diagrams are not to scale. Ask,

➤ *What do the lines surrounding each magnetic object represent?* [The magnetic field of that object.]

SCIENCE AND ENGINEERING PRACTICES

Developing and using models

CROSSCUTTING CONCEPTS

Patterns

Systems and system models

SCIENCE AND ENGINEERING PRACTICES

Developing and using models

Constructing explanations

➤ *What similarities and patterns do you notice?* [Curved lines connect the north and south poles of each object.]

16. Return to the model

Ask students to return to the "Chair Demonstration" notebook entry where they drew a model. If students' paper-clip/chair models did not include lines representing fields, encourage them to revise their drawings at this time. Students can refer to teacher master B as they revise their models.

17. View video: *Magnetism*

Ask students to think about their model as they watch a brief video summarizing what they've learned so far about magnets and magnetic fields.

Play the Magnetism video chapter in "Resources by Investigation."

- Chapter 2: "Basic Characteristics of Magnets and Magnetism" (duration 4.5 minutes)

At the end of the video, give students a moment to add any details to their model as needed.

18. Record ideas

Distribute a copy of notebook sheet 8, *Response Sheet—Investigation 2*, to each student. Have students work on the sheet individually.

19. Assess progress: response sheet

Collect a sample of the response sheets to consider students' ability to explain magnetic fields.

What to Look For

- *Students explain that magnetic fields are invisible regions (lines) extending out from and around magnets.*
- *Students explain that a magnetic field induces magnetism in iron to turn it into a temporary magnet, which is attracted to the magnet.*
- *Students write that a magnetic field can act through most materials.*

Plan to spend 15 minutes reviewing the selected student responses. Using *Embedded Assessment Notes* as a tool, review the responses, record any alternative concepts that are evident, and decide if any next-step strategies are required before moving forward.

After your review, return the response sheets to students to be taped or glued into their science notebooks.

SESSION 3 *45–50 minutes*

READING *in Science Resources*

20. Read "Magnetic Force"

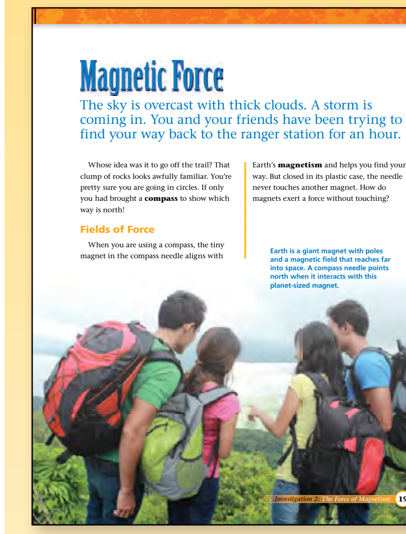
Tell students that the article "Magnetic Force" will help them think about properties of magnets and magnetic fields. Distribute a copy of *FOSS Science Resources* to each student.

21. Use a reading comprehension strategy

Have students preview the text by discussing the images and diagrams with a partner. Discuss the structure of the text and suggest they set up their notebooks to take notes for each of the subtitles. Have them make each subtitle into a question they think will be answered in the text. For example, the first subtitle questions might be, "What are fields of force?" or "How do we know fields of force exist?"

Tell students to read the text independently, jotting down any unknown words or phrases, or questions they have along with their subheading notes.

When students finish reading, give them a moment to discuss any questions or difficulties they had with reading in their small groups. (For those who finish early, have them start writing their responses to the Think Questions.) Use the following guide to conduct a whole-class discussion.



FOSS Science Resources

ELA CONNECTION

These suggested strategies address the Common Core State Standards for ELA for literacy.

RST 4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases.

RST 5: Analyze the structure an author uses to organize a text.

WHST 8: Gather relevant information from multiple print and digital sources.

RST 10: Read and comprehend science texts independently and proficiently.

SCIENCE AND ENGINEERING PRACTICES

Obtaining, evaluating, and communicating information

A

Connect to real life: Give students a moment to discuss any personal connections they've had using compasses. They might draw a model of a compass in their notebooks to explain how it works.

SCIENCE AND ENGINEERING PRACTICES

Developing and using models

Magnetic Force

The sky is overcast with thick clouds. A storm is coming in. You and your friends have been trying to find your way back to the ranger station for an hour.

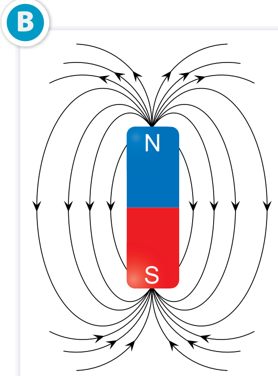
Whose idea was it to go off the trail? That clump of rocks looks awfully familiar. You're pretty sure you are going in circles. If only you had brought a **compass** to show which way is north! **A**

Fields of Force

When you are using a compass, the tiny magnet in the compass needle aligns with Earth's **magnetism** and helps you find your way. But closed in its plastic case, the needle never touches another magnet. How do magnets exert a force without touching?

Earth is a giant magnet with poles and a magnetic field that reaches far into space. A compass needle points north when it interacts with this planet-sized magnet.

It is similar to how a falling apple and Earth exert a force of gravity on each other. Both the apple and Earth have a gravitational force that extends from them because of their masses. It forms an invisible **gravitational field**. Like gravity, magnetism is another invisible force of nature. Magnetism extends out from a magnet into the surrounding space to form what is called a **magnetic field**. **B**



A field of magnetism extends out from every magnet. The magnetic force is strongest near the magnet's north and south poles.

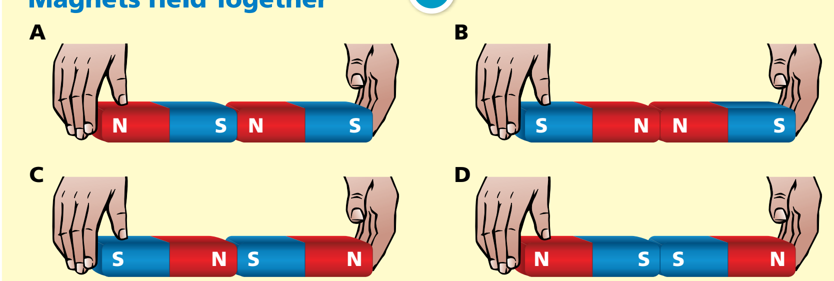
Force of Attraction or Repulsion

You feel magnetic force when you try to separate two magnets that are stuck together. You also feel magnetic force when you push two magnets together and they push away from each other. Magnetic force makes magnets act the ways they do.

The magnets used in class are **permanent magnets**. They exhibit magnetic properties pretty much all the time. Every magnet has two different sides or ends called **poles**, the north pole and the south pole. A simple bar magnet has its two poles on opposite ends. A horseshoe magnet has a pole on each end of the horseshoe. The doughnut magnets you worked with have poles on the two flat sides.

What happens when you hold two magnets close to each other? They exert a force on each other, but will they **attract** or **repel**? It all depends on how the poles are oriented. Below are four pairs of bar magnets being held together. Which ones will push apart when they are released?

Magnets Held Together **C**



These pairs of magnets are held together in different configurations. What will happen when they are released?

B

Discuss reading strategy: Ask a volunteer to share his/her question and response for this section with the group. If they haven't noted the main idea in their notebooks yet, model how to summarize the important point here: *Gravity and magnetism are two of the invisible forces of the universe.*

C

Analyze diagrams: Pause for students to discuss what they notice and can infer from the lower set of diagrams.

- *What are they trying to explain?* [How magnets are held together in different configurations.]
- *What do the different colors and letters represent?* [Red with (N) indicates north pole; blue with (S) indicates south pole.]

ELA CONNECTION

These suggested strategies address the Common Core State Standards for ELA for literacy.

RST 2: Determine the central ideas or conclusions of a text; provide an accurate summary.

RST 7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.

SCIENCE AND ENGINEERING PRACTICES

Developing and using models

Constructing explanations

D

Compare diagrams in the text: Have students compare their predictions with the diagrams here. Refer to Think Question 1 and have students come up with a general rule to record in their notebooks.

E

Develop vocabulary: Focus on the words in bold (temporary magnet and induced magnetism) and have students take turns explaining what these terms mean to a partner. These terms along with a definition and/or example should be in their notes.

F

Take note: Take a few minutes to have volunteers share examples from the classroom investigations and others they may have experienced.

ELA CONNECTION

These suggested strategies address the Common Core State Standards for ELA for literacy.

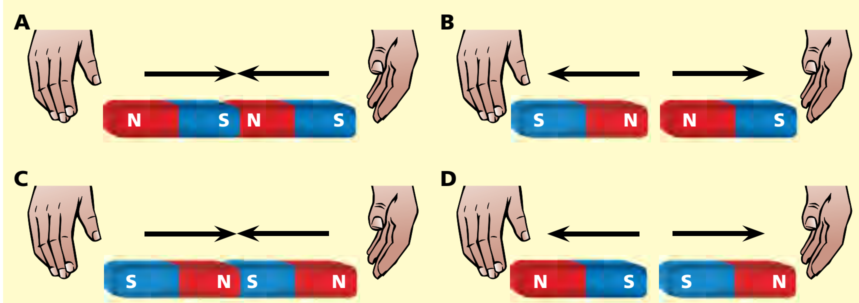
RST 9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

SL 6: Adapt speech to a variety of contexts and tasks.

L 6: Acquire and use academic and domain-specific words and phrases.

D

Magnets Are Released



Observe how the magnets move when they are not held together. Opposite poles pull together, or attract, and like poles push apart, or repel.

The diagram above shows what happens when the magnets are released. Two general rules apply here. Can you figure out what the rules are?

The two pairs of magnets on the left attract each other. The two pairs of magnets on the right repel each other. Two north poles always repel each other. Two south poles always repel each other. We can state a general rule: like poles repel.

A north pole and a south pole always attract each other. It does not matter which magnet has the north pole and which has the south pole. We can state another general rule: opposite poles attract.

How Magnets Stick to Iron

If opposite poles attract, why does a magnet stick to a piece of iron, like an iron nail, that is not a permanent magnet? Remember that magnetism extends out from a magnet in an invisible area called a magnetic field. When a magnet comes close to a piece of iron, such as an iron nail, the magnetic field interacts with the iron in the nail. The nail becomes a **temporary magnet**. The end of the nail becomes one pole of a magnet. The magnet then sticks to the temporary magnet.

E

So magnets do not really stick to iron. Magnets stick to other magnets, even if they are temporary. The temporary magnetism in the iron is called **induced magnetism**. Induced magnetism happens only when a magnet is nearby.

Take Note F

What are some examples of induced magnetism you observed in class?

Particle Properties G

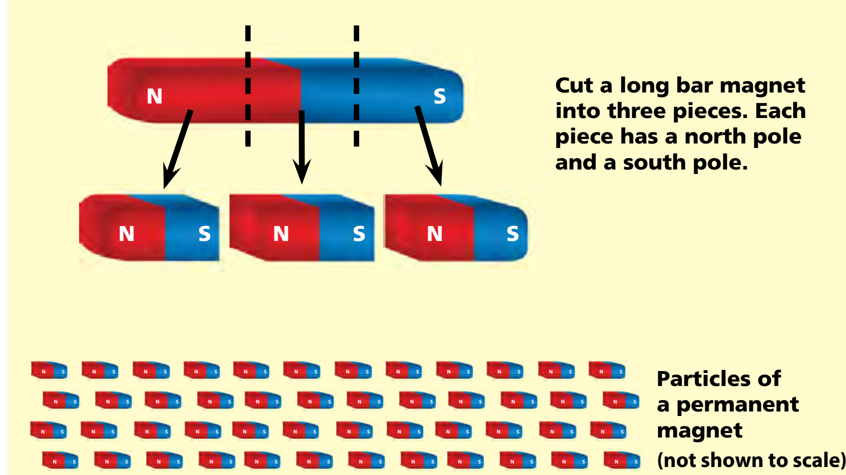
To understand why some materials have induced magnetism and others do not, we have to explore the properties of magnets at the **particle** level. That means at the level of atoms and molecules. We can start to think about particles by considering what happens when a bar magnet breaks. Do you have a magnet with just one pole?

No, both pieces still have a north pole and a south pole. The same is true for all other magnets. No matter how many pieces you cut a magnet into, each piece still has a north pole and a south pole.

Each magnet piece has poles lined up the same way. If you did this a million million times, until you had the tiniest particle of the magnet that was still a magnet, you would see that each particle has poles lined up the same way.

This property defines a permanent magnet. Each particle has properties of magnetism. As

Magnets Cut Into Pieces



Even at the particle level, a magnet is still a magnet. Each atom of a magnet has a magnetic field and poles lined up in the same orientation.

G

Discuss reading strategy: Call on a few volunteers to share the question they formed from this subtitle and the answers they found from the text. If needed, guide students through the process of finding the main idea of this section. Have them discuss how the model is used to explain the concept of induced magnetism.

SCIENCE AND ENGINEERING PRACTICES

Developing and using models

ELA CONNECTION

This suggested strategy addresses the Common Core State Standards for ELA for literacy.

RST 2: Determine the central ideas or conclusions of a text; provide an accurate summary.

H

Analyze diagrams: Have students compare and contrast the diagrams in these models.

What is the same and different about the two kinds of particles outside a strong magnetic field and in a strong magnetic field? [Outside a magnetic field, the particles of each substance are oriented in any direction (randomly). Inside a magnetic field, the plastic particles stay random but the iron particles line up.]

How does this model relate to phenomena they have observed? [When iron objects are placed in a magnetic field (like a paper clip next to a magnet), they can become magnetized and act as a temporary magnet. Plastic materials are unaffected.]

SCIENCE AND ENGINEERING PRACTICES

Developing and using models

ELA CONNECTION

This suggested strategy addresses the Common Core State Standards for ELA for literacy.

RST 7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.

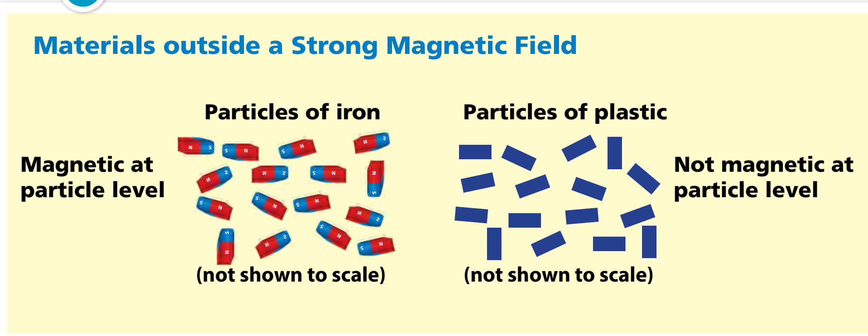
the particles line up, each tiny magnetic field adds itself to form one big magnetic field.

Nonmagnetic Materials

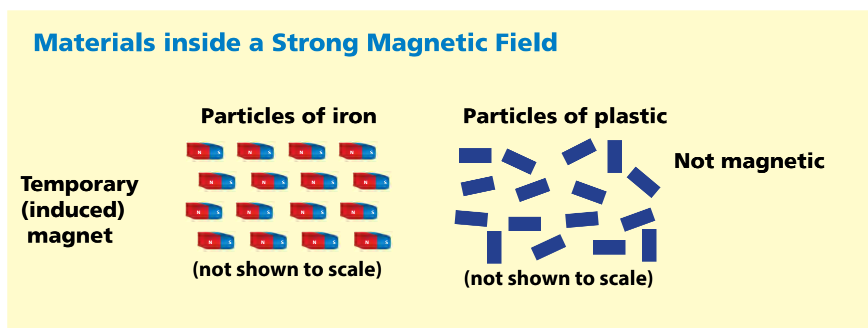
All nonmagnets can be split into two general categories, magnetic materials and nonmagnetic materials. Magnetic materials, such as the elements iron, nickel, and cobalt, have magnetic properties at the particle level. But the particles are not all aligned the same way. Those particles can line up when they are in a magnetic field. The materials become a temporary (induced) magnet.

Nonmagnetic materials, like plastic, do not have magnetic properties at the particle level. Those particles are not affected when they are in a magnetic field.

H

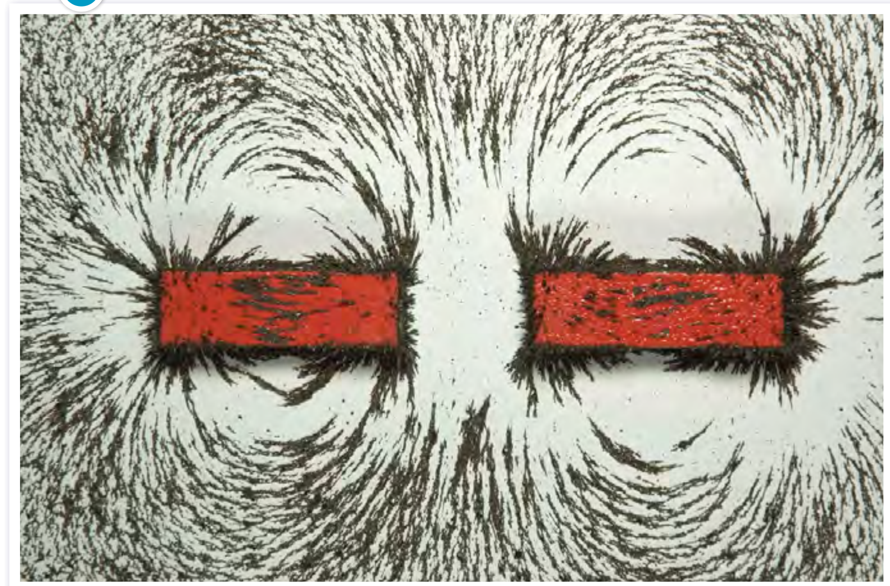


The iron and plastic particles are oriented in different directions.



The iron particles orient to the magnetic field and form a temporary magnet. The plastic particles do not change.

I



Iron filings spread around a magnet will form a pattern that shows the shape of the magnet's magnetic field.

If you bring a strong magnetic field close to a magnetic material, the particles in the material will line up with the magnetic field. They create weak temporary magnets. Particles in the nonmagnetic materials will not line up. So even the strongest magnet cannot attract or repel a material like plastic or wood.

Think Questions **J**

1. What rules determine whether magnets will attract or repel each other?
2. How can a magnet attract or repel another magnet even if they are not touching?
3. If you bring the south pole of a magnet close to the head of an iron nail, what changes will happen to the iron particles?

I

Analyze image: Give students a moment to discuss the photograph and to share any other observations they have made that indicate the presence of a magnetic field.

How does this image relate to the models you've seen using lines to represent the magnetic field? [The iron filings line up like the lines in models.]

J

Think Questions: Have students discuss the last two Think Questions in their small groups, and then call on Reporters for each group to share their groups' responses.

What rules determine whether magnets will attract or repel each other? [Opposite poles attract each other, and like poles repel each other.]

How can a magnet attract or repel another magnet even if they are not touching? [A magnetic field extends out from a magnet. The magnetic force extends through the field.]

If you bring the south pole of a magnet close to the head of an iron nail, what changes will happen to the iron particles? [The iron particles are like tiny magnets. The particles will line up when they are within a strong enough magnetic field. The iron particles will have their north poles attracted to the south pole of the nearby magnet. The iron nail becomes a temporary magnet.]

induced magnetism
magnetic field
magnetism
temporary magnet

ELA CONNECTION

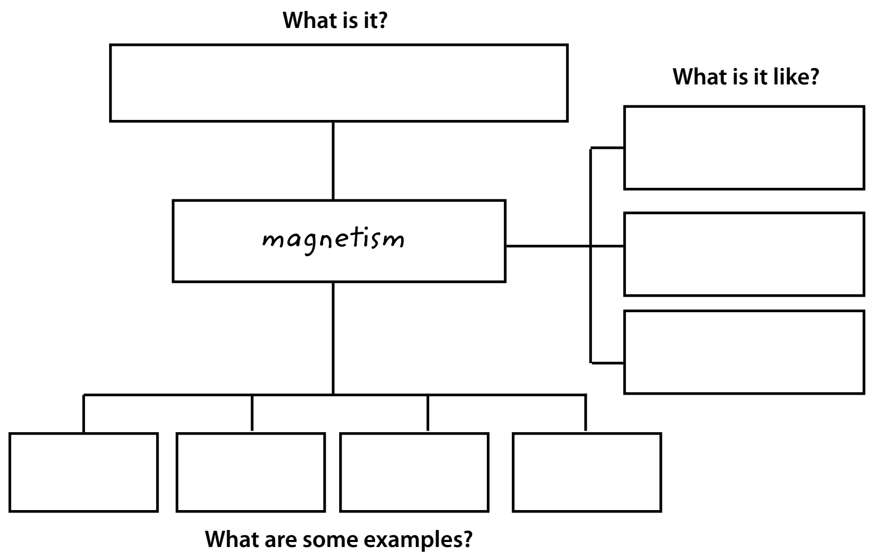
This suggested strategy addresses the Common Core State Standards for ELA for literacy.

L 5: Demonstrate understanding of word relationships and nuances in word meaning.

22. Record vocabulary

Give students a few moments to review and clarify the vocabulary developed in this investigation. Have students add diagrams and explanations of these terms in their notebooks, and to update their indexes if they haven't done so already. Students can also add to their existing definition of *force*.

If students need more support, have them make a concept definition map for *magnetism*. They should include all the terms in bold from the reading. See example.



EL NOTE

For students who need support, give them a few minutes to discuss the question before writing. You can also provide writing frames such as
A magnetic field is ___.
We observed ___.
The diagram shows ___.

23. Answer the focus question

Have students review the focus question.

➤ *How can we detect a magnetic field?*

Give students a few minutes to write an answer to the focus question. Encourage them to think about multiple examples from the investigation and to use diagrams where appropriate.

24. Extend the investigation with homework

What questions do students have about magnets, magnetic fields, and magnetic force? Have students write a list of ten or more questions that could be answered in the rest of the investigation or later researched online.

SCIENCE AND ENGINEERING PRACTICES

Asking questions

WRAP-UP/WARM-UP

25. Review notebook entries

Ask students to return to the notebook entry where they drew their model of the "Chair Demonstration." Give students a few minutes to share responses with someone from a different group. Encourage them to give each other constructive feedback and to revise and/or add ideas to their responses under a line of learning.

SCIENCE AND ENGINEERING PRACTICES

Obtaining, evaluating, and communicating information

Contents

NOTE
For the most up-to-date assessment masters, answer sheets, and coding guides, go to FOSSweb for this course.

THE FOSS ASSESSMENT SYSTEM *for Middle School*

"Assessment is like science. …To assess our students, we plan and conduct investigations about student learning and then analyze and interpret data to develop models of what students are thinking. These models allow us to predict the effect of additional teaching addressing the patterns we notice in student understanding and misunderstanding. Assessment allows us to improve our teaching practice over time, spiraling upward" (*2016 Science Framework for California Public Schools, Kindergarten through Grade 12,* chapter 9, page 3).

An important rule of thumb in educational assessment is that assessments should be designed to meet specific purposes. One size does not fit all. The FOSS assessment system provides ample opportunities for both formative and summative assessment. Formative assessments provide short-term information about learning by making students' thinking visible in order to guide instructional decisions. Summative assessments provide valid, reliable, and fair measures of students' progress over a longer period of time, at the end of a course, or the end of the year. The purpose for the assessment determines the choice of instruments that you will use.

The FOSS assessment system is designed to assess students in cycles: short, medium, and long. The assessment tasks allow students to demonstrate their facility with three-dimensional understanding of science.

Short cycle. Embedded assessment opportunities are incorporated into each part of every investigation. These assessments use student-generated artifacts, including science notebook entries, answers to focus questions, response sheets, and **performance assessments**. Embedded assessments provide daily monitoring of students' learning and practices to help you make decisions about instructional next steps. Embedded assessments using science notebooks provide evidence of students' overall conceptual development. Performance assessments focus on science and engineering practices, crosscutting concepts, and disciplinary core ideas.

I-Check opportunities occur at the end of one or two investigations. These assessments are hybrid tools that provide summative information about students' achievement, and have even more power when used for formative assessment. Daily embedded assessments provide a quick snapshot of students' immediate learning; I-Checks challenge students to put this learning into action in a broader context. Now students must think about the science and engineering practices, disciplinary core ideas, and crosscutting concepts they have been learning, and know when, where, and how to use them. I-Checks (short for "I check my own understanding") also provide opportunities for guided self-assessment, an important skill for future learning and development of a growth mindset. Properly executed feedback can help a student focus attention on areas that need strengthening. When a student responds to feedback, you can develop an even more precise understanding of the student's learning. A feedback/response dialogue can develop into a highly differentiated path of instruction tailored to the learning requirements of individual students.

Medium and long cycle. *Entry-Level Surveys*, *Posttests*, and portfolios are tools provided for medium- and long-cycle assessment. Students take the *Entry-Level Survey* before instruction begins. This entry-level assessment provides you with information about students' prior knowledge of disciplinary core ideas and science and engineering practices. What emerging conceptions do they have that you will be able to build upon as you move through the course? Students are encouraged to answer the questions as best they can, so you get the information you need to move instruction forward effectively.

The *Posttest* is given at the end of the course. It provides summative information about students' three-dimensional learning. It also lets students compare their *Entry-Level Survey* responses to those on the *Posttest* to see how their understanding has grown. You can also use the *Posttest* for formative instructional evaluation by making notes about things you might want to focus on or do differently next time you teach the course.

Students can also collect work samples in a portfolio as they work through the course. At the end of each investigation, they can create derivative products to document their three-dimensional learning.

See more about these assessments in the section "Benchmark Assessment."

EMBEDDED *Assessment*

TEACHING NOTE

FOSS recommends that you do not grade notebook entries. This ensures a risk-free environment for students to write freely, knowing mistakes are part of learning. If you need to give a grade, have students complete a derivative product based on a notebook entry. Students might rewrite a focus-question answer, write up part of a lab, or revise a response sheet and turn it in, knowing that this product will be graded.

In FOSS middle school, the unit of instruction is the course—a sequence of conceptually related learning experiences that leads to a set of learning outcomes. A science notebook gives students a place to record their thinking and develop deeper understanding of the course content by articulating relationships, patterns, and conclusions, as well as by asking questions that will guide further exploration. Science notebook entries give both you and your students opportunities to review and reflect on students' thinking.

From the assessment point of view, a science notebook is a collection of student-generated artifacts that exhibit student learning. You can informally assess student skills, such as the ability to use charts to record data, while students are working with materials. At other times, you collect the notebooks and review them for insights or errors in conceptual understanding. The displays of data and analytical work provide a measure of the quality and quantity of student learning.

As you progress through the course, you will see different strategies used throughout the *Investigations Guide*. These will be marked with the notebook or assessment icon. As you try these strategies, take note of the positive effect that keeping notebooks have on students' work, as students continually practice expressing their conceptual development in writing. Embedded assessments help you better understand and address students' misconceptions.

Assessment Opportunities

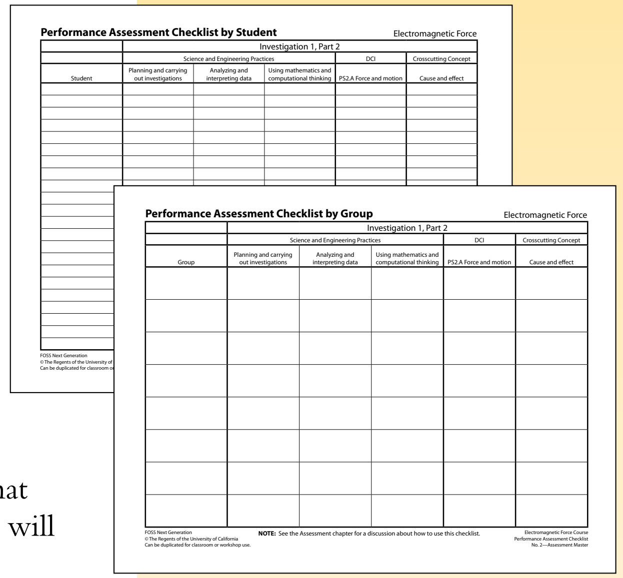
Notebook entries serve as assessment opportunities for learning. Each part of each investigation is driven by a **focus question**. Each part usually concludes with students writing or revising an answer to the focus question in their notebooks. Their answers reveal how well they have made sense of the investigation and whether they have focused on the relevant actions and discussions.

At times, students use prepared **notebook sheets** to help organize and think about data. You can note how carefully students are making and organizing observations and how they think about analyzing and interpreting the data. Sometimes students answer a specific question that provides additional insight into understanding. You will find answers for notebook sheets in the Notebook Answers chapter.

Response sheets provide more formal embedded-assessment data. These are a specific kind of notebook sheet that assesses specific scientific knowledge that students often struggle with, giving you an additional opportunity to help students untangle concepts that they may be overgeneralizing or have difficulty differentiating.

Students also generate **free-form notebook entries** that can be used for assessing progress. These may occur when you choose to have students organize their own data, or when events in the classroom suggest a new aspect of students' learning that you want to know more about.

The ***Entry-Level Survey*** and **quick writes** (or quick draws) present questions that students answer before instruction, so you can analyze their prior knowledge and misconceptions. Knowing students' intuitive ideas (or prior knowledge) will help you know what parts of the investigations need the most attention. Make sure students date their entries for later reference. Quick writes can be done on a quarter sheet of paper or an index card. You collect them, review them, and return them to students to affix into their notebooks for self-assessment later in the investigation.



Performance assessments occur at times in the course as a way to specifically check students' three-dimensional progress, checking science and engineering practices, crosscutting concepts, and disciplinary core ideas. These assessments happen during class as you circulate among student groups during their investigations. Sometimes you will simply watch what students are doing; at other times prompts or interview questions will be suggested.

Time Management

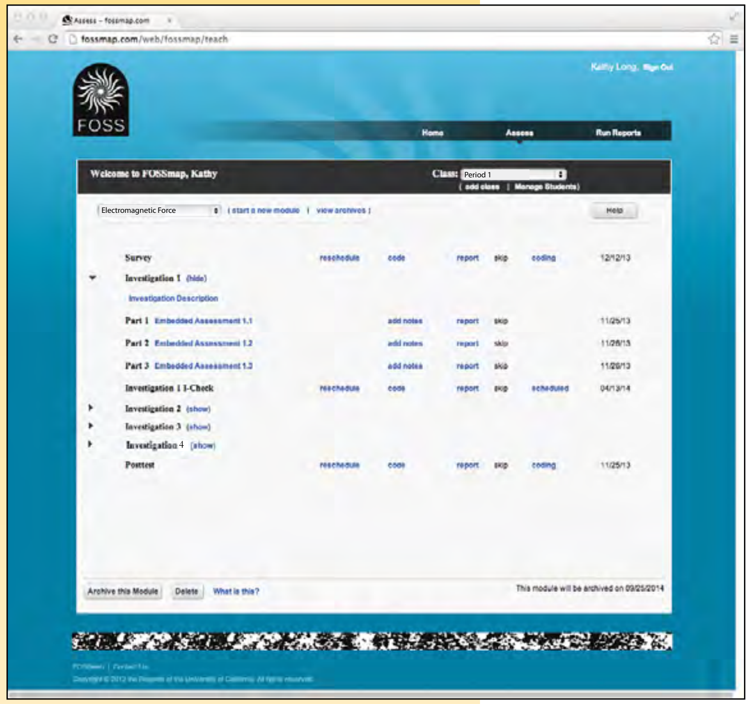
In order to collect enough data from embedded assessment to adequately inform instruction, plan to spend 15 minutes after each part of an investigation is completed, reviewing student learning by examining student work. In middle school, you face the challenge of having a large number of students. This may mean collecting only a portion of students' notebooks at a time to keep your workload manageable. A sample of student notebooks across your classes should represent the general levels of conceptual understanding that students have. Some work, such as quick writes and notebook sheets, can first be completed on separate sheets of paper. These are easier to collect, read, and later return to students for their notebooks.

NOTE

You need only 15 minutes after an investigation part to review student work and gather evidence of learning. See the reflective-assessment practice later in this chapter.

FOSSMAP *and Online Assessment*

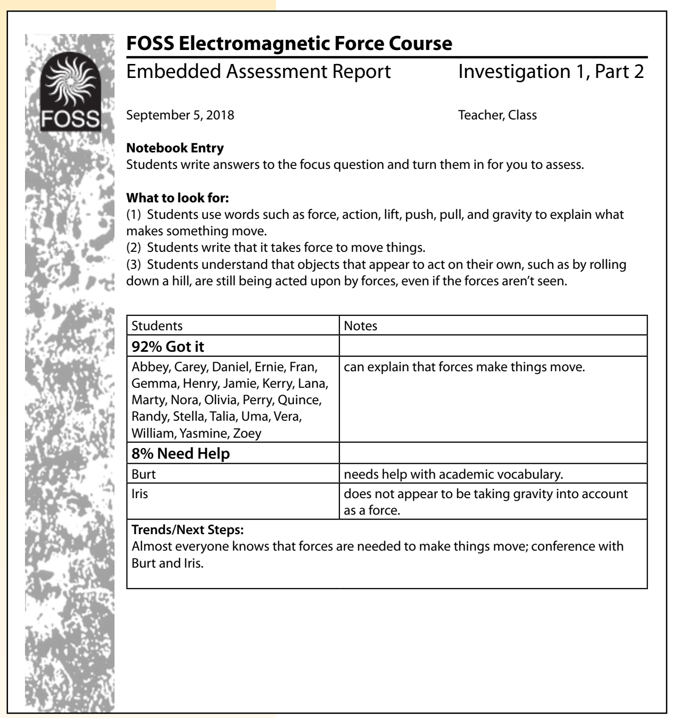
FOSSmap (fossmap.com) is the assessment management program designed specifically for teachers using the FOSS Program in middle school. This user-friendly system allows you to open online assessments for students, to review codes for student responses, and to run reports to help you assess student learning. FOSSmap was developed at the Lawrence Hall of Science in conjunction with the Berkeley Evaluation and Assessment Research (BEAR) center at the University of California, as part of a 5-year research and development project funded by the National Science Foundation. It is based on the tools developed in the Assessing Science Knowledge (ASK) project.



Embedded-assessment data can be entered into FOSSmap to provide evidence of differentiated instruction, to run reports for formative analysis, and to print notes to provide feedback in student notebooks. It is also a tool for teacher reflection and instructional improvement from year to year.

FOSSmap allows you to give students access to the **online assessment** system (fossmap.com/icheck). Students log in to this system to take the benchmark assessments (I-Checks and *Posttest*). Responses are automatically sent to the FOSSmap teacher program, where most are automatically coded. You will need to check short answers (mainly for correct answers that include inventive spelling), and to code open-response items. Students can answer open-response items on the computer or using paper and pencil, depending on the resources you have available.

If you choose to have students take the *Entry-Level Survey* on FOSSmap, the answers will not be coded, but you will be able to look at all of the students' responses in one convenient place, and make notes about each item for use when you teach the different parts of the course.



FOSS Electromagnetic Force Course
Embedded Assessment Report — Investigation 1, Part 2
September 5, 2018 — Teacher, Class

Notebook Entry
Students write answers to the focus question and turn them in for you to assess.

What to look for:
(1) Students use words such as force, action, lift, push, pull, and gravity to explain what makes something move.
(2) Students write that it takes force to move things.
(3) Students understand that objects that appear to act on their own, such as by rolling down a hill, are still being acted upon by forces, even if the forces aren't seen.

Students	Notes
92% Got it	
Abbey, Carey, Daniel, Ernie, Fran, Gemma, Henry, Jamie, Kerry, Lana, Marty, Nora, Olivia, Perry, Quince, Randy, Stella, Talia, Uma, Vera, William, Yasmine, Zoey	can explain that forces make things move.
8% Need Help	
Burt	needs help with academic vocabulary.
Iris	does not appear to be taking gravity into account as a force.
Trends/Next Steps: Almost everyone knows that forces are needed to make things move; conference with Burt and Iris.	

Navigation page and a sample Embedded Assessment Report

FOSSmap Reports

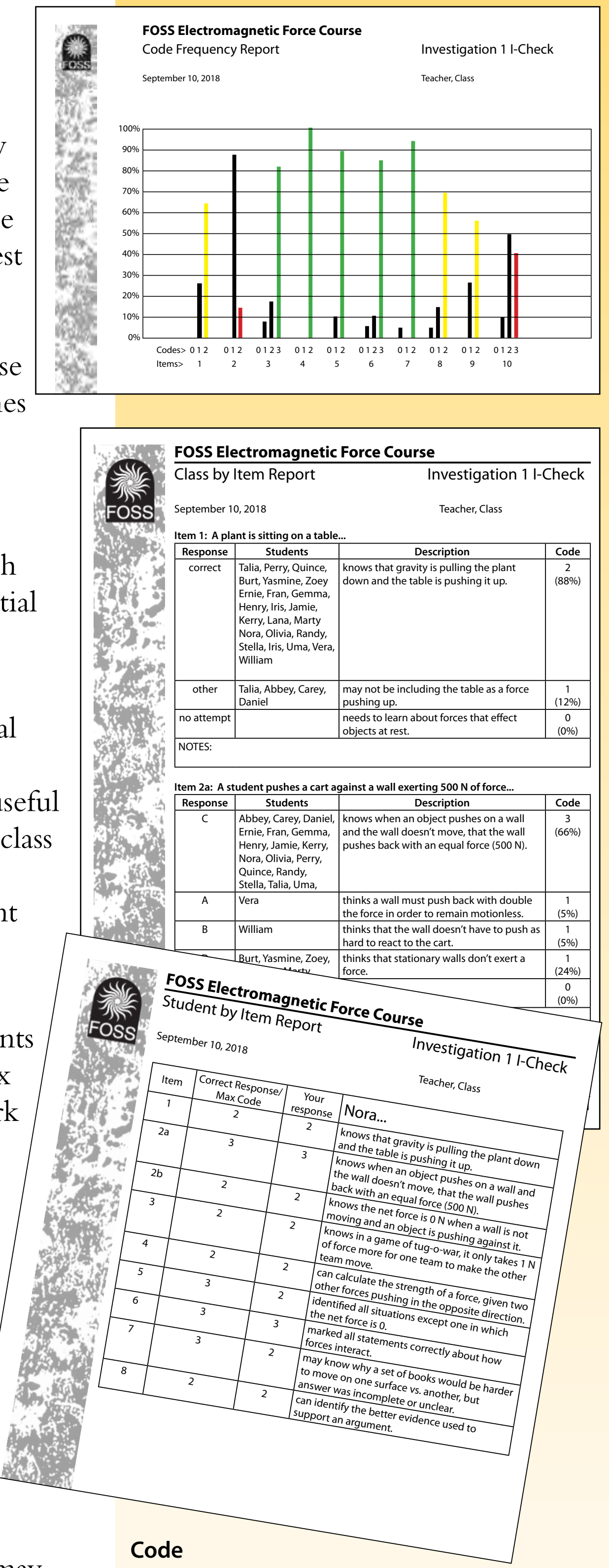
The **Code Frequency Report** tells you at a glance which items were problems for the class. Each bar on the report represents how many students received a particular code. The colored bars indicate how many students received the highest (max) code possible for the item. Green bars indicate that 70% or more students got the highest code. Yellow bars indicate that 51% to 69% of students got the highest code. Red bars indicate that 50% or fewer of the students got the highest code on that item. So the quick and easy way to use this report is to look for the red bars. The red-bar items are the ones you want to take back to students for self-assessment activities.

Run the **Class by Item Report** to get the details on each item, especially the "red bar" problem items from the Code Frequency Report. This report displays students' names for each response, with a brief description of what each code means in terms of full or partial understanding. The report helps you decide what steps need to be taken next.

The **Student Responses Report** provides a printout of individual students' responses to all items answered online (including open-response items if they were typed into the system). This report is useful for student self-assessment activities. You can project the items for class discussion, and students can make notes in their notebooks, add to, or revise answers based on the discussions during the self-assessment activities.

The **Student by Item Report** (a good report to send home to parents) lists all the items on a test and shows how individual students responded to each item. It also provides the correct answer, or max code, and a description of what the student knows or needs to work on, based on the evidence inferred from each item.

The **Class All Codes Report** provides a spreadsheet that can be opened in any spreadsheet program. It gives you a list of the students, the maximum code for each item and the code each student received on each item. You can use this sheet if you want to convert codes into scores in order to determine percentage correct if that is needed for giving grades. To do that, you need to subtract 1 from each code, so that you are not actually awarding a point for wrong answers. Remember though, that FOSS assessments are designed to be diagnostic and not minimum mastery, so you may need to adjust your cut points for giving ABC grades. For example, instead of 90% being an A, you may decide that 80% is a better cut point for an A.



Code Frequency, Class by Item, and Student by Item Reports

SAMPLE ASSESSMENT ITEMS

ANSWERS

INVESTIGATION 2 I-CHECK

ELECTROMAGNETIC FORCE

4. People often stick notes and other objects to refrigerator doors, using magnets. A student tried to do this, but the object he wanted to stick to the refrigerator fell to the floor.

   Write **E** next to each statement that helps explain why the magnet was not able to hold the object to the refrigerator door; write **X** if the statement does not help explain what happened.

   X The refrigerator door is made of steel (that contains iron).
   E The magnet is too weak.
   E The object is too thick.
   X The object is too light.
   E The refrigerator door is made of aluminum.

5. Write **T** if the sentence is true; write **F** if the sentence is false.

   F Magnets stick to all metals.
   T Two magnets can attract or repel.
   F A magnet has a north pole or a south pole, but not both.
   T A magnet has an invisible magnetic field extending from its poles.

6. The ancient Romans knew about an earth material called lodestone. Lodestone is a rock that is a natural magnet. The Romans created a monument in one of their temples that included a statue suspended in midair. How might they have used lodestone to create this effect?

   The Romans could have made the statue out of lodestone, or placed a core of lodestone inside. Then the frame of the statue would have had to be made of iron in order to have equal net forces around the statue. (Or vice versa, the statue is iron and the frame is made of lodestone.)

Item 4

Focus on Disciplinary Core Ideas
Focus on Crosscutting Concepts

This item provides evidence that students can identify causes for certain effects in which a magnet is used.

Code	If the student . . .
3	writes from top to bottom: X, E, E, X, E.
2	marks two of the "E" statements (second, third, and last), but other "X" statements are marked correctly.
1	marks any other way.
0	makes no attempt.

Item 5

Focus on Disciplinary Core Ideas

This item provides evidence that students can identify the properties and nature of magnets.

Code	If the student . . .
2	writes from top to bottom: F, T, F, T.
1	writes anything else.
0	makes no attempt.

Item 6

Focus on Science and Engineering Practices
Focus on Disciplinary Core Ideas
Focus on Crosscutting Concepts

This item provides evidence that students apply what they know about magnetic forces (cause) to explain the effect the Romans created in building the floating statues.

Code	If the student . . .
3	provides any logical explanation that involves the use of lodestone and iron (e.g., the statue was carved out of lodestone and the frame was made of iron, so the statue was equally attracted from all sides to keep it in place).
2	indicates that lodestone and iron materials must have been used; gives incomplete or unclear explanation.
1	writes anything else.
0	makes no attempt.

ITEM 4 Next Steps

Have students consider their notes from the magnet activities and discuss this item in small groups. Students then reflect and revise their answers as needed.

ITEM 5 Next Steps

Have students review "Magnetic Force" in *FOSS Science Resources*. Groups should discuss any lingering discrepancies and attempt to reach consensus. Students then reflect and revise their answers.

ITEM 6 Next Steps

Use the class-debate strategy as you review this question. Students then draw a line of learning and build upon their response to this question. See Next-Step Strategies section for more information.

TEACHING NOTE

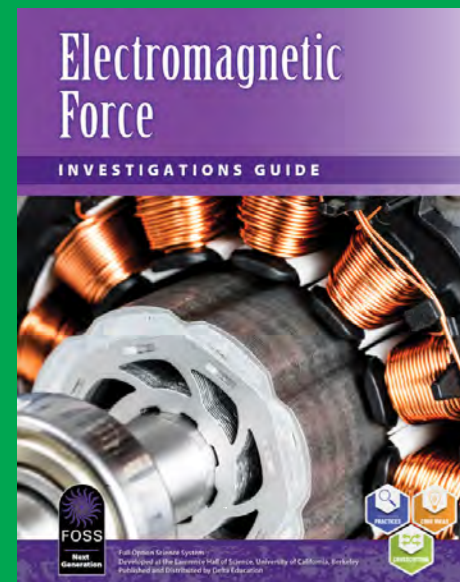
The statue could be lodestone while the top of the frame is iron, so the upward magnetic force would be in balance with the weight of the statue. If the bottom is also iron it would be hard to make the statue hover. Both the frame and the statue could be made of lodestone, and like poles could be repelling at the bottom and attracting at the top to provide enough force to balance the statue's weight.

FOSS Includes:

Investigations Guide

The Investigations Guide is a spiral-bound guide containing everything you need to teach the module. FOSS active investigation lesson plans include:

- Three-dimensional learning objectives
- Relevant and local phenomena storylines with driving questions
- Sense-making discussions
- Embedded assessment and "What to Look For" guidance
- Vocabulary reviews
- English language support strategies
- ELA strategies and connections

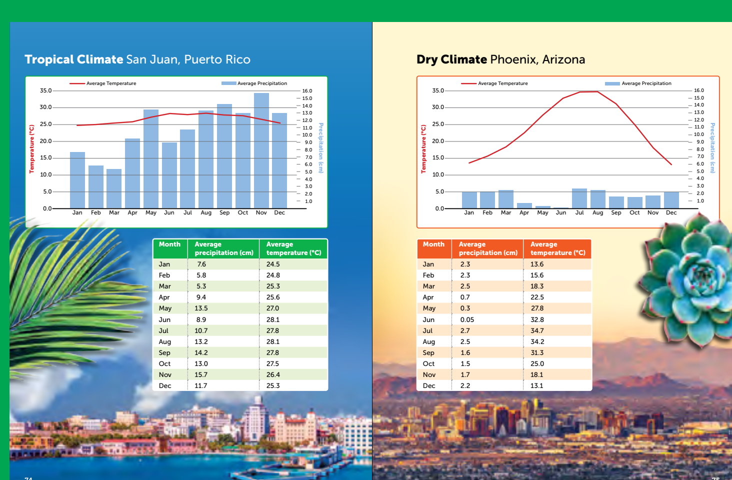


Science Resources Student Book

The *FOSS Science Resources* student book contains readings developed to reinforce, extend, or apply core ideas covered during FOSS active investigations. Readings give students opportunities to:

- Use text to obtain, evaluate, and communicate information
- Use evidence to support their ideas during sense-making discussions and focus question responses
- Integrate information from multiple sources
- Interpret graphs, diagrams, and photographs to build understanding

Available in print and as an interactive eBook in English and Spanish.



▶ **Images on this page include actual components, resources and/or materials provided in FOSS kits.**

Equipment Kit

FOSS provides the equipment needed for all the investigations, including metric measuring tools. Our high-quality, classroomtested materials are long-lasting and packaged by investigation to facilitate preparation and clean up. There is enough permanent equipment in each kit for 32 students. Consumable materials are supplied for three uses. Convenient grade-level and refill kits are available.

Technology

Online resources include duplication masters, eInvestigations Guide, teaching slides, streaming videos, virtual investigations, and tutorials, as well as a library of teacher resources, including access and equity, three-dimensional teaching and learning, and environmental literacy.

SCAN HERE FOR A TOUR OF FOSSWEB!

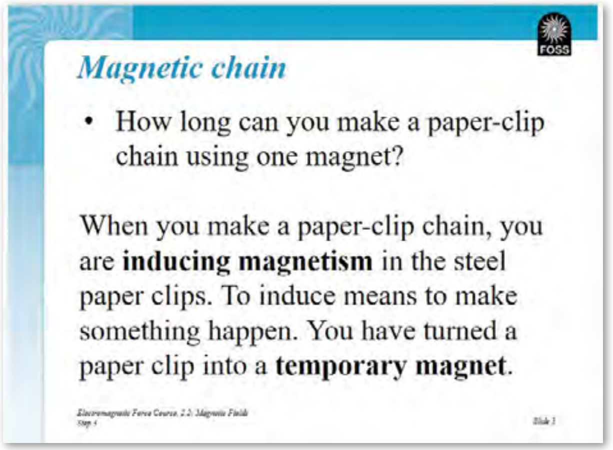
FOSSweb on ThinkLink

FOSSweb digital resources are delivered on School Specialty's curriculum platform called ThinkLink.

- Supports single sign-on and class management with Google classroom and learning management systems.
- Provides access to both teacher and student digital resources, including duplication masters, teaching slides, FOSSmap online assessment, streaming videos, and online activities.

Teaching Slides

Downloadable and editable slides from FOSSweb can be used to facilitate each part of each investigation. Teaching slides are available as Google slides in English and Spanish.

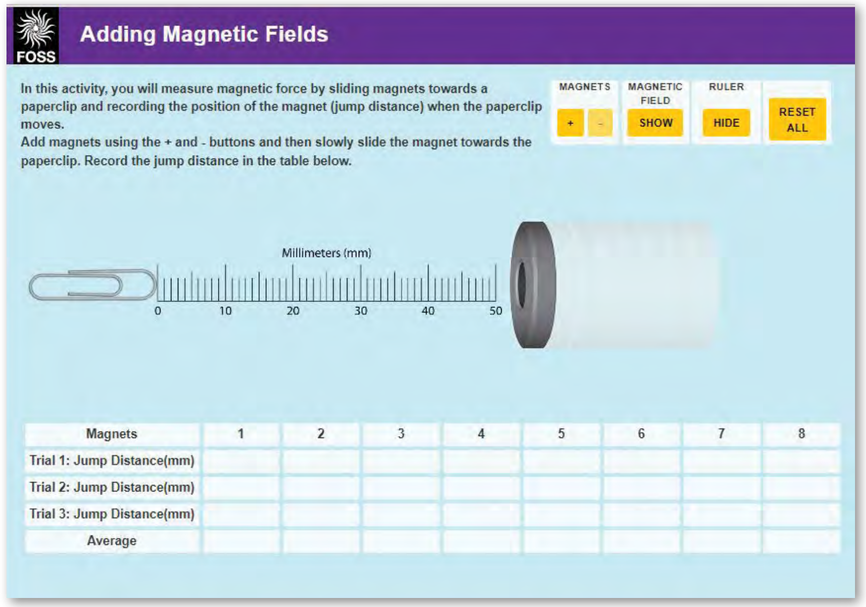


Streaming Videos

Engaging content videos in English and Spanish were developed to specifically support FOSS investigations.

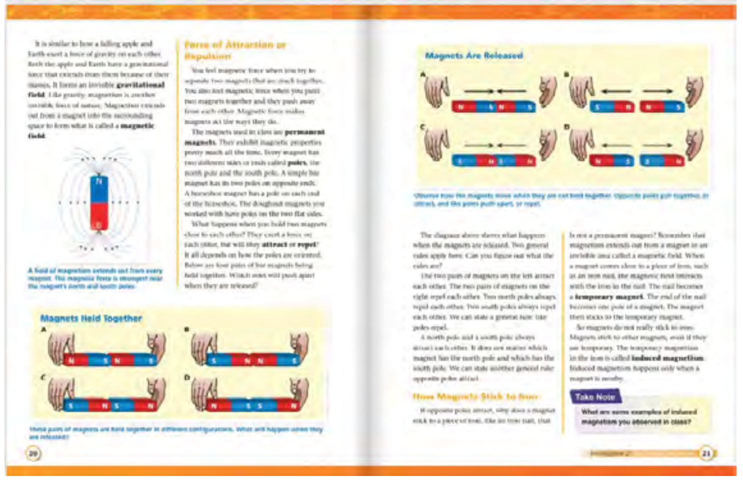
Online Activities

Engaging simulations developed to address core ideas in FOSS, and interactive virtual investigations and tutorials offer additional content support for students.



Interactive eBooks

Keep your students engaged while teaching literacy skills with interactive *FOSS Science Resources* eBooks. The eBooks include integrated audio with text syncing and links to online activities and videos that bring the photos to life.



Join the Next Generation.

Recommended 6-8 Scope and Sequence

FOSS® Middle School Scope & Sequence

Grade	Integrated Middle Grades					STEM Enrichment
8	Heredity & Adaptation* ES, LS	Electromagnetic Force* PS, ES, E	Gravity & Kinetic Energy* PS, E	Waves* PS, E	Planetary Science PS, ES	Variables & Design† Grades 5-8 E
7	Chemical Interactions PS, ES, E	Earth History PS, ES, LS	Populations and Ecosystems ES, LS, E			
6	Weather and Water PS, ES, E	Diversity of Life LS	Human Systems Interactions* LS			

PS: Physical Science content, ES: Earth Science content, LS: Life Science content, E: Engineering content *Half-length courses
†STEM Enrichment courses and modules can supplement the FOSS core curriculum or be purchased separately for STEM electives or extracurricular activities.

Learn more.

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