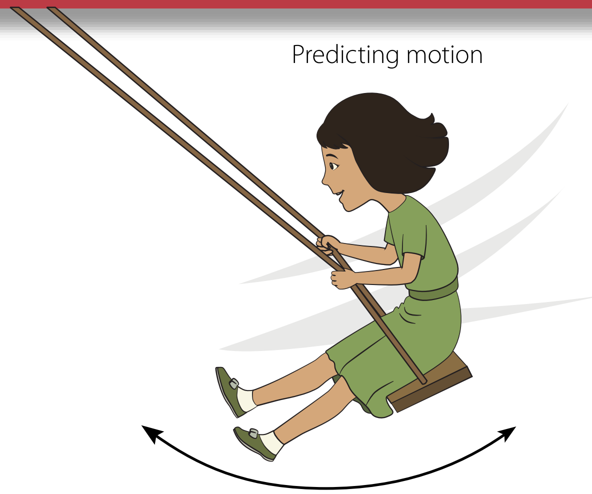
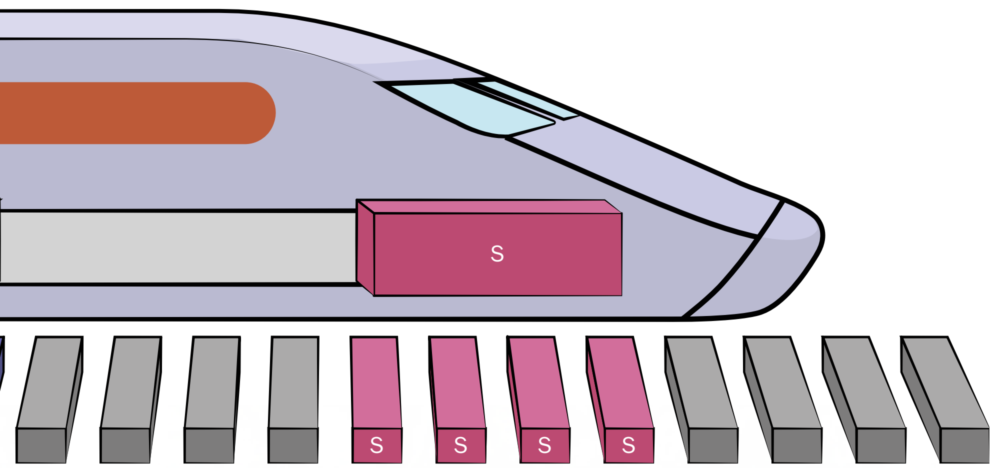
Core Knowledge® SCIENCE

Investigating Forces

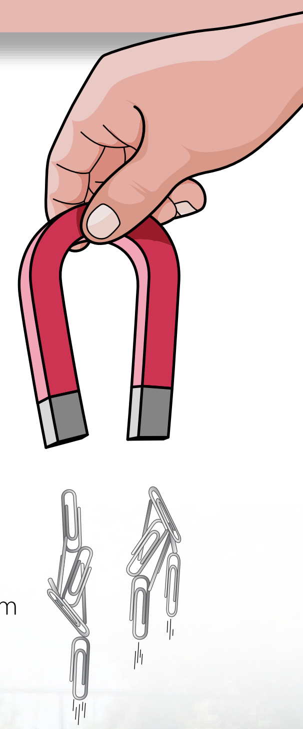
Teacher Guide



Predicting motion



Using forces to solve problems



Magnetism

Balanced and unbalanced forces

Investigating Forces

Teacher Guide

Core Knowledge®

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Investigating Forces

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Teacher Guide

Core Knowledge Science™ 3

UNIT 1

Introduction

About this Unit

The Big Idea

This unit focuses on the scientific concept that forces change motion.

Students may know intuitively that objects at rest tend to remain at rest. They might have a sense that an object in motion will keep going. However, the scientific concept that *forces change motion* can prove initially challenging for young students. This concept is best explained and understood through many concrete examples and experiences.

In this unit, the focus on forces is qualitative and descriptive, not quantitative. Students are not expected to measure or understand forces in terms of magnitude, velocity, or momentum. Students explore concepts that include

- the qualitative size and direction of forces and motion;
- an object on Earth has forces acting on it even when the object is at rest;
- any change in the speed or direction of motion is the result of a change in the forces acting on that object;
- motion can be predicted based on regular patterns and with knowledge of forces; and
- magnetism is a force that can be applied to solve problems.

Engineers and engineering designers use knowledge of forces as they develop solutions to problems and make things that are useful to people. This series of lessons incorporates learning goals that support the principles and practices of engineering design, such as defining problems and evaluating and optimizing possible solutions.

Note to Teachers and Curriculum Planners

This unit introduces Grade 3 students to real-world examples and fundamental concepts of forces, which will be explored in greater depth in later grades. Students will learn about observable effects of balanced and unbalanced forces on an object's motion, describe and predict patterns of repeating motion, and explore how forces are associated with cause-and-effect relationships. The following are preliminary considerations for planning and instruction relative to this unit:

- While the unit engages Grade 3 students in exploring forces in relation to strength and direction, it does not use the terms *magnitude*, *velocity* or *momentum*. However, understanding of how and why objects move is investigated.
- Teachers should correct the misconception that only moving objects have forces acting on them or that moving objects must have a force acting on them.
- The energy of motion is explored in greater depth in Grade 4 Unit 1, *Energy Transfer and Transformation*. Grade 4 students extend their learning of motion and forces to investigate collisions between objects.

Note to Core Knowledge Teachers

Thanks to ongoing research in the field, our understanding of how children learn continues to evolve. In the subject area of science, in particular, students benefit from not just reading about concepts and ideas, but from hands-on experiences. Following the release of the Next Generation Science Standards (NGSS), the Core Knowledge Foundation used this opportunity to update and enhance the science portion of the *2010 Core Knowledge Sequence*. The result of this effort is the revised *2019 Core Knowledge Science Sequence*.

While there have been some shifts in the grade levels at which certain topics are recommended, the fundamental principles of pedagogy inherent to the Core Knowledge approach, such as the importance of building a sequential, coherent and cumulative knowledge base, have been retained.

Online Resources

To download the *2019 Core Knowledge Science Sequence* use the links found in the Online Resources Guide.

www.coreknowledge.org/cksci-online-resources

This science unit, aligned to the *2019 Core Knowledge Science Sequence* and informed by NGSS, embodies Core Knowledge's vision of best practices in science instruction and knowledge-based schooling, such as the following:

- building students' knowledge of core ideas in life, physical, and earth sciences, as well as engineering design;
- developing scientific practices that give students' firsthand experience in scientific inquiry, engineering, and technology; and,
- connecting scientific learning to concepts across various disciplines, such as mathematics and literacy.

To see how you can continue to use your current Core Knowledge materials with the 2019 CKSci curriculum, please see below an example of how this unit compares to the *2010 Core Knowledge Sequence*.

Examples of content retained from the *2010 Core Knowledge Sequence*	Examples of Core Knowledge content in this CKSci Unit
Friction (Grade 2) • Ways to reduce friction (lubricants, etc.) **Magnetism (Grade 2 and Grade 8)** • Magnetism demonstrates that there are forces we cannot see that act upon objects. • Law of magnetic attraction: unlike poles attract, like poles repel **Forces (Grade 8)** • The concept of force: force as a push or pull – A force has direction and strength • Unbalanced forces cause changes in motion.	**The Force of Friction** • Friction opposes motion, or makes it difficult for an object to move across a surface. • Ways to reduce friction (for example, lubricants) **The Force of Magnetism** • Magnetism works over a distance; it can cause a push or pull not in contact with each other • Familiar uses of magnets to solve problems **Forces and Motion** • Force as a push or a pull • Forces can cause changes in an object's motion: – changes in direction and speed • The effect of balanced and unbalanced forces
For a complete look at how CKSci relates to the 2010 Sequence, please refer to the full Correlation Charts available for download using the Online Resources Guide for this unit: **www.coreknowledge.org/cksi-online-resources**	

What are the relevant NGSS Performance Expectations for this unit?*

This unit, *Investigating Forces*, has been informed by the following Grade 3 Performance Expectations for the NGSS topic *Forces and Interactions*. Students who demonstrate understanding can:

3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

3-PS2-4 Define a simple design problem that can be solved by applying scientific ideas about magnets.

Online Resources

For detailed information about the NGSS references, follow the links in the Online Resources Guide for this unit. Use the following link to download any of the CKSci Online Resources Guides:

www.coreknowledge.org/cksci-online-resources

Sources:

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

National Research Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K–12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Building Science Knowledge

What Students Should Already Know

The concept of progressions, articulated in the National Research Council's *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, is very much aligned to the Core Knowledge principle of building new knowledge on prior knowledge. According to the NRC, students build "progressively more sophisticated explanations of natural phenomena" over the course of many years of schooling. "Because learning progressions extend over multiple years, they can prompt educators to consider how topics are presented at each grade level so that they build on prior understanding and can support increasingly sophisticated learning." In schools following NGSS recommendations, teachers can build on the "prior understandings" captured in the following summaries of NGSS Disciplinary Core Ideas:

PS2.A: Forces and Motion

Grades K–2

- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.

PS2.B: Types of Interactions

Grades K–2

- When objects touch or collide, they push on one another and can change motion.

PS3.C: Relationship Between Energy and Forces

Grades K–2

- A bigger push or pull makes things speed up or slow down, and change direction more quickly.

ETS1.A: Defining Engineering Problems

Grades K–2

- A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.

What Students Need to Learn

For this unit, the Core Knowledge Science Sequence specifies the following content and skills. Specific learning objectives are provided in each lesson throughout the unit. NGSS References, including Performance Expectations, Disciplinary Core Ideas, and Crosscutting Concepts, are included at the start of each lesson as appropriate.

A. Forces and Motion LESSONS 1–3

- Identify force as a push or pull.
- Describe forces in terms of strength and direction.
- Describe changes in motion in terms of speed and direction.
- Compare balanced and unbalanced forces.
- Plan and conduct an investigation of the cause-and-effect relationships between balanced and unbalanced forces and the motion of objects.

B. Friction Is a Force LESSONS 4–5

- Investigate the effects of friction on an object's motion.
- Identify and describe examples of friction.
- Compare examples of helpful and harmful friction in daily life.
- Describe the characteristics of friction as a force.

C. Predicting Motion LESSON 6

- Describe patterns in the motion of an object.
- Describe regular patterns in an object's motion, and use data to predict future motion by describing the forces acting on that motion.

D. Magnetism Is a Force LESSONS 7–9

- Classify materials according to whether they are or are not attracted by a magnet.
- Based on patterns in observed data, predict whether a magnet will attract another object.
- Investigate the effects of distance on magnetic attraction.
- Explain cause-and-effect relationships between the like and unlike poles of two magnets.
- Describe the characteristics of magnetism as a force.
- Describe a device that uses magnets to solve a problem.

What Teachers Need to Know

Supportive information on the content standards and the science they address is provided throughout the lessons at points of relevance:

Know the Standards: These sections, found later in this Teacher Guide, explain what to teach and why, with reference to NGSS and Core Knowledge expectations.

Know the Science: These sections provide supporting, adult-level, background information or explanations related to specific examples or Disciplinary Core Ideas.

Using the Student Reader

Student Reader

The *Investigating Forces* Student Reader has six chapters and a student Glossary providing definitions to Core Vocabulary words. Engaging text, photographs, and diagrams encourage students to draw upon their own experiences and the world around them to understand scientific concepts. In addition to Core Vocabulary, the Student Readers include a feature called Word to Know, which provides background information to help students understand key terms, and may sometimes include additional informational boxes, such as Think About.

Explore, then read: In the CKSci program, lessons are sequenced to provide active engagement before reading. First, students explore phenomena through hands-on investigations or teacher demonstrations, accompanied by active questioning and analysis; then, students study the informational text provided in the Student Readers. The icon, shown at left, will signal Core Lesson segments that focus on Student Reader chapters.

CKSci Student Readers extend, clarify, and confirm what students have learned in their investigations. The text helps students develop a sense of the language of science, while images, diagrams, charts, and graphs deepen conceptual understanding. Use of the CKSci Student Readers supports the Science and Engineering Practice "Obtaining, Evaluating, and Communicating Information" as described in *A Framework for K–12 Science Education*.

Independent reading or group read aloud: While the text in the Student Readers is written for independent reading, we encourage group read aloud and engagement with the text. The Teacher Guide provides Guided Reading Supports to prompt discussion, clarify misconceptions, and promote understanding in relation to the Big Questions.

Using the Teacher Guide

Pacing

The *Investigating Forces* unit is one of four units in the Grade 3 CKSci series. To meet NGSS Performance Expectations we encourage teachers to complete all units during the school year. To be sure all NGSS Performance Expectations are met, each Core Lesson should be completed, and each requires thirty to forty-five minutes of instruction time. The time it takes to complete a lesson depends on class size and individual circumstances.

Within the Teacher Guide, the Core Lessons are divided into numbered segments, generally five or six, with approximate times listed per segment. The final segment is always a Check for Understanding, providing the teacher with an opportunity for formative assessment.

At the end of this unit Introduction, you will find a Sample Pacing Guide on page 13 and a blank Pacing Guide on pages 14–15, which you may use to plan how you might pace the lessons, as well as when to use the various other resources in this unit. We strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson. As a general rule, we recommend that you spend no more than twenty days teaching the *Investigating Forces* unit so that you have time to teach the other units in the Grade 3 CKSci series.

The Core Lessons

- Lesson time: Each Core Lesson constitutes one classroom session of up to forty-five minutes. Understanding that teachers may have less instructional time, we show a time range of thirty to forty-five minutes per lesson. Teachers may choose to conduct all Core Lesson segments, totaling forty-five minutes; may choose to conduct a subset of the lesson segments; or may choose to spend less time per segment.
- Lesson order: The lessons are coherently sequenced to build from one lesson to the next, linking student engagement across lessons and helping students build new learning on prior knowledge.

PART	LESSON	BIG QUESTION
A. Forces and Motion (3-PS2-1)	**1.** Pushes, Pulls, and Motion	What is force?
	2. A Force Is a Push or a Pull	What are balanced and unbalanced forces?
	3. Investigating Forces (two class sessions)	How do forces affect the motion of objects?
B. Friction Is a Force (Core Idea PS2)	**4.** Investigating Friction (two class sessions)	How does the force of friction affect motion?
	5. Friction Is a Force	What are the characteristics of the force called friction?
C. Predicting Motion (3-PS2-2)	**6.** Predicting Patterns of Motion (two class sessions)	Can we predict the motion of an object that moves in regular patterns?
D. Magnetism Is a Force (3-PS2-3)	**7.** Investigating Magnets	How do magnets interact with different materials and each other?
	8. Magnetism Is a Force	What are the characteristics of the force called magnetism?
	9. Solving Problems with Magnets (two class sessions)	What problems can be solved with magnets?
Unit Review and Assessment	Forces and Trains	How have engineering designers improved trains?
	Unit Assessment	What have I learned about forces?

Activity Pages and Unit Assessment

Activity Pages

AP 1.1
AP 2.1
AP 3.1
AP 3.2
AP 4.1
AP 5.1
AP 5.2
AP 6.1
AP 7.1
AP 8.1
AP 8.2
AP 9.1
AP UR.1

Black line reproducible masters for Activity Pages and a Unit Assessment, as well as an Answer Key, are included in Teacher Resources on pages 86–113. The icon shown to the left appears throughout the Teacher Guide wherever Activity Pages (AP) are referenced.

Students' achievement of the NGSS Performance Expectations is marked by their completion of tasks throughout the unit. However, a combined Unit Assessment is provided as a summative close to the unit.

Lesson 1—Push It, Pull It (AP 1.1)

Lesson 2—Lesson 2 Check (AP 2.1)

Lesson 3—Investigating Forces—Plan (Day 1) (AP 3.1)

Lesson 3—Investigating Forces—Test (Day 2) (AP 3.2)

Lesson 4—Table Hockey (AP 4.1)

Lesson 5—Friction Finder (AP 5.1)

Lesson 5—Lesson 5 Check (AP 5.2)

Lesson 6—Forces and Patterns (AP 6.1)

Lesson 7—Fishing with Magnets (AP 7.1)

Lesson 8—Lesson 8 Check (AP 8.1)

Lesson 8—Core Vocabulary Review (AP 8.2)

Lesson 9—Problem and Solution (AP 9.1)

Unit Review—Big Questions About Forces (AP UR.1)

Online Resources for Science

Online Resources

For each CKSci unit, the Teacher Guide includes references to online resources (including external websites and downloadable documents) to enhance classroom instruction. Look for the icon on the left.

Use this link to download the CKSci Online Resources for this unit:

www.coreknowledge.org/cksci-online-resources

Teaching Strategies

Start with the familiar.

Lead with an experience. Begin each lesson with a demonstration, activity, or question about a phenomenon to engage students and focus their attention on the topic. Start with the familiar. Every science topic introduced to students relates in some way to their known world and everyday experiences. The purpose of every lesson is to build a bridge between what is familiar to students and broader knowledge about the way the world works.

Ask the Big Question.

At the beginning of each Teacher Guide lesson, you will find a Big Question and Core Lesson segment devoted to encouraging students to think about this question as they are introduced to new science content. Use this opportunity to engage students in conversation, to think about how their own real-world experiences relate to the topic, or to participate in a demonstration that relates to the Big Question.

Encourage scientific thinking.

Approach the lessons with students not as learning about science but as learning about the world with a scientific mind. Science learning models science practice.

Throughout the lessons, encourage students to ask questions about what they observe, do, and read. Record relevant questions in a prominent place in the classroom. Guide students back to these questions as opportunities to answer them emerge from readings, demonstrations, and activities.

Use continuous Core Vocabulary instruction.

As a continuous vocabulary-building strategy, have students develop a deck of vocabulary cards, adding a card for each Core Vocabulary term as it is introduced. Students can add illustrations and examples to the cards as their comprehension of terms expands. During instruction, emphasize Core Vocabulary terms and their meanings in context rather than relying on isolated drill for memorization of definitions. Students will be given the opportunity to preview Core Vocabulary words early in the lessons and to engage in Word Work activities toward the end of the lessons. Encourage students to come up with definitions in their own words and to use the words in their own sentences.

Core Vocabulary words for each lesson, as well as other key terms teachers are encouraged to use in discussing topics with students, are provided at the start of each lesson. You can find Core Vocabulary definitions in the Word Work lesson segments, as well as in the Glossary on pages 114–115.

Emphasize observation and experience.

Lessons employ various ways for students to learn, including watching, listening, reading, doing, discussing, and writing. To meet the NGSS Performance Expectations, which are multidimensional standards, students must not only gain factual knowledge associated with Disciplinary Core Ideas, but also *use* the content knowledge they acquire.

Use science practices.

Give students opportunities to discover new content knowledge through investigation and to use their new knowledge both in problem-solving exercises and as evidence to support reasoning. Students learn what science and engineering practices are by engaging in those same practices as they learn.

Core Lesson segments are designed to reinforce the idea of science as an active practice, while helping students meet NGSS Performance Expectations. Each lesson segment is introduced by a sentence emphasizing active engagement with an activity.

Make frequent connections.

Use a combination of demonstrations and reading materials, rich with examples, to help students recognize how the science concepts they are learning apply in their everyday lives. Prompt students to relate lesson content to their own experiences, to relate the new and unfamiliar to the familiar, and to connect ideas and examples across disciplines. Refer to the Crosscutting Concepts cited in the lessons, often included in the NGSS References listed at the start of each lesson.

Monitor student progress.

Use verbal questioning, student work, the Check for Understanding assessments at the end of each lesson, and the Unit Assessment at the end of the unit (see pages 104–107) to monitor progress during each lesson and to measure understanding at the conclusion of the unit. Many lessons provide tips to help you support students who need further explanations or clarifications.

Effective and Safe Classroom Activities

Online Resources

Conducting safe classroom demonstrations and activities is essential to successful elementary science education. The following resources provide Core Knowledge's recommendations for developing effective science classroom activities.

These resources, included at the back of the Teacher Guide on pages 116–120, consist of the following:

- Classroom Safety for Activities and Demonstrations
- Strategies for Acquiring Materials
- Advance Preparation for Activities and Demonstrations
- What to Do When Activities Don't Give Expected Results

These resources may also be accessed within the CKSci Online Resources Guide for this unit, available at

www.coreknowledge.org/cksci-online-resources

Materials and Equipment

The unit requires a variety of materials to support various ways of learning (including doing, discussing, listening, watching, reading, and writing). Prepare in advance by collecting the materials and equipment needed for all the demonstrations and hands-on investigations.

Part A: Forces and Motion

Lesson 1

- pencils
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 2

- rubber ball
- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/videos for whole-class viewing

Lesson 3

- rubber eraser (1 per student)
- rubber ball
- index cards for student vocabulary deck (1 per student)

Part B: Friction Is a Force

Lesson 4

- materials to create two ramps, such as: books, blocks, clipboard, cardboard
- sandpaper (enough to cover each ramp)
- scissors
- glue
- block (wooden or plastic)
- oil (cooking, such as vegetable oil)
- paper towels or rags/cloths (for cleanup)

For each group of students:

- baking sheet pan
- large piece of felt (large enough to cover the bottom of the baking sheet)
- large piece of aluminum foil (large enough to cover the bottom of the baking sheet)
- large piece of sandpaper (large enough to cover the bottom of the baking sheet)
- plastic cup (for the oil)
- bottle cap (such as those for milk jugs)
- sand (to fill each bottle cap)

- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 5

- eraser
- pencil
- paper
- sticky notes
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing (examples of friction)

Part C: Predicting Motion

Lesson 6

- image of grandfather clock
- pencils or crayons
- string
- scissors
- yo-yo
- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/videos for whole-class viewing

Part D: Magnetism Is a Force

Lesson 7

- index cards for student vocabulary deck (5 per student)
- internet access and the means to project images/videos for whole-class viewing

Teacher Demonstration

- ring (or donut) magnet
- assortment of metal and plastic paper clips
- pair of metal scissors
- metal binder clip
- pushpins
- plastic utensil
- roll of masking tape
- pencil
- bowl
- yarn
- long wooden sticks

Student Investigation

- ring (or donut) magnets
- bowls
- yarn
- long wooden sticks
- assorted magnetic and nonmagnetic items
    - coins
    - metal marbles/balls
    - keys or key rings
    - rocks/pebbles
    - erasers
    - shoelaces
    - chalk
    - feathers

Lesson 8

- shoebox lid
- white paper
- water-based paint, such as tempera (multiple colors)
- metal ball
- craft magnet
- bar magnets (1 per student)

Lesson 9

- compass
- metal hairpins (bobby pins)
- magnetic strip
- magnets
- paper
- glue
- cabinet
- additional materials as necessary (see Step 3 in Day 2)
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Unit Review

- magnetic tape roll
- narrow box with ends cut off
- cardboard from one end of the box
- small, thin piece of foam or sponge
- thin clear tape
- glue
- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/videos for whole-class viewing

Sample Pacing Guide

The sample Pacing Guide suggests use of the unit's resources across a fifteen-day period. However, there are many ways that you may choose to individualize the unit for your students, based on their interests and needs. You may elect to use the blank Pacing Guide on pages 14–15 to reflect alternate activity choices and alternate pacing for your class. If you plan to create a customized pacing guide for your class, we strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson.

Online Resources

For a yearlong pacing guide, please use the link found in the Online Resources Guide for this unit. This yearlong view of pacing also includes information about how this CKSci unit relates to the pacing of other programs, such as CKLA and CKHG in the *Core Knowledge Curriculum Series*™.

www.coreknowledge.org/CKSci-online-resources

TG–Teacher Guide; SR–Student Reader; AP–Activity Page

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5
Pushes, Pulls, and Motion TG Lesson 1 AP 1.1	*A Force Is a Push or a Pull* TG Lesson 2 SR Chapter 1 AP 2.1	*Investigating Forces* DAY 1 TG Lesson 3 AP 3.1, 3.2	*Investigating Forces* DAY 2 TG Lesson 3 AP 3.1, 3.2	*Investigating Friction* DAY 1 TG Lesson 4 AP 4.1

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10
Investigating Friction DAY 2 TG Lesson 4 AP 4.1	*Friction Is a Force* TG Lesson 5 SR Chapter 2 AP 5.1, 5.2	*Predicting Patterns of Motion* DAY 1 TG Lesson 6 SR Chapter 3 AP 6.1	*Predicting Patterns of Motion* DAY 2 TG Lesson 6 SR Chapter 3 AP 6.1	*Investigating Magnets* TG Lesson 7 AP 7.1

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15
Magnetism Is a Force TG Lesson 8 SR Chapter 4 AP 8.1, 8.2	*Solving Problems with Magnets* DAY 1 TG Lesson 9 SR Chapter 5 AP 9.1	*Solving Problems with Magnets* DAY 2 TG Lesson 9 SR Chapter 5 AP 9.1	*Forces and Trains* TG Unit Review SR Chapter 6 AP UR.1	Unit Assessment AP Unit Assessment

Pacing Guide

Fifteen days have been allocated to the *Investigating Forces* unit to complete all Grade 3 science units in the *Core Knowledge Curriculum Series*™. If you cannot complete the unit in fifteen consecutive days of science instruction, use the space that follows to plan lesson delivery on an alternate schedule.

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15

Week 4

Day 16	Day 17	Day 18	Day 19	Day 20

Week 5

Day 21	Day 22	Day 23	Day 24	Day 25

Week 6

Day 26	Day 27	Day 28	Day 29	Day 30

Week 7

Day 31	Day 32	Day 33	Day 34	Day 35

Week 8

Day 36	Day 37	Day 38	Day 39	Day 40

PART A

Forces and Motion

Overview

Lesson	Big Question	Advance Preparation
1. Pushes, Pulls, and Motion	What is force?	Gather materials for teacher demonstration. (See Materials and Equipment, page 11.)
2. A Force Is a Push or a Pull	What are balanced and unbalanced forces?	Read Student Reader, Chapter 1.
3. Investigating Forces (2 days)	How do forces affect the motion of objects?	Gather materials for hands-on investigations. (See Materials and Equipment, page 11.)

Part A: What's the Story?

A force is a push or a pull. When the net force acting on an object is balanced, the object will undergo no change in motion. It will remain at rest or continue with the same motion. When the net force acting on an object is unbalanced, the object's movement will change. This section allows students to visualize this phenomenon by exploring pushes and pulls, as well as the ways that forces affect the motion of objects.

In Lesson 1, students start by engaging in a discussion around a teacher demonstration. They explore relative differences in the kinds of forces an object can experience and start to build their understanding that a force can be either a push or a pull. The goal is for students to recognize that forces, which occur (often in combination) at almost all times in our daily lives, cause changes to the motion of objects.

In Lesson 2, students read about balanced and unbalanced forces. The goal of this lesson is for students to grasp that an unbalanced net (total) force changes the speed and/or direction of an object's motion.

Balanced forces do not change an object's motion, regardless of whether the object is moving or not moving. For example, an object such as a meteoroid may remain in constant motion in a constant direction if no unbalanced forces are applied. There will be no **change** in motion because no force acts to change its motion. An object at rest may have many forces acting on it, but if all the forces are balanced, the object will not show a change in motion.

In Lesson 3, students plan and conduct an investigation of the cause-and-effect relationship between balanced and unbalanced forces and motion. This two-day lesson invites students to set up investigations and identify patterns to make predictions about how the motion of an object will change based on the forces acting on it.

In short, **forces acting on an object can be balanced or unbalanced. If the net force is unbalanced, the pushes and/or pulls acting on the object will change the object's speed or direction of motion**. Help your students grasp this concept in these three lessons, and you will lay the groundwork for meeting the NGSS expectations addressed in later parts of this unit.

LESSON 1

Pushes, Pulls, and Motion

Big Question: What is force?

At a Glance

Learning Objectives

✓ Identify a force as a push or a pull.

✓ Describe forces in terms of strength and direction.

✓ Describe changes in motion in terms of speed and direction.

Lesson Activities

- hands-on activity
- discussion
- writing
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS2.A: Forces and Motion

Disciplinary Core Idea PS2.B: Types of Interactions

Crosscutting Concept: Cause and Effect

Cause-and-Effect relationships will be explored during this lesson as students discuss pushes and pulls. Students will discuss different kinds of motion that an object can experience (the effect) and begin to explore characteristics of the forces that cause changes in speed and direction of an object's movement.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in green below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 114–115 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

direction	**motion**	push	strength
force	pull	speed	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include Core Vocabulary terms designated in green on the previous page.

Instructional Resources

Activity Page

AP 1.1

Activity Page
Push It, Pull It (AP 1.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- pencils
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 10 min

What is force? Challenge students to give examples of unexpected movements, such as a picture hanging on a wall that falls for no apparent reason.

Online Resources

- Display images of the "sailing stones" of Death Valley National Park near the border of California and Nevada. It is the driest and lowest place in North America. Explain that although no one has ever seen them moving, people have observed evidence that large rocks move across the desert ground, seemingly by themselves. They even leave trails behind them. Discuss what might cause a rock to move. (See below, **Know the Science 1** for support with the discussion.)

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

- Have students demonstrate a push, such as pushing a book or pencil across a desk. Then have them demonstrate a pull. Ask the following:
  - » What happens to an object when you give it a push? (*A push makes an object move away.*)
  - » What happens when you give it a pull? (*A pull makes an object move closer or follow the direction of the pull.*)
  - » What could be pushing or pulling on those sailing stones in Death Valley? (*Weather, such as wind, water, and ice, may make these rocks move.*)

Know the Science

1. What causes the sailing stones of Death Valley to move? *Wind, water, and ice.* In 2014, time-lapse photography revealed the rocks moved when rain formed a pond that froze overnight, creating a sheet of ice. Wind slowly pushed the rocks forward as the ice melted under them. The force of the wind caused the rocks to move, leaving a trail behind them.

- Throughout the discussion, reinforce these ideas:
  - A force is a push or a pull.
  - Pushes and pulls act on objects in certain directions.
  - Forces can cause objects to change motion, direction, or speed.

  SUPPORT—Model and scaffold use of terms that describe direction, strength, and speed in relative terms. Students should be comfortable with using terms such as *strong, weak, faster, slower,* etc. to describe events.

- Ask volunteers for other ways to apply a push or a pull, such as with wind by blowing or vacuuming. Record their responses on the board or chart paper.
- Prompt students to think of at least five ways pushes and pulls affect their daily lives. For example, students push and pull doors open, they pull their socks on, and they push their lunches, papers, and books into their backpacks.
- Model for students an "I wonder . . ." statement or question about forces. For example, "I wonder if I can push on something without touching it." Prompt students to pose their own questions and record responses on the board or chart paper.

2. Preview the investigation. 5 MIN

Activity Page

AP 1.1

- Distribute and review Push It, Pull It (AP 1.1). Review the directions for this hands-on activity. **Note:** Students will be drawing examples of pushes and pulls on their Activity Pages in Step 4. Ask students to keep the goals of the activity in mind as they discuss the following:
  - Ask students to describe how the object moved differently in each part of the demonstration. (*If the student chose a pencil for the activity, a push could have moved the pencil along a piece of paper. A pull could have been used to pick up the pencil.*)
  - Discuss how the pencil changed motion. (*The pencil changed motion by the amount of pressure used to move it back and forth when writing.*)
  - Discuss what happened to the pencil when more force was applied to it. (*More force pressing down made the writing darker.*)
  - Students should identify that they were pushing on the pencil when they moved it forward and pulling on it when they returned it to its original position. They should also understand that the greater strength they applied to the pencil, the more speed with which it moved.
- Ask students to describe what pushes and pulls are. (*forces*)
- Discuss the direction in which push/pull forces act.

  SUPPORT—Include in this part of the activity a brief discussion of the effort involved in pushing and pulling different objects, e.g., the effort needed to move a desk compared to the effort needed to move a book on the desk.

3. Demonstrate examples and guide discussion. 5 MIN

- Have students identify objects to push and pull around them to solve a problem, such as pushing and pulling doors, chairs, books, and desks.
- Then have each student demonstrate pushing and pulling an object such as a door, drawer, chair, or book.
  - » Discuss how the force of the push or pull causes each object to change motion, direction, or speed. Note: getting a moving object to stop or getting a stopped object to move are examples of a change in motion.
  - » Discuss how motion and speed of an object are affected by the strength of a push or pull.

4. Facilitate the investigation. 10 MIN

Activity Page

AP 1.1

- Have students return to Push It, Pull It (AP 1.1). Remind students that they will create a visual model that shows an example of a push force and a pull force.
- Then have them complete the Activity Page. To help students further understand how forces act on objects, have them draw an arrow to show the direction in which the force is acting. (*Push forces should have an arrow facing the object; pull forces should have an arrow moving away from the object.*)

  SUPPORT—If students have difficulty completing the Activity Page, individually have them describe things they push and pull. Discuss how they can show those objects and movement, and provide examples.

5. Summarize and discuss. 5 MIN

- Use the visual model that students drew on their Activity Page to reinforce the idea that forces acting on objects move the objects. (See below, **Know the Science 2**, for support.) Ask guiding questions to help students link details in their model back to the activity with the pencils. For example, how is what they drew like what they did to the pencil? (*Pushing a book on a table and pushing a pencil to write cause the objects to move forward.*) How is it different? (*The book was pushed in a straight line. The pencil was moved in different directions.*)
- Ask students to share the push/pull examples they drew with the class. As time permits, discuss some of the examples, or have students come up with more.

Know the Science

2. What is a force? *A push or a pull.* Forces can change an object's motion. When, for example, students move a pencil away from them, a push force is acting on the object. When students move a pencil toward themselves, a pull force is acting on the pencil. The push/pull forces are examples of energy transferring from students' muscles into the pencil. By pushing or pulling on the pencils, students are able to make them move. Students are even able to make the pencils change direction, first moving them in one direction (away from students) and then in another (back toward students).

6. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Instruct students to prepare Core Vocabulary cards for the terms **force** and **motion**. Have students write each term in the upper left corner of an index card and underline it (one term per card).

Word Work

- **force:** (n. a push or a pull) On the first card, ask students to write a sentence using the word *force*. Have students add a simple drawing of a force acting on an object. The force can be a push, a pull, or both. Be sure that students do not reuse the drawings they did for Push It, Pull It (AP 1.1). Ask students to include arrows to show direction.
- **motion:** (n. the process of an object changing position) On the second card, have students draw and label a simple representation of an object in motion.

7. Check for understanding. 5 MIN

Activity Pages

AP 1.1 and Answer Key

Formative Assessment Opportunity

Have students summarize what they have learned about forces and motion.

Review student responses to Push It, Pull It (AP 1.1) and their visual models to determine student understanding of the following concepts:

- A force is a push or a pull.
- Pushes and pulls act on objects in certain directions.
- Forces can cause objects to change motion, direction, or speed.

See the Activity Page Answer Key for correct answers and sample student responses.

LESSON 2

A Force Is a Push or a Pull

Big Question: What are balanced and unbalanced forces?

At a Glance

Learning Objectives

✓ Describe force as a push or pull.

✓ Compare balanced and unbalanced forces.

Lesson Activities

- teacher demonstration
- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea: PS2.A: Forces and Motion

Disciplinary Core Idea: PS2.B: Types of Interactions

Crosscutting Concept: Cause and Effect

Cause and Effect is important to this lesson because it extends learning from Lesson 1 to explore how forces and changes in motion can be compared. Students will need to demonstrate understanding of both core ideas **PS2.A** and **PS2.B** by exploring the relationship between the strength and direction of a force (the cause) and the relative speed and direction of motion (the effect) on an object.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in green below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 114–115 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

at rest	**force**	**motion**	strength
balanced forces	**gravity**	speed	**unbalanced forces**
direction			

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green on the previous page.

Instructional Resources

Student Reader

Ch. 1

Activity Page

AP 2.1

Student Reader, Chapter 1
"A Force Is a Push or a Pull"

Activity Page
Lesson 2 Check (AP 2.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- rubber ball
- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/videos for whole-class viewing

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 5 MIN

What are balanced and unbalanced forces? Remind students that in the previous lesson they observed and demonstrated pushes and pulls and talked about forces that move things, even when you can't see or feel them. Have students describe the pushes and pulls they think are acting on objects in the following examples:

» a ball being dropped to the ground

» a book sitting on a table

» a crayon being used to color something

» the sailing stones in Death Valley

» a tree branch that breaks suddenly

- Make a class list of questions students can ask themselves, such as "What forces are acting on objects that are at rest?" as a way to start making closer observations and learning how to look for evidence in phenomena.
- Encourage students to ask questions and to answer others' questions. Try to get students to use evidence statements and make claims when discussing forces so they can become familiar with how to support their discussions with facts or observations. For example, if a student makes a claim that the force of gravity is acting on all objects, ask, "How do you know that gravity is acting on objects? What evidence do you have?" (*Gravity keeps objects on Earth rather than floating in air.*)

2. Demonstrate the investigation. 10 MIN

- Place a single rubber ball on a flat surface such as a desk, a table, or the floor, where all students can see it. Point out that the ball is *at rest*, or not moving. That's because the forces acting on it are **balanced**. (See **Know the Science 1** for support with the analysis.) The forces acting on the ball from above and below are equal, so the ball is not moving.

  SUPPORT—Place a pencil on a desk. Ask students to consider why the pencil stays at rest and doesn't move. Explain that forces are at work but that they are balanced. The force of the desk is balancing the force of gravity, which may be hard for students to understand because it is also at rest. Then pick up the pencil, and drop it on the floor. Ask: What force caused the pencil to fall? Lead students to understand that the desk was pushing against the force of gravity pulling the pencil to the floor. When the desk wasn't there to push, the pencil dropped. Now the floor is pushing against the pencil.

- Have students discuss other objects in the room that have balanced forces working on them, and support students as they identify forces. (They should understand that any object that appears to be at rest has balanced forces working on it.)
- Then give the rubber ball a push. Explain that the ball has changed from being *at rest* to being in **motion**. When the forces acting on an object are unbalanced, the object will undergo a change in speed or undergo a change in the direction of motion.
- Invite students to consider questions about balanced and unbalanced forces. Prompt students to describe and ask questions about forces that affect objects that are already moving. (*Moving objects can change direction and speed up or slow down if unbalanced forces are at work.*) Record selected questions on the board or chart paper to revisit after the reading.

3. Read and discuss: "A Force Is a Push or a Pull." 10 MIN

Student Reader

Ch. 1

Prepare to read together, or have students read independently, "A Force Is a Push or a Pull," Chapter 1 in the Student Reader. This chapter further explains that what students have observed in the teacher demonstration of Lesson 1 can cause changes in an object's motion.

Know the Science

1. When an object is at rest, are the forces acting on it balanced? Gravity is a force that pulls objects down to Earth. In the example of the ball, gravity pulls down on the ball. The desk, table, or floor are pushing up on the ball. (The atoms of the table resist, with an upward push, the downward push of the atoms of the ball.) Because these forces are equal, the ball is not moving. Whenever an object is at rest, the forces acting on it are balanced. This means that forces are acting equally on the object from different directions. The net force on the ball is zero. The object will remain at rest until one of the forces becomes stronger or weaker. When forces become unbalanced, the object will change motion and move.

Preview Core Vocabulary Terms

Before reading, write the following terms on the board or chart paper. Have students identify the words as they read. Stop and discuss the meaning of each term in context.

balanced forces	**gravity**	**unbalanced forces**
force	**motion**	

Focus on the word *balanced*. Discuss the meaning of the word, and have students demonstrate something in balance, showing that when things are in balance, they are not moving. Then ask students to consider these guiding questions as they read:

- What causes an object to experience unbalanced forces? (*One force is stronger than another force.*)
- What is the effect on an object that experiences unbalanced forces? (*It will move in the direction of the strongest force.*)

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 1

- What is a force? (*a push or a pull*) What evidence can be used to know that a force has acted on something? (*The object moves.*)

  SUPPORT—Remind students that *evidence* means details or clues that prove an idea.

  SUPPORT—If needed, revisit and discuss the sailing stones from Lesson 1. Ask students how they know that a force is acting on the stones. Lead them to the conclusion that even if we don't know what the causing force is, we know that movement of an object is evidence that a force has acted on it.

- What kind of forces are acting on or around you right now? (*gravity, pushes, and pulls*)

Pages 2–3

- What is the relationship between the force on an object and its motion? (*A force causes a change, so the object is moved by the force.*)
- Why does a ball sitting on the ground not move on its own? (*A ball that is on flat ground will not move unless a force greater than gravity is applied.*)

Page 4

- What is gravity? (*Gravity is a force that pulls everything to Earth.*)
- What evidence shows that gravity is a force acting upon everything on Earth? (*When an object is dropped, it always falls downward.*)

Pages 5–6

- What is a way to show that a force has direction? (*An object reacts to a push or a pull by moving away from or toward the force. The direction of gravity is a force that pulls all objects down.*)
- What is a way to show that a force has strength? (*When a ball is thrown with a lot of strength, it moves faster than a ball that is gently tossed.*)

4. Demonstrate examples and guide discussion. 10 MIN

Online Resources

Show a short video of a boys' and girls' soccer game.

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

- Ask students to describe the different forces that cause the ball to move forward, up, down, and backward. (*Kicking the ball moves it forward, but blocking the ball moves it backward. Hitting the ball with your head moves it up, down, or forward. Gravity makes the ball move down.*)

Return to the rubber ball example used earlier. Ask students to identify forces placed on the ball as either pushes or pulls. Demonstrate moving the rubber ball in one direction using a push. Have students write down the type of force you used. Move it in another direction using a pull. Have students write down the type of force you used.

- Drop the ball from various heights. Again, have students write down what type of force is evident. (*Gravity pulls the ball to the ground.*)
- If time permits, have students pass the ball around, instructing each one to move it using either a push or pull. If you do not have enough time, allow them to do this exercise during the following discussion.

Help students understand that in each of these cases, the forces acting on the ball are unbalanced. (See **Know the Science 2** for support.)

Ask guiding questions to help students link details in each example back to the earlier demonstration and reading selection. For example, ask: Is gravity a push or a pull force? How is a push force different from a pull force? What must happen, in terms of forces, for an object to move or change direction? (*The ball changes directions when the forces are not balanced, such as tossing the ball.*)

Know the Science

2. What makes a set of forces unbalanced? You know that when the sum of all forces acting on an object equals out, an object is said to experience balanced forces. A sheet of paper on a table has the forces of gravity and air pressure acting on it in a downward direction. The table pushes back with an equal amount of force in the opposite direction, and the sheet of paper does not move.

5. Teach Core Vocabulary. **5 MIN**

Prepare Core Vocabulary Cards

- Have students locate their cards for **force** and **motion**. Students can refer to these cards to support their Word Work for the new Core Vocabulary terms introduced in this lesson.
- Have students also prepare new Core Vocabulary cards for these terms by writing each term in the upper left corner of an index card and underlining it.

balanced forces **gravity** **unbalanced forces**

Word Work

- **balanced forces:** (n. a collection of forces acting on an object that cancel each other out and produce no change in the object's motion)
- **unbalanced forces:** (n. a collection of forces acting on an object that result in a change in the object's motion)

Instruct students to write one or two sentences explaining how the demonstration and examples help to show *balanced forces* and *unbalanced forces*.

When students have finished, have them share their sentences with the class. (*When an object's motion does not change, it experiences balanced forces. If the object's motion changes, it experiences unbalanced forces.*)

Ask students to draw an example of unbalanced forces to accompany their sentences.

- **gravity:** (n. a force that pulls objects toward Earth's surface) Instruct students to define *gravity* in their own words.

6. Check for understanding. **5 MIN**

Activity Pages

AP 2.1 and Answer Key

Formative Assessment Opportunity

- Have students summarize what they have learned about balanced and unbalanced forces. Ask guiding questions to help students link their learning to the reading they have done so far.
- Review student questions, and identify any that remain unanswered.
- Prompt students to express any new questions they may have and add them to the list. Discuss strategies for answering remaining questions.
- Have students complete Lesson 2 Check (AP 2.1). Collect the assessment, and check students' answers to identify students who need more support and concepts that need clarification.

LESSON 3

Investigating Forces

Big Question: How do forces affect the motion of objects?

At a Glance

Learning Objective

✓ Plan and conduct an investigation of the cause-and-effect relationships between balanced and unbalanced forces and the motion of objects.

Lesson Activities (2 days)

- student investigation
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS2.A: Forces and Motion

Disciplinary Core Idea PS2.B: Types of Interactions

Science and Engineering Practices: Planning and Carrying Out Investigations

Crosscutting Concept: Cause and Effect

In this two-day lesson, students will combine their background knowledge from Lessons 1 and 2 to **plan and carry out investigations** on balanced and unbalanced forces, using scientific questions to guide their activity.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in green below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 114–115 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

balanced forces	effect	**predict/prediction**	**unbalanced forces**
cause	pattern		

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green on the previous page.

Instructional Resources

Activity Pages

AP 3.1
AP 3.2

Activity Pages
Investigating Forces—Plan (AP 3.1)

Investigating Forces—Test (AP 3.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- rubber eraser (1 per student)
- rubber ball
- index cards for student vocabulary deck (1 per student)

The Core Lesson TWO DAYS, 45 MIN EACH

1. Day 1: Focus student attention on the Big Question. 15 MIN

How do forces affect the motion of objects? Have students place an eraser on a flat surface and apply push and pull forces to the eraser. Ask them which direction the eraser moved in each instance. Have them tell if the forces acting on the eraser were balanced or unbalanced when the eraser was **at rest** and when it was in **motion**. Have students sketch the direction of the forces with arrows. Explain that a force is a **cause** and the movement of an object is the **effect**.

- Invite students to consider questions about balanced and unbalanced forces and motion. Ask students if every object in motion has a force acting on it. (*No. An object in motion does not have a force acting on it unless its motion is changing in some way.*)

2. Encourage discussion. 10 MIN

Activity Page

AP 3.1

- Distribute and review Investigating Forces—Plan (AP 3.1). Inform students that they will develop a class-written scientific question that will be the basis of their investigation. The question they come up with should be more specific than the lesson's Big Question. An example question is *What happens when two forces push and pull on an object in the same direction?*

3. Encourage student questions. 20 MIN

- Discuss with students how to ask scientific questions. When asking scientific questions, students should determine what is known and what is to be answered. Explain that sometimes scientists predict the answers of their investigation. Allow students to predict the investigation outcome and results. (See **Know the Science** for support for this discussion.)
- Separate students into small groups. Discuss with students the importance of group roles and making sure that each student has a chance to participate in the investigation, as well as a chance to be the recorder or observer.
- Give each group time to complete their plans and make a prediction, completing Investigating Forces—Plan (AP 3.1). Guide students to select materials that can be safely manipulated with balanced and unbalanced forces.
- Explain that because students will carry out their plan, they will need to pick a small, safe object to use in their investigation.
- Remind students that their predictions should be based on patterns they have seen in the demonstrations or activities in the previous two lessons.
- Students should be able to discuss two aspects of any force: its strength and its direction.

Know the Science

What is a prediction? *An educated guess.* A prediction is an educated guess about what will happen in the future and is based on something that has already happened or is happening now. A prediction may not always be correct, but a prediction may be right if a pattern is recognized. When making predictions, scientists look at patterns. If every part of the pattern is the same, it will likely repeat itself. For example, if you throw a piece of wood in the water and it always floats, then the wood floating is a pattern. You can predict that similar pieces of wood thrown into the water will also float. Even though you may predict this to be true, you still have to test your ideas to find out if your predictions are accurate. For instance, some kinds of wood will actually sink.

Scientists use patterns to help them make predictions. They test their educated guesses to see if they are correct. Scientists record the data and share their results with other scientists. Others can then also conduct the same investigation to see if the same results occur again. This process of reproducing investigations and results is central to the nature of science as a human endeavor.

1. Day 2: Focus student attention on the Big Question. 5 MIN

Activity Pages

AP 3.1
AP 3.2

How do forces affect the motion of objects?

- Have students review their work on Investigating Forces—Plan (AP 3.1). Explain that they will now carry out their investigation.
- Distribute and review Investigating Forces—Test (AP 3.2), and introduce the instructions and prompts that each student will answer.

Preview Core Vocabulary

Write **predict** on the board or chart paper. Encourage students to pay special attention to this term as they complete the investigation.

2. Preview the investigations. 15 MIN

- Ask students to divide themselves into the same small groups as Day 1. Have the groups organize their materials and carry out their investigations. To do this, they should use the small, safe objects they selected the previous day.
- Circulate among the groups, observing balanced and unbalanced forces and their effects on the motion of objects, and answer any questions the students may have.

  SUPPORT—Students may wonder about how to create balanced or unbalanced forces using the materials they selected.
- Explain that sometimes students might want to repeat an investigation several times to answer the question.
- After the tests are completed and their responses on Investigating Forces—Test (AP 3.1) are finished, have students do the following:
  - Select another group to partner with, and trade investigation plans.

    SUPPORT—If time permits, ask students to study the plan of their partner group, and prompt them to ask any questions about how and why the other group designed their investigation in that way.
  - Carry out the other team's investigation.

3. Support the investigations. 10 MIN

- Once students have had the chance to conduct their investigations, bring the class back together, and discuss the observations they made. Within the discussion, have students compare each team's results for consistency.
- Have students make claims about their observations and support them with evidence. Claims should link back to the questions that students investigated. They should also return to their predictions, discuss whether they were correct, and why.

4. Summarize and discuss. 5 MIN

Use the results of the investigations to reinforce in students' minds how balanced and unbalanced forces work on objects to

1. keep them at rest,
2. make them start to move,
3. change the direction of their movement, and/or
4. speed up or slow down the object.

The goal of this discussion is to return to the Lesson 2 objective in which students are expected to compare the effects of balanced and unbalanced forces on an object's motion.

- Ask questions that prompt students to consider how pushes and pulls affected how the objects moved. For example:
  - » What direction did an object move when pushed? (*An object moves in the direction that it was pushed, away from the push.*)
  - » Did the object move in the same direction when it was pulled? (*No, a pull moves an object closer rather than away.*)
  - » What happened when two or more equal forces were applied in opposite directions? (*The object does not move if the push and pull forces are the same.*)
  - » What different kinds of motion happened when multiple forces were applied in different directions? (*The direction of motion changes with each bump or when a stronger force cancels out a lighter force.*)

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Card

Direct student attention to the Core Vocabulary word (displayed on the board or chart paper earlier in the lesson). Have students write the term in the upper left corner of an index card and underline it.

predict

Word Work

- **predict:** (v. to say that something is expected to happen) Have students locate their card for the Core Vocabulary term *predict*. Ask students to write on the card two sentences using the word *predict*. The first sentence should use the word *predict* in a scientific way, and the second sentence should use the word *predict* in a nonscientific way.

SUPPORT—Examples of sentences include, "I predict that the forces will be unbalanced," and "I predict the game will be fun." Provide students with examples to encourage them to construct their own sentences.

- Point out to students that the sentences in which they predict things are called *predictions*.

6. Check for understanding. 5 MIN

Activity Pages

AP 3.2 and Answer Key

Formative Assessment Opportunity

- Review student questions asked across this lesson, and identify any that remain unanswered.
- Review students' results on Investigating Forces—Test (AP 3.2) to determine student understanding of the following concepts:
  - » An object experiencing balanced forces does not move.
  - » An object experiencing unbalanced forces moves.
- Have students summarize what they have learned about balanced and unbalanced forces, asking them to consider, as a whole class, an answer to the Big Question: *How do forces affect the motion of objects?* Prompt them to use the results of their investigations as evidence.
- Record student answers to the Big Question on the board. Ask students to explain the following concepts.
  - » What is a force? (*A force is a push or a pull.*)
  - » How do balanced forces affect objects that are at rest? (*There is no movement of the object, so it stays at rest.*)
  - » How do unbalanced forces affect the speed and direction of objects that are in motion? (*Objects in motion go faster or farther in the same direction as the stronger force.*)
- Prompt students to express any new questions they may have and add them to the list. Discuss strategies for answering remaining questions.

See the Activity Page Answer Key for correct answers and sample student responses.

PART B

Friction Is a Force

Overview

Lesson	Big Question	Advance Preparation
4. Investigating Friction (2 days)	How does the force of friction affect motion?	Gather materials for teacher demonstration and hands-on investigation. (See Materials and Equipment, page 11.)
5. Friction Is a Force	What are the characteristics of the force called friction?	Read Chapter 2 in the Student Reader.

Part B: What's the Story?

Friction is a force that exists between two surfaces in contact with one another. Friction can be an engaging concept for students to explore because they can observe, firsthand, evidence of friction and its effect on an object's motion. Children who slide down slides, push heavy objects across a floor, and even perform sports activities all are interacting with the force of friction. This section introduces students to friction as a force, which, if they pay close attention to what is happening around them, they will recognize as a very common and important force in their everyday lives.

In Lesson 4, students begin with a demonstration and start a hands-on investigation of friction that occurs over two days. The objective is for students to understand that friction occurs when the surfaces of objects are in contact with one another. Students identify that friction is a force that opposes motion. It may also oppose potential motion. Friction may be acting on an object to keep it at rest. Students use a variety of materials, such as sandpaper, felt, and aluminum foil, to investigate the effects of different surfaces on the friction forces that occur when two objects come in contact with one another. Students also extend their previous learning about balanced and unbalanced forces. For example, an object sitting still on an incline, at rest, experiences the balanced forces of friction and gravity. The frictional force opposes potential motion. As the ramp is lifted, the forces become unbalanced, and motion occurs.

In Lesson 5, students are introduced to other characteristics of friction forces. The goal is for students to recognize ways in which friction can be helpful or harmful to people. We are purposefully using these terms *harmful* and *helpful* to support students as they make connections between friction and the role it plays in everyday life.

So, to repeat, **friction is a force that opposes motion and potential motion**. Help your students grasp this concept, and you will lay the groundwork for meeting the NGSS expectations addressed in later parts of this unit, such as making predictions about the future motion of an object.

Although the force of friction is not directly referenced by the Next Generation Science Standards for Grade 3, it is an important part of both Disciplinary Core Ideas PS2.A and PS2.B that are part of the NGSS Topic 3 **Forces and Interactions**.

LESSON 4

Investigating Friction

Big Question: How does the force of friction affect motion?

At a Glance

Learning Objective

✓ Investigate the effects of friction on an object's motion.

Lesson Activities (2 days)

- teacher demonstration
- student observation and investigation
- discussion
- writing
- vocabulary instruction

NGSS References

Disciplinary Core Ideas:

PS2.A: Forces and Motion

PS2.B: Types of Interactions

PS3.D: Energy in Everyday Life

Science and Engineering Practices: Planning and Carrying Out Investigations

Crosscutting Concept: Cause and Effect

Students continue to explore and identify cause-and-effect relationships during this two-day lesson. They will identify variables and use evidence to explain the effects on the forces observed throughout the lesson.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in green below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 114–115 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

contact force **friction** **lubricant** surface

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards, which will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green on the previous page.

Instructional Resources

Activity Page

AP 4.1

Activity Page
Table Hockey (AP 4.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following:

- materials to create two ramps, such as:
    - books
    - blocks
    - clipboards
    - cardboard
- sandpaper (enough to cover each ramp)
- scissors
- glue
- block (wooden or plastic)
- oil (cooking, such as vegetable oil)
- paper towels or rags/cloths (for cleanup)

One of the following for each group of students:

- baking sheet pan
- large piece of felt (large enough to cover the bottom of the baking sheet)
- large piece of aluminum foil (large enough to cover the bottom of the baking sheet)
- large piece of sandpaper (large enough to cover the bottom of the baking sheet)
- plastic cup (for the oil)
- bottle cap (such as those for milk jugs)
- sand (to fill each bottle cap)

- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Prepare Demonstration Materials

1. Build two ramps using books, blocks, clipboards, or cardboard (or any other materials). The ramps should be equal distance/length and height.
2. Cut a strip of sandpaper that is the length of the ramp. Tape or glue the sandpaper to Ramp #2.
3. Have the block, oil, and paper towels nearby to use during the demonstration.

Prepare Hands-On Materials

1. Pour the oil into plastic cups that each group will use at their stations.
2. Precut the felt, aluminum foil, and sandpaper to fit, and cover the inside of the baking sheet pans.

The Core Lesson Two days, 45 min each

1. Day 1: Focus student attention on the Big Question. 10 min

How does the force of friction affect motion? Start by asking a question about the everyday phenomenon of friction to establish a sense of familiarity, such as the following:

» How many of you have ever been skiing, ice skating, or sledding? (*Students may raise their hands or tell their stories.*)

» Was it easy to slide on a smooth surface? (*A smooth surface makes sliding easier.*)

» What happened when you slid on a rougher surface? (*It was harder to slide.*) Did it make you not be able to glide as smoothly? (*Yes, and sometimes a rough surface is too bumpy to slide at all.*)

- Tell students that friction is a type of force that occurs when the surfaces of two objects are in contact with one another (students will have a chance to learn more about, and define, friction later in the lesson). A lot of friction makes it difficult for an object—like a sled—to move across a surface. Too little friction between surfaces can make it difficult to move too, such as oil on a floor that causes a person to slip and slide.

Online Resources

- Show a video of a person sliding on ice. (See the Online Resources Guide for a link to a suggested video.) Invite students to consider questions about friction. (See **Know the Science 1** for support.) Record selected questions on the board or chart paper. Prompt students to think about ways they can investigate to find answers to the questions.

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Know the Science

1. Friction, like all forces, acts in specific directions. For example, when a bicycle is pedaled forward, a force of friction resists the movement of the wheel and propels the bike forward as the wheel rubs against the ground. Important note for instruction: It is not expected that Grade 3 students identify the direction of frictional forces. Research has indicated that college-level and adult students often maintain persistent misconceptions about the direction of frictional forces, which require careful instruction to overcome. Keep the objectives of this lesson and Lesson 5 in mind as you support students: to identify and investigate friction as a force that opposes motion in relative terms.

2. Demonstrate examples and guide discussion. **20 MIN**

The goal of this demonstration is to show how friction is a force that occurs when the surfaces of two objects are in contact with one another.

- Begin the demonstration. Place a block at the top of Ramp #1 (without the sandpaper), and gently push it until it slides down the ramp. Ask students to observe what happened using the following guiding questions:
  - » Was it easy or hard for the block to slide down the ramp? What kind of force did I use to start the block moving? (*A push started the block moving, but gravity kept it going down the ramp.*)
  - » What did you notice about the block and ramp? Were they touching?
- Perform the demonstration again, this time showing them what happens when you increase friction by changing a surface. Place the block at the top of Ramp #2 (with sandpaper), and gently push it down the ramp. The block might get stuck on its way down. If this happens, allow it to stay stuck. Ask students what they observed:
  - » Did the block move fast or slow down this ramp? (*The block moved slowly on the sandpaper.*)
  - » Did the block go down the ramp easily, or was it hard to go down the ramp? (*It did not move as easily as it did on the first ramp.*)
  - » What was changed between the first ramp and the second ramp? (*One is a smooth surface, but the other is a rough surface.*)
- Perform the demonstration again, but raise the ramp to be higher, creating a steeper slope. Explain to students that, as the ramp is raised at one end to become steeper, we can observe the relationship between the force of gravity and the force of friction acting on the block at the same time. The force of gravity has to overcome the force of friction if we want to get the block to move down the ramp.
  - ◦ Prompt students to think about how this relates to balanced and unbalanced forces. If there are two equal forces (gravity and friction) acting on the block, then the forces are balanced. When the force of gravity overcomes the force of friction (when the slope of the ramp is steeper), then the forces become unbalanced, and the block begins to move.
- Reset the demonstration by lubricating Ramp #1 with oil. (This might get messy, so consider using a baking sheet pan under the ramp to catch the oil that drips down, and have paper towels or rags/cloths nearby.) Place the block at the top of Ramp #1, and gently push it until it slides down the ramp. The block should slide more quickly down the ramp because of the lubricant. Discuss why this is an example of unbalanced forces. (*The block's motion was changed by different circumstances.*) Ask students what they observed:
  - » What happened to the block this time? (*It moved farther.*)
  - » Did it go down the ramp more quickly or more slowly? (*more quickly*)
  - » Why do you think the block moved more quickly? What happened to the surface of the ramp? (*The block moved faster because the ramp was oily.*)
- Students should start to understand that friction and lubrication impact how well objects can move across a surface.

3. Encourage student questions. 10 MIN

- Prompt students to ask questions and to answer others' questions regarding the different ramp surfaces and their effects on the different kinds of objects.
- Draw attention to similar comments or questions about how adding the sandpaper slowed or stopped the motion of the block. Relate this observation to something that students may have experienced in real life, such as the following:
  - » going down a slide (*Too much friction may stop you on the slide.*)
  - » pushing a box across a floor (*You may want to use a wheeled cart to reduce the friction and make pushing the box easier.*)
  - » using an eraser (*Friction between the eraser and the paper is helpful to erase pencil writing.*)

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Have students write each term in the upper left corner of an index card and underline it.

friction **lubricant**

Word Work

- **friction:** (n. a force that occurs between the surfaces of two objects that are touching) Ask students to share what they think *friction* means based on the demonstration of the ramps, affirming correct explanations and adjusting misconceptions. Friction opposes motion, but it also opposes potential motion—a motion that would occur if friction were not present. Have students write this definition on their cards: *There is a force of friction on a block on a ramp even when the block is not moving.*

  SUPPORT—Point out that *friction* is a type of force. This force requires surfaces to be in contact. Explain that two surfaces in contact can result in a lot of friction, or there can be little friction between the two surfaces depending on the surfaces that are in contact. Have students write on their cards a sentence using the word *friction*. (*Example: There is not much friction when a sled slides over snow.*)

- Direct student attention to the following vocabulary terms: *force, contact, lubricant, surface*
    - Ask students to share what they think these words mean at this point, using examples to help them explain their thinking. They should already be familiar with the term *force*, so affirm understanding of its meaning.
- **lubricant:** (n. a substance that reduces friction between objects in contact)
    - Tell students that a lubricant is a substance that reduces friction between objects in contact, such as the oil used on the ramp during the earlier demonstration. A lubricant helps make the surface of something slicker to reduce friction and let objects move more smoothly as they rub against each other. (Students will add more to their Core Vocabulary term for this card in the next lesson.)
    - Remind students that *contact* means touching. Objects are in contact if they touch each other.
    - Ask students to identify examples of different kinds of surfaces.

        SUPPORT—Students may think that friction only occurs between solid objects and surfaces. In fact, friction also occurs when liquids or solids rub against each other. This is known as *drag*. Vehicles with smoother surfaces, swim caps on swimmers, and smooth helmets on bike riders are all done to reduce the amount of drag, or friction, between the surface and the air or water.

5. Day 2: Support the investigation. 40 MIN

Activity Page

AP 4.1

- Divide students into small groups to investigate how friction affects the motion of an object. Explain that in this hands-on activity, each group will play a game of table hockey to observe how friction changes the way a hockey puck glides across different types of surfaces.
- Distribute and review Table Hockey (AP 4.1). Model for students how they will complete this Activity Page during their activity, paying attention to the tables. Explain that they will do the following:
    - carry out an investigation to learn about friction
    - notice which surfaces and materials make the "hockey pucks" move most freely and smoothly
    - record their observations
- Make sure to leave time at the end of class for students to answer the questions at the end of their Activity Page.
- If time allows, ask one or two volunteers to share their thinking about how they might answer the first set of questions on Table Hockey (AP 4.1) page 2. Engage the whole class as they think about evidence that can be used to support their written responses to the questions.

- As students conduct the activity, remind them to think about cause and effect. (See **Know the Science 2** for additional support.) Ask students the following guiding questions:
  » What caused the hockey puck to get stuck in the pan?
  » What was the result of adding oil into the pan?
- Next, have students use their observations to write or say a sentence that describes the cause-and-effect relationship of friction. Encourage students to practice using the phrase, "The __________ caused__________." For example:
  » The friction between the pan surface and the hockey puck surface caused the hockey puck to slow down.
  » The lubricant (oil) caused the hockey puck to move more easily across the pan.

6. Check for understanding. 5 MIN

Activity Page

AP 4.1 and Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

- Review student questions, and identify any that remain unanswered.
- Have students summarize what they have learned about friction, asking them to answer the Big Question: How does the force of friction affect motion?
- Record answers to the Big Question on the board or chart paper. Ask students to explain the following concepts:
  » what friction is
  » the cause-and-effect relationship between different types of surfaces and the amount of friction observed

  SUPPORT—If time allows, ask students to add examples or drawings to their Core Vocabulary card for the term *friction* to help them remember how different types of surfaces coming into contact can affect motion.
- Prompt students to express any new questions they may have and add them to the list. Discuss strategies for answering remaining questions.

Know the Science

2. What are cause-and-effect relationships? *When one event is the result of another.* Cause-and-effect relationships are routinely identified, tested, and used to explain change in science. Scientists and engineers often look at cause-and-effect relationships like this to construct explanations about why certain things happen.

Students experience examples of cause-and-effect relationships during the activity. Remind students of these changes. The surface materials changed how the hockey puck moved across the pan:

- Some surface materials caused the hockey puck to slow down quickly.
- Other surface materials caused the hockey puck to slow down much more slowly.

LESSON 5

Friction Is a Force

Big Question: What are the characteristics of the force called friction?

At a Glance

Learning Objectives

✓ Identify and describe examples of friction.

✓ Compare examples of helpful and harmful friction in daily life.

✓ Describe the characteristics of friction as a force.

Lesson Activities

- teacher demonstration
- student demonstration
- reading
- discussion
- writing
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS2.A: Forces and Motion

Crosscutting Concept: Patterns

Patterns will be explored during this lesson as students read about and discuss friction. Students will learn about the characteristics of friction in order to tell how objects move or stop as a result of forces.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in green below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 114–115 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

contact force **friction** **lubricant** **oppose**
surface

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green above.

Instructional Resources

Student Reader

Ch. 2

Activity Pages

AP 5.1
AP 5.1

Student Reader, Chapter 2
"Friction Is a Force"

Activity Pages
Friction Finder (AP 5.1)

Lesson 5 Check (AP 5.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- eraser
- pencil
- paper
- sticky notes
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

What are the characteristics of the force called friction? Open the lesson with a hands-on demonstration/activity of friction based on an example from the Student Reader.

- Have students place their hands on their cheeks. Tell them to notice that their hands may feel cool.
- Model for students how to safely rub their hands together, and then ask students to vigorously rub their hands together.
- After a minute or so, have students place their hands back on their cheeks.
- Ask how their hands feel now! Students should note that their hands are warm. Explain that the heat that results is from the two surfaces rubbing and that a force called friction must be overcome to let the surfaces rub against each other. The movement of each surface is opposed by the force of friction. Friction opposes the motion of each hand as they slide across one another. The motion energy of each hand can only result when friction is overcome. As each hand slides in contact with the other, motion energy is converted to heat energy.
- Could you warm your hands the same way if each hand were covered with a slippery lotion? Why or why not?
- Introduce to students the definition of *friction*: it is a force that opposes movement when two surfaces are in contact.

2. Demonstrate examples and guide discussion. 5 min

- Discuss where we can observe evidence of friction in the classroom. For example, a drawer that opens easily may have less friction than a drawer that is hard to open. A floor that is slippery has less friction than a carpeted floor. Ask students to identify, in each case, the two surfaces in contact with each other.

Activity Page

AP 5.1

- Distribute and review Friction Finder (AP 5.1). Let students know they will be looking at and thinking about everyday examples of friction that they interact with and use all the time. They will be doing this to answer the question, "What are examples of the force of friction?" In each case, ask them, "How is the movement resisted by the force of friction?" Then, have them complete the Activity Page.

    SUPPORT—You may need to clarify the term *resist* for students to help them understand its meaning and context related to friction. Model the term *resist* in a variety of contexts to support this, such as, "When I push against a stuck door, the door resists my force."

- Lead a discussion about the examples students recorded on their Activity Page. Encourage students to ask questions, and ask for volunteers to help answer each other's questions about friction. Draw attention to similar examples that different students have identified, such as braking on a bicycle, going down a slide, or roller skating. In every case, have students describe the surfaces that are in contact as well as the motion that is opposed by the force of friction.

    SUPPORT—If needed, help students use terms such as *rough*, *smooth*, *bumpy*, *slick*, etc. to describe the surfaces of objects. Terms such as *faster*, *slower*, *quick*, etc. may also help students to describe changes in motion caused by the force of friction.

- Have students think about their examples of friction. Ask the following:
    - » What does each surface feel like? (*Some are smooth, and some are rough.*)
    - » How would you describe the speed each object could move across a surface? (*Objects that move slow are on rough surfaces, and objects that move fast are on smooth surfaces.*)
    - » What pattern do you see from your examples? (*Smooth surfaces result in less friction, and rougher surfaces result in more friction.*)

Online Resources

To finish the discussion and prime students' thinking ahead of reading Chapter 2 in the Student Reader, display an image/video of a student sitting still on the slope of an outdoor slide. (A suggested image is linked within the Online Resources Guide for this unit.)

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Ask students to determine whether they agree or disagree with this claim/statement:

"Friction is not acting on this student because she is not moving."

Record student answers by tallying the number of agreements versus disagreements or by creating a T-chart where students place sticky notes either in an Agree column or a Disagree column.

3. Read and discuss: "Friction Is a Force." 15 MIN

Student Reader

Ch. 2

Prepare to read together, or have students read independently, "Friction Is a Force," Chapter 2 in the Student Reader. The selection reiterates what students investigated and observed in the previous lesson about friction. The chapter also reveals the characteristics of the force of friction, including that it can be either a useful or a harmful force depending on the scenario. It presents several examples of ways that friction is used in everyday life.

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read.

contact force **friction** **lubricant** **oppose**

Guided Reading Support

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 7 After reading, have students describe a time they slipped and fell. Have them describe that event in terms of the forces of friction that were involved. Ask: What is friction? Encourage students to use their own words to describe it.

Page 8 Prompt students to think about the advantages and disadvantages of carpeting. Ask: Would it be easier to move a couch across carpet or a smooth floor? Why? (*A couch would be more easily moved against a smooth floor because there is less friction to stop the motion of the couch.*)

SUPPORT—If needed, prompt students to think about words that describe smooth surfaces and words that describe rough surfaces.

Page 9 Prompt students to recall what they know about balanced and unbalanced forces. Remind them that they learned about balanced and unbalanced forces in Lesson 2. Ask students to think about how friction relates to balanced and unbalanced forces in different situations. See if students can come up with examples not provided in the Student Reader.

Page 10 Discuss with students that starting a fire with sticks takes a long time and that not everyone knows how to do it. Today, there are easier ways to start fires. Ask: How is friction involved when someone strikes a match to start a fire in a fireplace?

SUPPORT—If needed, ask students what the surface of the match would need to be like. Would it need to be rough or smooth to cause enough friction?

Page 11 Ask students to think about some ways friction is helpful and harmful to them. Encourage students to think of examples not presented in the Student Reader.

Page 12 Ask students to think of other examples of the force called friction at work in our everyday lives.

SUPPORT—If needed, have students return to Friction Finder (AP 5.1), to help generate additional examples. If time allows, prompt students to write their new examples in the corresponding places on the Activity Page.

4. Demonstrate examples and guide discussions. 10 MIN

Choose one of the following, or a similar example, to stimulate further discussion about friction. (If time permits, use more than one example to help students connect friction to their everyday lives.) Support students as they identify and analyze 1) how friction occurs in the example; 2) what causes the friction and how it affects the motion of the objects; and 3) whether the friction is helpful or harmful.

- Use an eraser to erase pencil marks on a piece of paper.
  - » What surfaces are involved? (*The paper has a smooth surface, and the eraser has a surface that slightly comes apart when it is rubbed.*)
  - » What movements are opposed by the force of friction? (*It's hard to keep the paper flat when rubbing the eraser back and forth.*)

Online Resources

- Show a video of different types of friction. (See the Online Resources Guide for this unit for a link to a suggested video.)

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Ask what examples of friction students can observe in the video:

- » What were some examples of friction from the video?
- » What surfaces are involved?
- » What movements are opposed by the force of friction?
- » Were these uses of friction helpful or harmful? Why?

- Use additional guiding questions to help students link details in this discussion back to the Activity Page and to the reading selection:
  - » Did you write any examples of friction in the Activity Page that are like the pencil eraser?
  - » How are these examples similar?
  - » Did you write any examples of friction in the Activity Page that are like the types of friction discussed in the video?
  - » How are these examples similar?

Now that students have read Chapter 2 about friction, return to the video and the claim that "When a student sits at rest (still) on a slide, friction is not acting on this student because she is not moving."

- ◦ Ask students to reconsider whether they agree or disagree with this claim.
- ◦ Prompt students to share their thinking about why they now agree or disagree with the statement.

SUPPORT—Ask students to review page 9 of the Student Reader. Support students as they use evidence from the text to support their agreement or disagreement with the claim.

- Students should come to understand that, even when forces are balanced and motion does not change, friction is likely one of the forces keeping the object from changing/moving.

5. Teach Core Vocabulary. 5 MIN

Preapare Core Vocabulary Cards

- If time allows, have students return to their Core Vocabulary card for **friction**, created during Lesson 4. Ask students to add a sentence or drawing that represents their understanding that friction applies a push even when no movement is observed.
- Have students locate their card for the Core Vocabulary term **lubricant**. Ask students to write a sentence in the card using the words *friction* and *lubricant*. Ask them to share their sentence with the class. Have students add a simple drawing of friction acting on an object. The drawing can be of a sled sliding down a snowy hill or a kid getting stuck on a slide.
- Instruct students to prepare new cards for the following Core Vocabulary terms.

contact force **oppose**

Word Work

- **contact force:** (n. a push or pull between two objects that are touching each other) Instruct students to write on the card an example of a contact force they can presently observe in the classroom.
- **oppose:** (v. to work against) Have students draw arrows to represent two forces that oppose each other.

6. Check for understanding. 5 MIN

Formative Assessment Opportunity

- Review student questions, and identify any that remain unanswered.
- Have students summarize what they have learned about friction, asking them to consider the Big Question: **What are the characteristics of the force called friction?** Have them use information from the Student Reader as evidence.
- Distribute and review Lesson 5 Check (AP 5.2), and ask students to complete it independently. Once finished, collect the assessment. Before the start of Lesson 6, check students' answers to identify concepts that need further clarification, and provide the support needed. See the Activity Page Answer Key for correct answers and sample student responses.

Activity Pages

AP 5.2 and Answer Key

PART C

Predicting Motion

Overview

Lesson	Big Question	Advance Preparation
6. Predicting Patterns of Motion (2 days)	Can we predict the motion of an object that moves in regular patterns?	Read Chapter 3 in the Student Reader. Gather materials for the hands-on investigation. (See Materials and Equipment, page 11.)

Part C: What's the Story?

Motion can be predicted when a prediction is based on patterns of past movement and an understanding of forces that are acting on a system. In previous lessons, students have already learned about examples of forces. In Lesson 2, students learned about pushes and pulls, as well as how to identify the effects of balanced and unbalanced forces. The purpose of the two-day experience in Lesson 6 is to introduce examples of regular patterns of motion and to allow students to experience patterns for themselves. This will help to build their understanding of the kinds of data that can be recorded about patterns and motion, and help them to predict future motion.

In Lesson 6, students develop their capacity to predict motion across two days of instruction. On the first day, students are provided with a model investigation and examples of using evidence and making predictions to explain motion. Students also read about regular patterns in the motion of an object, such as swinging and playing on a seesaw.

On the second day of Lesson 6, students carry out their own investigations in which they collect data. The students use their evidence to make predictions about an object's motion. Students are also asked to explain their predictions by citing support from other examples or outside sources.

Although students may intuitively understand what patterns are, the goal here is to make a connection between 1) identifying patterns of motion, 2) collecting evidence of those patterns, and 3) using the patterns and evidence to make a prediction. Students will satisfy the NGSS Performance Expectation 3-PS2-2 by carrying out investigations that a pattern can be used to predict motion. We purposefully stick to clearly defined terms, such as *patterns*, and do not include more technical terms such as *period* and *frequency*, which will appear in later grades.

LESSON 6

Predicting Patterns of Motion

Big Question: Can we predict the motion of an object that moves in regular patterns?

At a Glance

Learning Objectives

✓ Describe patterns in the motion of an object.

✓ Describe regular patterns in an object's motion and use data to predict future motion.

Lesson Activities (2 days)

- teacher demonstration
- student investigation
- reading, writing
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS2.A: Forces and Motion

Science and Engineering Practice: Planning and Carrying Out Investigations

Crosscutting Concept: Patterns

Pay special attention to the Science and Engineering Practice of **Planning and Carrying Out Investigations**. In a busy classroom, we often use reading and demonstration to teach the facts associated with this Science and Engineering Practice, but to satisfy the Performance Expectation, students must have the opportunity to plan and carry out an investigation for themselves in this two-day lesson.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in green below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 114–115 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

direction	motion	**predict/prediction**	push
force	**pattern**	pull	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green on the previous page.

Instructional Resources

Student Reader

Ch. 3

Activity Page

AP 6.1

Student Reader, Chapter 3
"Predicting Patterns of Motion"

Activity Page
Forces and Patterns (AP 6.1)

Materials and Equipment

Collect or prepare the following items:

- image of grandfather clock
- pencils or crayons
- string
- scissors
- yo-yo
- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/videos for whole-class viewing

THE CORE LESSON   TWO DAYS, 45 MIN EACH

1. Day 1: Focus student attention on the Big Question. 10 MIN

Can we predict the motion of an object that moves in regular patterns? To better help students understand the question, engage in a discussion about what they learned in the previous lessons about forces and motion.

- When objects are at rest, the forces acting on them are balanced.
- When objects change motion, that is, they change speed or direction, the forces acting on them are unbalanced.
- Gravity is a force that pulls objects toward Earth's surface.
- Friction is a force that happens when the surfaces of objects move against each other.
- Invite students to consider examples about repeating patterns of motion. Record selected examples on the board or chart paper. Prompt students to think about ways they can investigate to find answers to the questions about regular motion patterns.

Online Resources

Show a video of a pendulum. (See the Online Resources for a link to a suggested video.) Tell students that in today's session, they will all get a chance to make a pendulum and watch it swing.

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

2. Demonstrate examples and guide discussion. 5 MIN

Explain to students that when scientists conduct investigations, they make observations and record data. Patterns can be found in shapes, cycles of seasons, Earth processes, the symmetry of flowers, and the movement of planets. Many kinds of motion can form patterns too. Patterns intrigue scientists, who ask questions about the pattern and plan investigations for exploring the reasons why patterns exist.

Discuss examples of patterns that result from forces, such as the following:

- If a force pushes an object from one direction, the object will move in the opposite direction.
- If a force pulls something from one direction, the object will move in the same direction.
- On Earth, gravity pulls objects down toward the ground.
- Friction opposes motion.

3. Preview the investigation. 5 MIN

Activity Page

AP 6.1

- Distribute and review Forces and Patterns (AP 6.1). Inform students that they will make observations and record data to describe what patterns exist in a moving pendulum.
- Explain that the data they record is known as evidence. Evidence helps to determine whether something is true or untrue. Here, the evidence helps determine a pattern. As part of the activity, students will do the following:
    - » make a prediction
    - » conduct an investigation
    - » record observations
    - » assess whether their predictions are accurate

4. Demonstrate an example. 10 MIN

- Show students how to make a pendulum. Take a string about seven inches long, and tie one end around a pencil. Then lift the string from the other end so that the pencil is dangling about an inch off a surface. Swing the pendulum lightly. (See **Know the Science** for support with the demonstration.)
- Provide each student with string and scissors, and make sure they all have pencils or another object they can tie the string around.

Know the Science

What forces are acting on a moving pendulum? *Gravity and friction.* There are several forces that act on a pendulum bob, the mass at the end of a pendulum arm or string. Once some force starts the pendulum moving back and forth, gravity pulls the pendulum bob down toward Earth. As the bob moves through the air, friction between air molecules and the bob occurs.

5. Encourage discussion. 15 MIN

Activity Page

AP 6.1

- Tell students that they will be investigating the interaction of forces and motion through the use of a pendulum. Separate students into pairs. Give each pair time to carry out their activities and to complete Forces and Patterns (AP 6.1). Remind them that their prediction should be based on any patterns they identified during the teacher demonstration.
- Then have each student trade off swinging the pendulum while the other measures and records its movement.

  SUPPORT—As students work on their investigations, remind them that there are different factors that can affect when the pendulum stops. For instance, they may need to make their strings shorter or longer. Remind students that they can remake their pendulums if they need to, and make sure students have enough string as you circulate around the room.

1. Day 2: Focus student attention on the Big Question. 5 MIN

Activity Page

AP 6.1

Can we predict the motion of an object that moves in regular patterns? Have students pull out their work on Forces and Patterns (AP 6.1) and give it a reread. Have them keep what they learned the previous day in mind as they continue their study of motion and patterns.

- Ask students to suggest and demonstrate with their hands or a pencil different patterns of motion as you make a class list, for example: up and down, back and forth, around, side to side. Explain that these are all patterns of motion.
- Invite students to consider questions about motion and patterns. Prompt students to think about the type of patterns that can result from specific types of forces acting on them. Mention the force of gravity affecting the orbits of planets and comets. If necessary, return to the examples of the previous day. Record selected questions on the board or chart paper to revisit after the reading.

2. Read and discuss: "Predicting Patterns of Motion." 15 MIN

Student Reader

Ch. 3

Prepare to read together, or have students read independently, "Predicting Patterns of Motion," Chapter 3 in the Student Reader. The selection explains what students have observed in their activities of the day before: forces acting on objects often cause patterns in those objects' motion, or movement.

Preview Core Vocabulary Terms

Before reading, write the following terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

pattern **predict/prediction**

Guided Reading Support

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Pages 13–14 After reading, ask: What forces act on a swing? (*gravity and friction*) What direction is the girl on the swing moving, or is she moving? (*She is moving back and forth and also up and down.*) Then ask if students can predict the movement if the forces continue to act on the swing. Can they predict future movement from the current pattern? (*The pattern will continue if the girl keeps using her muscles to swing. If she stops helping the motion, the motion becomes less and less until the swing stops.*)

Page 15 After reading, ask: What forces are acting on the seesaw? (*gravity and pushing*)

SUPPORT—If needed, remind students that gravity is the force that pulls matter down toward Earth. Even if the kids in the picture are using their legs to push themselves into the air on the seesaw, gravity is still at work. The force of the push needs to overcome the force of gravity in order for the kids to go up on their side of the seesaw. Then, gravity pulls them back down again.

Pages 16–17 Remind students that they saw a picture of an old clock with a pendulum in the previous class session. After reading, prompt students to think about the direction that the pendulum is moving. Have them think back to the pendulum that they made and the direction that pendulum moved. Ask: Can you predict future movement from the current pattern? (*The pendulum will continue to move back and forth until it is stopped or needs to be wound up.*)

Draw student attention to the word *regular* in the Student Reader.

SUPPORT—If needed, discuss with students that when patterns repeat themselves over and over again, it is considered regular motion. Motion becomes *irregular* when movement is more random. Ask students to think of examples of regular motion.

Page 18 After reading, ask: What forces are acting on the tetherball? What direction is the tetherball moving? (*A hitting or pushing force causes the ball to move around and around.*)

See if students can predict future movement from the current pattern. What happens to the regular pattern if the boy hits the ball? (*The tetherball will continue to go around and around until the rope gets too short to continue.*)

3. Demonstrate examples and guide discussion. **5 MIN**

Conduct the following demonstration to stimulate further discussion. Analyze with students 1) the pattern that they notice and 2) whether they can make a prediction about the motion.

Make a yo-yo go up and down a few times. Then let the yo-yo unwind, and it will go up and down and finally stop. Repeat this a few times so students can observe any patterns.

» What patterns do you see? (*The yo-yo moves downward from gravity, but it will not move all the way back up without a tug. As it repeats, the distance back up is shorter and shorter.*)

» Can you make a prediction about what will happen if I let the yo-yo unwind? (*The yo-yo will stop.*)

» What forces are involved in this movement? (*Gravity pulls down and a tug from the hand pulls up.*)

4. Encourage discussion. **5 MIN**

Ask guiding questions to help students link details in this analysis back to the demonstration and reading selection. For example, ask the following:

» What happens to objects that experience a push force? (*They move away from the push force.*)

» What happens to objects that experience a pull force? (*They move toward the pull force.*)

» How does this provide evidence for patterns of motion? (*Objects that are pushed or pulled by unbalanced forces will have motion forward or backward.*)

5. Teach Core Vocabulary. **10 MIN**

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words **pattern** and **predict** (displayed on the board or chart paper earlier in the lesson). Ask students to locate from their Core Vocabulary decks the cards for the terms **force**, **motion**, and **predict** that they completed in previous lessons. Then have students prepare a new card to add the Core Vocabulary term *pattern*.

Word Work

- **pattern**: (n. something that keeps repeating) Have students locate the card for *pattern*. Have students list patterns of motion on their cards. When they have finished, have them share their ideas with the class. Ask students to draw an example of different patterns of motion.

- **predict/prediction**: Reinforce the meaning of the word *predict*. Explain that these words are forms of the same word. The prefix *pre-* means "before" as in *prepare, preview, pretest, prevent*. To *predict* is to "say beforehand." Then ask students these guiding questions: What are some other forms of the word *predict?* (*predicted, predicting, predictable*). What would happen if you could not predict how a swing would move?

6. Check for understanding. 5 MIN

Formative Assessment Opportunity

- Review student questions, and identify any that remain unanswered.
- Have students summarize what they have learned about patterns of motion, asking them to answer the Big Question: **Can we predict the motion of an object that moves in regular patterns?** Have them use the results of the investigation as evidence.
- Record answers to the Big Question on the board or chart paper. Then check to see if students can do the following:
  - Describe patterns in the motion of an object.
  - Describe regular patterns in an object's motion, and use that to predict future motion.
- Prompt students to express any new questions they may have and add them to the list. Discuss strategies for answering remaining questions.

PART D

Magnetism Is a Force

Overview

Lesson	Big Question	Advance Preparation
7. Investigating Magnets	How do magnets interact with different materials and each other?	Gather materials for teacher demonstration and student investigation. (See Materials and Equipment, page 12.)
8. Magnetism Is a Force	What are the characteristics of the force called magnetism?	Read Student Reader, Chapter 4.
9. Solving Problems with Magnets (2 days)	What problems can be solved with magnets?	Read Student Reader, Chapter 5. Gather materials for student design exploration. (See Materials and Equipment, page 12.)

Part D: What's the Story?

Forces are pushes and pulls. Students understand this intuitively. They know when something hits the floor softly or hard. The idea of gravity balancing other forces acting on an object at rest is hard to understand. But the idea of forces acting on objects that are not even touching is even more difficult.

To meet the Performance Expectations, students must recognize the cause-and-effect relationships of electric or magnetic interactions between two objects that are not in contact. They must ask questions and define problems that help them understand these relationships. The hands-on activity allows students to identify problems that can be solved with magnets and to offer solutions.

In Lesson 7, students will conduct activities with magnets to determine which materials are and are not attracted or repelled by a magnetic force. They experience the push and pull of magnetic force and how distance affects magnetic force. The idea that a force can act upon an object and make it move without even touching it is established.

In Lesson 8, students recognize that magnetism can make life a lot easier when applied to human wants and needs. Instead of using tape, they can post a message or picture to a refrigerator. Cupboard doors can close more easily with magnets. Screwdrivers can hold screws in place while they are tightened. The Student Reader goes from simple applications of magnetic force to maglev trains.

Lesson 9 gives students an opportunity to identify and solve a problem using magnetic forces. This two-day lesson not only reinforces the idea of forces acting on objects without touching (not in contact), but gives students an engineering design experience. During the second day of Lesson 9, students will identify a problem and design a solution as they consider causes and effects of magnetic forces.

LESSON 7

Investigating Magnets

Big Question: How do magnets interact with different materials and each other?

At a Glance

Learning Objectives

✓ Classify materials according to whether they are or are not attracted by a magnet.

✓ Based on patterns in observed data, predict whether a magnet will attract another object.

✓ Investigate the effects of distance on magnetic attraction.

Lesson Activities

- teacher demonstration
- student observation
- student predictions
- discussion
- writing
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS2.A: Forces and Motion (See **Know the Standards**)

Disciplinary Core Idea: PS2.B: Types of Interactions

Science and Engineering Practices: Asking Questions and Defining Problems

Crosscutting Concept: Cause and Effect

Cause-and-Effect relationships will be explored during this lesson as students discuss magnetism. Students will investigate how magnets interact with different materials to observe their causes and effects on other types of matter.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Know the Standards

What are examples of magnetic force and cause-and-effect relationships in the following Clarification Statement from NGSS Performance Expectation 3-PS2-3? Examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paper clips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause-and-effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force. [*Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.*]

Core Vocabulary

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attract	**magnet**	**magnetism**	**repel**
distance	**magnetic poles**	orientation	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards, which will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green above.

Instructional Resources

Activity Page

AP 7.1

Activity Page
Fishing with Magnets (AP 7.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- internet access and the means to project images/videos for class viewing
- index cards for student vocabulary deck (4 per student)

Teacher Demonstration

- ring (or donut) magnet
- assortment of metal and plastic paper clips
- pair of metal scissors
- metal binder clip
- pushpins
- plastic utensil
- roll of masking tape
- pencil
- bowl
- yarn
- long wooden sticks

Student Investigation

- ring (or donut) magnets
- bowls
- yarn
- long wooden sticks
- assorted magnetic and nonmagnetic items (coins, metal marbles/balls, keys or key rings, rocks/pebbles, erasers, shoelaces, chalk, feathers)

Advance Preparation

Assemble one setup per group of two or three students so you can easily pass these materials out to groups during class:

1. Construct the "fishing poles" for the teacher demonstration and for each group by tying one end of the yarn to the wooden stick and the other end of the yarn to a magnet.
2. Fill a bowl with all of the assorted magnetic and nonmagnetic items.

The Core Lesson 45 MIN

1. Focus student attention on the Big Question. 15 MIN

How do magnets interact with different materials and each other? Demonstrate and discuss the force of magnets. The goal of this demonstration is to show that certain materials/objects are attracted to magnets and others are not and to explore what students already know about the force of magnetism.

- Start off by showing students a magnet. Ask a relatable question about the magnet to establish a sense of familiarity, such as the following:
  - » Have you seen or used a magnet? (*Most students will answer yes.*)
  - » Do you know of or use magnets in your home or in the classroom? (*Magnets are commonly used on cabinet doors and to attach paper and pictures to a refrigerator.*)
  - » Have you ever wondered how a magnet works? (*I know that some objects stick to it and some don't.*)
- Tell students that magnets have a force—called *magnetism* (students will have a chance to learn more about, and define, magnetism later in the lesson). Remind them that any force is a push or pull. (See **Know the Science 1** for support.) Begin by asking students to predict what happens when a magnet is held directly (closely) over a set of metal paper clips. The paper clips will move to and stick to the magnet. Ask students what they observed: What happened to the paper clips? (*The paper clips jumped up to the magnet or to other paper clips that were touching the magnet.*)

Know the Science

1. What is magnetism? ***An invisible force caused by the attraction of certain metals to each other.*** Unlike other materials, in a magnet atoms are arranged so all the electrons spin in the same direction. This results in a north and a south pole in each magnet and forms a magnetic field around the magnet. Two poles of the same type repel each other. But the north and south poles are attracted to each other. Earth is a magnet. That's why compasses point north. Some birds and whales navigate by the detection of Earth's magnetic field.

- Reset the demonstration with the paper clips, and start the demonstration over, this time holding the magnet farther away from the paper clips. Ask students what they observed: What happened to the paper clips this time? (*They did not move.*)
- Next, model what happens when a magnet is held next to plastic paper clips, and ask students to predict what might occur. There will be no interaction. Move the magnet farther away from the plastic paper clips to ensure students see that the plastic clips will not attach to the magnet regardless of distance to the magnet.
- Repeat this process with the rest of the teacher demonstration materials, being sure to vary the distance of the magnet for each object. You can perform the demonstrations for each of the materials in any order. Before each demonstration, ask students to predict whether they think the object will attract to the magnet. For example:
  - » Do you think this pencil will be pulled to the magnet? What if I move the magnet closer to the pencil? (*The pencil will not move unless it has some metal on it that the magnet attracts.*)
  - » What do you think will happen to these pushpins when I put the magnet over them? How about when I move the magnet far away? (*The metal part of each pushpin may turn toward the magnet. Moving the magnet farther away will not attract the pins.*)
- Ask students to think of and share "rules," general ideas that might guide them, as they are predicting whether an object is attracted to a magnet or not. For example:
  - » Ask: What makes something be attracted to a magnet? (*Certain metals are attracted to magnets, such as iron and nickel.*)
  - » Support students as they note characteristics in common to each of the objects that are and are not attracted to the magnet. Capture student ideas about "rules" that can help them on the board or chart paper.
  - » Students should start to notice that the shiny metal objects (e.g., pair of metal scissors, binder clips, pushpins) are the things that are pulled toward and stick to the magnet. Noticing this pattern will help them make their predictions for each demonstration. Note: Later in the lesson, you should return to the "rules" about what makes something attracted to magnets that were generated through discussion. Returning to this list of ideas will help you to address any student misconceptions about magnets and the types of materials that interact with them (e.g., not all metals are attracted to magnets; see **Know the Science 2** for support).

Know the Science

2. What kinds of materials interact with magnets? ***The primary magnetic metals include nickel, iron, and cobalt.*** Some forms of steel are magnetic, but other forms of steel are nonmagnetic. Not all metals are magnetic, such as aluminum, copper, tin, lead, zinc, and titanium. Brass, bronze, gold, and silver are also nonmagnetic metals.

- Ask students to consider questions about magnets. Record their questions on the board or chart paper to think about as they investigate magnetism.

  SUPPORT—Give students the opportunity to experience the force of magnetism by sharing the materials.

2. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Display the following Core Vocabulary words on the board or chart paper. Have students write each term in the upper left corner of an index card and underline it (one term per card).

attract **magnet** **magnetic poles** **magnetism** **repel**

Word Work

- **attract:** (v. to pull something closer) Ask students to share what they understand *attract* to mean. Have students talk about familiar examples of *attract* (e.g., flowers attract bees). Tell them to write this definition on their cards: *to cause something to come closer.* Then, have students write on their cards a sentence using the word *attract*.
- **magnet:** (n. a material that applies the force of magnetism) Ask students to use what they have learned about *magnets* so far to write what it means. Point out that a magnet is *a material that applies the force of magnetism*. Have students identify the magnet they used in the previous exploration.
- **magnetism:** (n. a force that can push or pull on some materials without touching them) Ask students to share what they think *magnetism* means based on the demonstration of magnets. Then have students write the following definition on their cards: *the ability of some materials to push or pull on other materials without contact.* Point out that *magnet* is part of the word *magnetism*. Draw students' attention to the words "push or pull" in the definition. Ask students to consider how magnetism relates/connects to what they have learned in this unit so far. You may need to remind students of the definition for *force* as a push or a pull. Students should recognize that *magnetism* is a type of force. This force acts from a distance (without touching or contact). Have students write on their cards a sentence using the word *magnetism*. Encourage students to add a simple drawing to their vocabulary card that represents *magnetism*.
- Given their work with the other terms, invite students to jot notes on their cards about what they understand *magnetic poles* and *repel* to mean at this point. Students will refine their definitions for these two terms in the next lesson.

3. Facilitate the investigation. 10 MIN

Activity Page

AP 7.1

Form small groups of two or three students. Explain that in this quick hands-on activity, each group will use a magnet to "go fishing." They will use their materials to find out which objects are attracted to a magnet and which are not.

Distribute and review Fishing with Magnets (AP 7.1). Model for students how they will complete this Activity Page as they work. Explain that they will do the following:

- make predictions about objects that will attract or not attract to magnets
- record the observations that they see
- describe and summarize if their predictions were correct

Prompt students to take turns going "fishing" during the activity. When one person catches an object, then the next person should try next to catch a new object. Circulate between the groups to support students as they complete Fishing with Magnets (AP 7.1).

4. Summarize and discuss. 10 MIN

After the activity, as a whole class, ask students to share how the teacher demonstration or the activity relates to magnetism.

» Did any of the objects attract to the magnet? Which ones?

- As you lead the discussion, return to the "rules" and students' questions captured earlier on the board or chart paper. Ask students to think how they might modify or extend their "rules" based on what they experienced during the activity.

Make Frequent Connections

Patterns:

- Ask students to share how they were able to guess (predict) which objects would be attracted to the magnet and which ones would not. Ask probing questions if necessary, such as the following:

  » What did the objects that were attracted to the magnet have in common? (*They had some form of metal on them.*)

  » Were the objects attracted to the magnet shiny? (*Some were shiny, and some had plastic on part, such as the pushpins.*)

  » Were they all a kind of metal? (*yes*)

- Then explain that these "rules" are examples of patterns. Patterns are used in science to help learn more about why things happen. They can also be used to make predictions of what will happen in the future. Tell students that in the activity, they used what they saw in the observation to find patterns to make predictions. This is an important science skill!

Cause and Effect:

- Cause-and-effect relationships are routinely identified, tested, and used to explain change in science. Discuss with students some common examples of cause and effect to activate prior knowledge:
  - The sunlight through the window (cause) is making my desktop warm (effect).
  - The breeze (cause) is drying up rain puddles on the sidewalk (effect).
  - I am out of breath (effect) because I ran during recess (cause).
  - The swing is moving (effect) because I gave it a push (cause).
- Students experienced examples of changes during the activity. Remind students of these changes:
  - Certain objects were standing still but then started to move toward the magnet.
  - The distance of the magnet affected whether the objects stuck to the magnet:
    - When the magnet was closer to the metal objects, it attracted them.
    - When the magnet was far away from the metal objects, they did not move.
- Ask students the following guiding questions:
  - What force caused the metal paper clips (or other metal objects) to move toward the magnet? (*magnetic force*)
  - What was the result, or effect, of magnetism? (*Magnetism affects objects that have certain contents that are attracted to magnets.*)
- Now have students use their observations to write or say a sentence that describes the cause-and-effect relationship of magnetism. Encourage students to practice using the phrase "The ______ caused ______." For example:
  - The magnet caused the paper clips to move toward it.
  - The magnet caused the binder clip to move toward it when it was close but not when it was far away.
- Remind students that scientists and engineers often look at cause-and-effect relationships like this to explain why certain things happen in science, such as, "What causes wind?"

5. Check for understanding. 5 MIN

Activity Pages

AP 7.1 and Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

- Have students summarize what they have learned about magnetism.
- Review student questions, and identify any that remain unanswered.
- Prompt students to express any new questions they may have and add them to the list. Discuss strategies for answering remaining questions.
- Collect the completed Fishing with Magnets (AP 7.1).

LESSON 8

Magnetism Is a Force

Big Question: What are the characteristics of the force called magnetism?

At a Glance

Learning Objectives

✓ Describe the characteristics of magnetism as a force.

✓ Explain cause-and-effect relationships between the interactions of like and unlike poles of two magnets.

Lesson Activities

- teacher demonstration
- student observation
- reading and discussion
- hands-on exploration
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS2.B: Types of Interactions

Crosscutting Concept: Cause and Effect

Science and Engineering Practices: Asking Questions and Defining Problems

Asking Questions and Defining Problems is important to this lesson because students begin to bridge their learning from previous hands-on investigations (Lesson 7) and learn new terminology about magnetism.

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attract	**magnet**	**magnetism**	**repel**
distance	**magnetic poles**	orientation	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green above.

Instructional Resources

Student Reader

Ch. 4

Activity Pages

AP 8.1
AP 8.2

Student Reader, Chapter 4
"Magnetism Is a Force"

Activity Pages
Lesson 8 Check (AP 8.1)

Core Vocabulary Review (AP 8.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- shoebox lid
- white paper
- water-based paint, such as tempera (multiple colors)
- metal ball
- craft magnet
- bar magnets (with north and south poles marked; 1 per student)

Test the strength of the craft magnet before doing the demonstration by verifying that it can move the ball through the cardboard.

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 10 MIN

What are the characteristics of the force called magnetism?

Open the lesson with a demonstration to show how magnetism works through materials such as cardboard. This is a fascinating property of magnetism.

1. Place the white paper neatly in the inverted lid of the shoebox. Drop different colors of the liquid paint onto the white paper in the shoebox lid.
2. Place the ball into the paint.
3. Carefully lift the lid.
4. Place the magnet underneath the cardboard lid, under where the ball is located.
5. Start to move the magnet around, and watch as it makes the ball move.
6. Bit by bit, move the magnet away from the bottom of the tray. Note the distance at which the magnetic force no longer moves the balls.

- Ask students the following guiding questions as you perform the demonstration:
  - » Is the magnet under the cardboard touching the metal ball? (*no*)
  - » Why does the metal ball move? (*The magnetic attraction works through the cardboard.*)
  - » What is being pushed or pulled in this activity? (*The magnet is pushed or pulled, and its magnetic force pushes or pulls the ball.*)
  - » Does this support the idea that magnetism is a force? (*yes*)
  - » Is the magnetic force visible? (*Magnetic force is invisible.*)

» Does magnetic force increase or decrease with distance? (*Magnetic force decreases with distance.*)

- Make a class list of questions students have about magnetism to investigate.

2. Read and discuss: "Magnetism Is a Force." 20 MIN

Student Reader

Ch. 4

Read together, or have students read independently, "Magnetism Is a Force," Chapter 4 in the Student Reader. The selection reiterates what students learned and observed in the previous lesson about magnets, as well as reveals the characteristics of the force of magnetism, including that it is an invisible force. (See **Know the Science 1** for support.) It presents several examples of ways that magnetism is used in students' everyday life.

Preview Core Vocabulary Terms

- Before reading, write the following terms on the board or chart paper. Have students identify the words as they read. Stop and discuss the meaning of each term in context.

  attract **magnetic poles** **repel**

  magnet **magnetism**

- Focus on the words *attract* and *repel*. Explain that these are opposites, or antonyms. Have students demonstrate with their hands attracting and repelling. Then ask students to consider these guiding questions as they read:

  » What makes two magnets attract? (*Opposite ends pull together.*)

  » What makes two magnets repel? (*The same type of ends, such as north and north, push apart from each other.*)

- Have students use the term *orientation* properly when discussing two magnets.

Guided Reading Supports

When reading together, pause for discussion of key terms and questions to check for understanding. Include suggested questions and prompts:

Page 19

- Ask students what experience they have had with magnets. Ask how to tell if you have a magnet.

Know the Science

1. What is a magnetic field? ***An area where there is an invisible force.*** The invisible force that we call magnetism results when electrons spin within a magnet in an aligned manner. (How this happens is beyond the scope of this lesson.) Unlike other materials, in magnets atoms are arranged so the electrons spin in the same direction. This results in a north and a south pole in each magnet and a magnetic field around the magnet. Two poles of the same type repel each other. But the north and south poles are attracted to each other. Earth is a magnet. That's why compasses point north to south.

Pages 20–21

- How do you know when something is or is not magnetic? (*If something is not attracted to a magnet, the object is not magnetic.*) (See **Know the Science 2** for support.)
- Does magnetic force increase or decrease with distance? (*decrease*)

Pages 22–23

- When do two magnets attract each other? When do they repel each other? (*Opposite poles attract each other, but like poles repel.*)
- How would different poles of a magnet attract or repel a piece of iron that is not a magnet? (*Either pole would attract a piece of iron that is magnetic but not a magnet.*)
- Do all magnets have the same amount of strength? (*no*)
- How do you know magetism is a force? (*You cannot see it, but you can see the result of it working.*)
- What is the relationship between magnetic strength and distance? (*The strength of the pull decreases as the distance increases.*)

  SUPPORT—The strength of a magnet decreases with distance. The amount of force a magnet has is measured in gauss, which equates to the amount of flux lines given off by a magnet over an area. As a magnet gets closer to an object that it can affect, the flux lines are closer to each other, and the pull of the magnet increases. As a magnet gets farther from an object it can affect, the flux lines are further apart, and the pull of the magnet decreases.

Page 24

- What is a way you have used magnets? (*I use magnets to hold notes on a refrigerator and to make sure a cabinet door stays closed.*)

3. Teach Core Vocabulary. 5 MIN

Word Work

- **repel:** (v. to push away from) Have students locate their card for the Core Vocabulary term *repel*. Ask students to share what they understand *repel* to mean. Have students write this definition on their cards: *to cause something to move farther away*. Have students write on their cards a sentence using the word *repel*.

Know the Science

2. Is an object magnetic, is it attracted by a magnet, or is it not attracted by a magnet? *It depends.* Only a few types of metal (iron, nickel, cobalt, and some rare earth elements) can acquire a magnetic field and become a magnet. Magnets can also be made using one of the magnetic metals and a combination of other elements. Objects that can be attracted by a magnetic field usually contain one of the magnetic metals. Most objects and materials are not magnetic or attracted by magnetic fields, which is to say a magnetic field does not affect the electrons in the object or material.

- **magnetic poles:** (n. the places on a magnet where the magnetic force is strongest) Have students locate their card for the Core Vocabulary term *magnetic poles*. Ask students to share what they understand *magnetic poles* to mean. Have students write this definition on their cards: *the places on a magnet where the magnetic force is strongest*. On a bar magnet the ends are strongest and can be north or south. Have students write on their cards a sentence using the term *magnetic poles*.
- Reinforce the key lesson concepts by making sure students understand, in context, the following terms: *distance* (the space between two things); *orientation* (the position of one thing in relation to something else); and strength (the relative power of the force). Engage students in a vocabulary activity that allows them to practice using or better understanding these concepts. Choose one of the following (or both, if time permits): Have students draw a picture or diagram that shows the meaning of *distance*, *strength*, and *orientation*. Have students form pairs and teach each other the definitions for *distance, orientation,* and *strength.*

4. Facilitate the investigation. 5 MIN

- Demonstrate the concept of magnetic poles to stimulate further discussion.
  - » Place students into pairs, and give each pair two bar magnets.
  - » Tell students to place the magnets on the desk. Then have them do the following:
    - ◦ Make one magnet push the other away.
      - » Can you push one magnet across the entire desk with the other magnet?
    - ◦ Now make one magnet pull the other to it.
      - » Can you pull one magnet across the desk with the other magnet?
    - ◦ Give students some extra time, if time permits, to play with moving the magnets around with the invisible force of magnetism.
- Discuss how magnets make things move without touching. Mention that magnetic forces are not the only forces that act at a distance. Gravity and electricity are other forces that do not require objects to be in contact/touching.
- Review with students the concept of magnetic strength.
- Discuss the factors that affect how strong magnetism is (such as chemical [metallic] composition, distance, orientation, and strength).
- If students are still in their pairs and still have the bar magnets on their desks, have them practice testing the strength of the magnets from close together to farther apart to see that the magnets get stronger and weaker.

- Address the common misconception that larger magnets have a larger force. (See **Know the Science 3** for support.) This is not always true. Small magnets can be stronger than large magnets, depending on what the magnets are made of. For example, neodymium-iron-boron magnets can be very small but can be very strong. Students do not need to know what neodymium-iron-boron magnets are but should understand the idea that chemical composition affects magnetic strength.
- Review with students the concept of cause-and-effect relationships as they relate to magnetism (see **Know the Standards**):
  - » Magnetism causes things to move at a distance (effect).
  - » Opposite poles cause two magnets to attract (effect).
  - » Same poles cause two magnets to repel (effect).
  - » Large distances cause magnets to have less effect (effect).
  - » Small distances cause magnets to have more effect (effect).

5. Check for understanding. 5 MIN

Activity Pages

AP 8.1
AP 8.2
Answer Key

Formative Assessment Opportunity

- See the Activity Page Answer Key for correct answers and sample student responses.
- Distribute and have students complete Lesson 8 Check (AP 8.1).
- Choose one or two questions to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas and correct misconceptions.
- Distribute and assign Core Vocabulary Review (AP 8.2) as a take-home exercise for reinforcement. Collect and evaluate students' completed review pages to determine where students might need additional support.

Know the Science

3. Do bigger magnets exert more magnetic force than smaller magnets? ***It depends on many factors.*** The strength of the magnetic force depends on the chemical nature of the magnet and the distance between the magnet and the object. Magnets of differing sizes/materials can have predictable patterns of magnetic strength. However, it is not always true that larger magnets result in larger fields.

Know the Standards

Science and Engineering Practices: Asking Questions and Defining Problems. Students are expected to learn how to ask questions that can be investigated based on patterns, such as cause-and-effect relationships. As you discuss cause-and-effect relationships related to magnetism, use this opportunity to reiterate that this is a type of pattern and that patterns can be used to guide investigations or make predictions.

LESSON 9

Solving Problems with Magnets

Big Question: What problems can be solved with magnets?

At a Glance

Learning Objective

✓ Describe a device that uses magnets to solve a problem.

Lesson Activities (2 days)

- teacher demonstration
- student observation
- hands-on activity
- reading, discussion, writing
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS2.3: Motion and Stability: Forces and Interactions

Disciplinary Core Idea PS2.B: Types of Interactions

Science and Engineering Practices: Asking Questions and Defining Problems

Crosscutting Concept: Interdependence of Science, Engineering, and Technology

Scientific discoveries can often lead to new and improved technologies, which are developed through the engineering design process.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in green below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 114–115 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

attract	engineering design	magnetism	repel
distance	magnetic poles	**problem**	**solution**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. This deck will include the Core Vocabulary terms designated in green above.

Instructional Resources

Student Reader

Ch. 5

Student Reader, Chapter 5
"Solving Problems with Magnets"

Activity Page

AP 9.1

Activity Page
Problem and Solution (AP 9.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following:

- compass
- metal hairpins (bobby pins)
- magnetic strip
- magnets
- paper
- glue
- cabinet
- additional materials as necessary (see **Step 3** in Day 2)
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

THE CORE LESSON   TWO DAYS, 45 MIN EACH

1. Day 1: Focus student attention on the Big Question.   5 MIN

What problems can be solved with magnets? (See **Know the Standards 1**.)

- Open the lesson with a scenario about getting lost and how scary it can be. Have students imagine what it must have been like to live during a time when there were no maps, no satellites or GPS, and no people that you could call right away for directions. When explorers went out to sea or traveled the land, they had to rely on other ways to know whether they were heading north or south or east or west.
- Discuss the following question with students: How can I tell if I am travelling north, south, east, or west? Ask students to suggest a solution. They will probably mention a compass or a smartphone app.

Know the Science

How does a compass work? *Magnetism!* The Earth is a magnet. It is surrounded by one gigantic magnetic field. The magnetic needle of a compass is made of iron. The south pole of the compass needle will be oriented to Earth's north magnetic pole at all times. Engineers label the end of the needle N to indicate it is pointing north. Even though it has an N on it, it is the south pole of the compass needle. The north pole of the needle will, of course, point to the south, so compass designers put an S on it, even though it is the north pole of the needle.

- Show students a compass. Tell them what a compass does and how it works (see **Know the Science** on the previous page). Say that the compass uses a magnet, one magnetized needle. Remind them that every magnet has a north and south pole. The N pointer of a compass needle will point toward Earth's north magnetic pole if it can swing freely. The compass was a solution to the problem of getting lost and not knowing directions.
- Give students a chance to hold the compass and spin around or walk around the room to see the needle find the magnetic north pole.
- Ask guiding questions as students explore the compass, such as the following:
  - » If the needle of the compass is a magnet, what do you think it is made of? (*iron, metal*)
  - » When the needle spins around, is it being pushed away from Earth's north magnetic pole or pulled toward Earth's north magnetic pole? (*One end is being pulled, and the other is pushed.*)
  - » The compass needle orients to a north-south position. What do you think would happen if you face south? (*You face a different direction, but the compass needle still points north.*)
- Explain to them that Petrus Peregrinus de Maricourt—who they will read about in their Student Reader—was one of the first people to discuss freely pivoting compass needles. He used his knowledge of magnets and magnetism to design and build a compass.
- Make a class list of questions students have about practical uses of magnets and the force of magnetism to solve problems.

2. Read and discuss: "Solving Problems with Magnets." 20 MIN

Student Reader

Ch. 5

Prepare to read together, or have students read independently, "Solving Problems with Magnets," Chapter 5 in the Student Reader. The selection sets up the idea of solving problems using magnets and discusses a few examples of magnets used as solutions to problems based on wants or needs. The article also includes a section on evaluating time, cost, and materials when considering design solutions.

Preview Core Vocabulary Terms

Before reading, write the following terms on the board or chart paper. Have students identify the words as they read. Stop and discuss the meaning of each term in context.

problem **solution**

Know the Standards

1. Problems Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.

Guided Reading Supports

When reading together, pause for discussion of key terms and questions to check for understanding. Include suggested questions and prompts:

Page 25

- Ask students how they use magnets to solve problems.
- Discuss different problems that can be solved with magnets.

Pages 26–27

- Relate finding studs to the magnetic painting activity in the last lesson. Discuss how magnetism can go through other materials. Use the room you are in when discussing walls and studs. You can buy a stud finder at any hardware store if you wish to demonstrate.

Page 28

- Have students explain how a maglev train works.
  - » Why is the ride on a maglev train so much smoother than on steel rails?

  SUPPORT—If needed, draw a model of a maglev train on the board or chart paper, and show how it works with a large electric power source, metal coils lining a track, and large magnets on the underside of the train. The magnetized coils in the track repel the train's magnets, so the maglev train floats on a cushion of air as magnetic fields push and pull the train along the surface.

Pages 29–30

- What is a way you can use magnetism to locate something, which is what happens with a stud finder?
- What is a way you can use a magnet to repel something, which is what happens with a maglev train?

3. Demonstrate examples and guide discussion. 10 MIN

Choose one of the following, or a similar example, to stimulate further discussion about how magnets can be used to solve simple problems. (If time permits, use as many examples as possible.)

- Demonstrate how a magnet will hold paper on a magnetic board. Place the magnet onto the board, showing that it sticks. Now place the paper between the magnet and the board, showing how the paper is held in place. Ask students the following:
  - » What is the problem that I needed to solve? (*I want to display the paper on a board.*)
  - » What was the solution that I used? (*I used a magnet to hold the paper on a magnetic board.*)

- Demonstrate how adhering a magnet strip to the wall will hold metallic bobby pins (hairpins) in an organized way. Glue a magnet strip to the wall, or attach the magnetic strip to the magnetic board. Show students how the hairpins stay attached to the magnet. Ask the following questions:
  - » What is the problem that I needed to solve? (*I needed to organize the bobby pins.*)
  - » What was the solution that I used? (*I used a magnetic strip to keep the bobby pins handy.*)
- Demonstrate how magnets can be used to hold cabinet doors shut. Show students a cabinet that will not stay closed. Then ask these guiding questions:
  - » What is the problem that you see? (*The door won't stay shut.*)
  - » What was the solution that I used? (*Magnets hold the door shut, but a little pull can open the door when needed.*)

  Then show students how the cabinet can be held shut after gluing magnets onto the cabinet doors.

Online Resources

- Show a video of a large magnet in a junkyard being held by a crane that is sorting materials to be used for recycling. Ask what students observe about the magnet:
  - » What do you think would happen if the crane held the magnet up higher? (*It may not pick up anything.*) Would the magnet still work from that distance, or would it get weaker? (*The farther away a magnet moves from an object, the weaker the pull will become.*)
  - » What makes the objects in the junkyard attracted to the magnet? (*They contain metals that are attracted to magnets.*)

Explain that these are all examples of problems that use magnets as part of the solution.

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

4. Encourage discussion. 5 MIN

- Emphasize the importance of solving problems. Tell students that problems exist all around us. Give an example of a problem, such as pollution. Then explain that scientists and engineers study problems to try to come up with designs to solve them. Solving problems can be a long process. But one of the first ways that they can start to solve problems is by asking questions.
- Scientists ask questions to learn more about the natural world and why things happen. Engineers ask questions to understand how something would work better. Asking questions is a skill. Knowing the right kinds of questions to ask can help people come up with solutions to problems.
- Give some examples of simple questions that may be asked in science or engineering, such as the following:
  - » Why does this thing work the way that it does?
  - » How can I make this thing work even better?

- Another important skill in science and engineering is identifying a problem and using the design process to solve it. (See **Know the Standards 2** for support.) Engineers have to think about the following:
  - desirable features
  - what people want/need
  - limits (constraints)
  - time
  - cost
  - materials
- Students will have already read about time, cost, materials, and limits for designs in the Student Reader selection. Have them discuss the time, cost, materials, and limits for the examples presented in the reading.

5. Check for understanding. 5 MIN

Formative Assessment Opportunity

- Have students summarize what they have learned about using magnets to solve problems. Ask guiding questions to help students link details in this analysis back to their activities with magnets and the reading they have done so far.
- Review student questions, and identify any that remain unanswered.
- Prompt students to express any new questions they may have and add them to the list. Discuss strategies for answering remaining questions.

1. Day 2: Focus student attention on the Big Question. 5 MIN

What problems can be solved with magnets?

- Remind students of what they reviewed in the previous class about simple problems that can be solved with magnets.
- Tell students that today they will be doing the following:
  - identifying and describing a simple design problem
  - telling how that problem can be solved using magnets
  - drawing a sketch of the solution
- If there is time and the materials are available, students can build and test their solutions to the defined problems. See **Step 3** ahead for more details.

Know the Standards

2. Engineering Design Process At this grade level, students are not introduced to the engineering design process in its entirety. However, they will learn about asking questions, identifying simple problems, and describing solutions, which form the basis of the engineering design process.

Students are also not assessed on the terms *criteria* and *constraint*. Instead, these concepts should be described as "desirable features" and "limits."

2. Demonstrate examples and guide discussion. 10 MIN

Activity Page

AP 9.1

Explain to students that they will identify a simple problem that can be solved by magnets. Distribute and review Problem and Solution (AP 9.1). Explain that students will be working in groups for the activity but that each student will complete the Activity Page independently.

- Model for students how to fill out the Activity Page, and describe what they will do for each of the steps. Explain the following:
    - First, students will state a simple problem.
    - Then, students will practice asking questions to think of an engineering design solution.
    - Next, students will draw a sketch of their engineering design solution and describe how it works.
    - Then, students will talk about the scientific ideas necessary for solving the problem. For example, force between objects does not require the objects to be touching. Magnetic force depends on the size of the objects, distance between the objects, and orientation of the magnets. If necessary, review with students the concepts for these scientific ideas.
    - Finally, students will evaluate the time, materials, limits, and cost for their design solution. (You may set a limit for them, even an arbitrary one such as "You can't use anything red.")
- Tell students that they cannot use a simple problem and design solution that was already discussed or demonstrated, either in their reading or in the classroom.

3. Facilitate the investigation. 15 MIN

- Have students work in small groups to complete the activity. Circulate around the room to provide support as needed. Students may need help with the following:
    - recalling the scientific ideas related to the force of magnetism
    - understanding how to evaluate the given factors of a design (such as cost or limits)
    - defining key concepts, such as *orientation*
- Provide continuous reminders to students that magnetism is a type of force that creates motion (pushes or pulls).
- When students complete the activity and have filled out the Activity Page, invite volunteers to share their design solutions with the class.

SUPPORT—If time permits and materials are available, have students build and test the solutions to their defined problems. You might prepare materials such as these:

- craft magnets
- cardboard
- paper
- glue
- scissors
- string
- paper clips

4. Teach Core Vocabulary. 10 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Have students write each term in the upper left corner of an index card and underline it (one term per card).

problem **solution**

Word Work

Activity Page

AP 9.1

Have students review Activity Page 9.1 and identify where they asked questions, identified simple problems, and described a solution.

- **problem:** (n. a want or need that requires a solution) Invite volunteers to provide examples of problems in terms of anything they'd like to change, improve, or fix. Ask students what these examples have in common. Then instruct students to compose their own definition of *problem* on their Core Vocabulary card.
- **solution:** (n. plan or object that solves a problem) Then, invite volunteers to provide examples of solutions to some of the problems they have identified. Ask students what these examples have in common. Then instruct students to compose their own definition of *solution* on their Core Vocabulary card.
- Remind students that the engineering design process can have many steps but that the basic steps are asking questions, identifying simple problems, and describing solutions.

5. Check for understanding. 5 MIN

Activity Pages

AP 9.1 and Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

- Have students summarize what they have learned about using magnets to solve problems. Ask guiding questions to help students link details in this analysis back to their activities with magnets and the reading they have done so far.
- Review student questions, and identify any that remain unanswered.

UNIT REVIEW

Forces and Trains

Big Question: How have engineering designers improved trains?

At a Glance

Learning Objectives

- ✓ Examine improvements to trains as examples of engineering solutions.
- ✓ Use examples from the reading about trains to answer the unit Big Questions.

Lesson Activities

- student reading
- teacher demonstration
- discussion
- vocabulary instruction

NGSS References

This unit addresses the following Performance Expectations from NGSS Grade 3 Topic *Forces*.

- Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. **(PE 3-PS1-1)**
- Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. **(PE 3-PS2-2)**
- Ask questions to determine cause-and-effect relationships of electric or magnetic interactions between two objects not in contact with each other. **(PE 3-PS2-3)**
- Define a simple design problem that can be solved by applying scientific ideas about magnets. **(PE 3-PS2-4)**

The Unit Review is intended to support students as they summarize their learning about these PEs and prepare for the Unit Assessment. For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

The Big Idea

This lesson focuses on the role of engineering design in making better trains. Engineers use knowledge of forces as they develop solutions to problems and build things that are useful to people. This lesson also incorporates learning goals that support principles and practices of engineering design (such as defining problems and evaluating and optimizing possible solutions).

This lesson also deals, in part, with the scientific concept of balanced and unbalanced forces. Students can see concrete manifestations of forces in the pushes and pulls all around them. Everything that is still is at rest with balanced forces. Getting a train at rest to move, for example, is an example of unbalanced forces at work. The scientific concept that forces are always acting on objects, even if they are not moving, can be challenging. This abstract idea of will become becomes clearer when students understand the following:

- Forces are pushes and pulls.
- Gravity, friction, and magnetism are forces.
- Unbalanced forces cause changes in motion.
- Motion has speed and direction.
- Forces such as magnetism can act on objects that are not touching.

Core Vocabulary

Language of Instruction: During instruction, remind students of their prior exposure to the following terms.

attract
balanced forces
contact force
force
friction
gravity
lubricant
magnet
magnetic poles
magnetism
motion
oppose
pattern
predict
problem
repel
solution
unbalanced forces

Instructional Resources

Student Reader

Ch. 6

Student Reader, Chapter 6
"Forces and Trains"

Activity Page

AP UR.1

Activity Page
Big Questions About Forces (AP UR.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following:

- magnetic tape roll (as much as needed)
- narrow box with ends cut off
- cardboard from one end of the box
- small, thin piece of foam or sponge
- thin clear tape
- glue
- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/videos for whole-class viewing

Advance Preparation

Prepare the following, or provide students with the steps and have them do it (15 min):

1. Glue thin magnetic strips along the long corners of the box so that they form two tracks aligning each side of the box. Make sure that the same poles are always facing upward.
2. The magnetic strips on the box should form a trackway inside the walls.
3. Take the piece of cardboard (about the same width as the box though not nearly as long), and glue one magnetic strip on one side where it fits to the width of the box. These should align with the strips in the trackway. Also, the poles facing down should be the same as the poles facing upward on the ruler.
4. Next, tape a thin piece of foam or sponge over the magnets on the opposite side of the piece of cardboard.

Online Resources

This will act as a "train" that will travel on the magnetic "trackway." For help in assembling the pieces, use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 5 MIN

How have engineering designers improved trains?

- Remind students that in previous lessons, they watched demonstrations, read materials, and carried out investigations to learn how engineers use forces, which are pushes or pulls, to cause a change in motion. Have students describe the kind of force that is acting on objects in each of the following examples:
  - » a ball being dropped to the ground
  - » a child sliding down a playground slide
  - » a compass needle pointing north
- Ask students to identify any patterns these examples might show (for example, on Earth, gravity always pulls objects down; compass needles always point to Earth's north magnetic pole).
- Invite students to consider questions about the ways that forces start or stop train motion. Prompt students to think about how train engineers have solved various problems related to friction either between track and wheel or between the sufaces of engine parts. Record selected questions on the board or chart paper to revisit after the reading.

2. Read and discuss: "Forces and Trains." 20 MIN

Student Reader

Ch. 6

Read together, or have students read independently, "Forces and Trains," Chapter 6 in the Student Reader. Connect the Student Reader to the previous lessons about forces and motion. The selection introduces students to Elijah McCoy, whose family escaped from slavery to the North, where, as a worker on trains, he developed a process to lubricate train engines while the train was moving. Students also learn about maglev trains, which reduce friction between the train and the train track to help trains travel more efficiently.

Preview Core Vocabulary Terms

Have students take out the Core Vocabulary card decks they have completed throughout the unit. Instruct students to quickly scan the cards as a reminder of terms to look for during today's reading and Unit Review discussion. Have students place the deck at the top left corner of their desks. When they encounter any term in the deck during reading or discussion, they should move the card for that term to the top right corner of the desk. Emphasis in this lesson is for students to use Core Vocabulary in context in the discussion and to be aware of their use of the terms.

Guided Reading Supports

When reading together, pause for discussion of key terms and questions to check for understanding. Include suggested questions and prompts:

Page 31

- What evidence tells you what kind of person Elijah McCoy was? (*He was trained to be an engineer, worked where he could find work, and was a problem solver.*)
- What is an engineer? What is an engineering designer? (*An engineer designs or builds machines or parts to create or improve ways to make work easier.*)

Pages 32–33

- Describe the forces that get a train at rest to move. (*There must be a powerful pushing or pulling force to get a train to move.*)
- How can you predict the motion of a train? (*A train moves forward or backward on a track.*)
- What problems must be overcome to start the movement of a heavy train? (*The obstacles to moving a train are the weight of the train, its position, gravity, and friction.*)
- What types of solutions to the problems have engineers developed? (*Some solutions include using various fuels, improving the wheels, reducing friction, and using lighter materials to build the train.*)

Pages 34–35

- How did Elijah McCoy's invention improve train travel? (*McCoy's way of lubricating the engine meant that the train could make fewer stops.*)
- Why do you think McCoy may have gotten a patent? (*A patent kept others from making money off of his invention.*)
- What are the advantages of maglev trains over other trains? (*Maglev trains use magnets instead of wheels, so friction is reduced, making train rides quiet and smooth.*)

Page 36

- How do maglev trains work? (*Magnets are used to levitate, or float, the trains over the tracks.*)

3. Demonstrate an example. 10 MIN

Place the model maglev train track where all students can gather round it. Place the piece of wood or plastic, with the foam-covered magnets facing downward, against the magnets on one end of the trackway, and give it a gentle push. It will fly along the track. Explain to students that this is how the magnets in a maglev train work to cause the train to move. (See **Know the Science** for support.)

> **SUPPORT**—If time permits, allow students to experience the magnetic forces in the model train.

4. Check for understanding. 10 MIN

Activity Page

AP UR.1 and Answer Key

Distribute and review Big Questions About Forces (AP UR.1). Have students review their answers to the Big Questions looking for the unit vocabulary words. Instruct students to refer to their cards throughout the exercise.

- Assign students to work in pairs to discuss and develop written answers to the unit's Big Questions.
    - Assign each pair one or two Big Questions to answer from the Activity Page.
- Instruct students to draft their answers first on paper as they work with their partner.
- Challenge students to use references from Chapter 6 of the Student Reader in their answers where appropriate.

Before the next class session, the Unit Assessment, collect and evaluate the Activity Page. Address any misguided or incomplete responses.

Return the Activity Page to students, and have selected students read their responses to the whole class in preparation for the Unit Assessment.

See Teacher Resources on page 110 for guidance in administering the Unit Assessment to conclude the unit.

Know the Science

When a train is at rest, balanced forces are acting on it. When it begins to move, slow down, or change direction, unbalanced forces are acting on it. Trains exhibit a pattern of motion by always moving along tracks, whether they are old-fashioned locomotives or maglevs. Gravity is a pull force always pulling trains down toward Earth, and when trains are moving, they face resistance from friction. Friction occurs when rail and wheel meet. The front surface of the train also encounters air friction. In maglev trains, magnetism is used to reduce or eliminate friction between the train and the track. However, it does not reduce friction from the air. In fact, friction with the air may increase because maglev trains can move faster than diesel locomotives.

UNIT 1

Teacher Resources

Name ______________________________ Date ________________

Activity Page 1.1 Use with Lesson 1

Push It, Pull It

Think about objects whose motion you have changed today.

Make a short list on the lines below.

____

____

____

____

____

Draw an object you pushed to make it move. Describe what happens to the object to make it move.

Draw an object you pulled to make it move. Describe what happens to the object to make it move.

Name ______________________________ Date ____________________

Activity Page 2.1 Use with Lesson 2

Lesson 2 Check

Circle the correct answer.

1. Which of the following are forces?

a) pushes

b) speed

c) direction

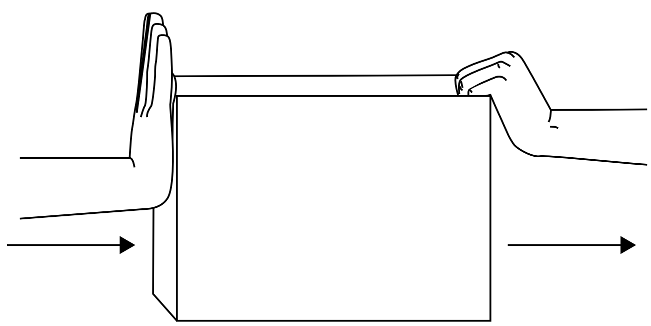
d) pulls

2. Which of the following happens when unbalanced forces are acting on an object?

a) The object's motion does not change.

b) The object's motion changes.

3.



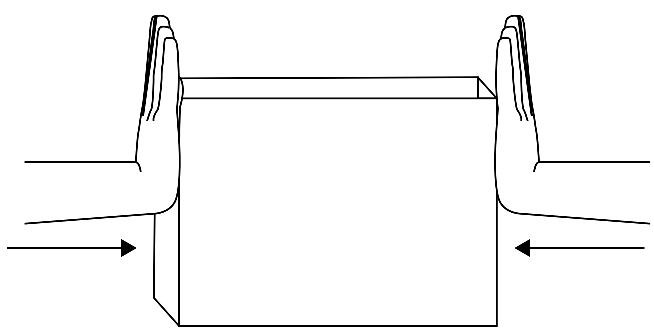
What will happen to the box?

a) It will move in the opposite direction of the push force.

b) It will move in the same direction as the pull force.

c) It will remain unchanged and at rest.

4.



What will happen to the box?

a) It will move in the opposite direction of the push force.

b) It will move in the same direction as the pull force.

c) It will remain unchanged and at rest.

Name ______________________________ Date ____________________

Investigating Forces (Day 1)

Plan

Complete the items below to plan your investigation.

1. What questions are you trying to answer about balanced and unbalanced forces?

____

____

____

2. In two or three sentences, summarize what you already know about forces.

____

____

____

____

____

3. Based on what you already know, predict an answer to your question.

____

____

____

4. What materials will you need to carry out your investigation?

____

____

____

5. In the box below, show how you will carry out your investigation. You may use pictures, a list, or complete sentences to describe your plan.

Name ______________________________ Date ____________________

Activity Page 3.2 Use with Lesson 3

Investigating Forces (Day 2)

Test

Test the idea you described on Investigating Forces (Day 1)—Plan (AP 3.1). Record your observations.

1. What forces were acting on the object when it was at rest?

____

2. What happened when you applied balanced forces to the object?

____

3. Were your predictions correct? Circle one choice below.

Yes No

4. Briefly explain why you think your results do or do not support your predictions.

____

____

____

5. Write about the other group's investigation plan that you tried to repeat. How were their results similar to or different from yours?

____

____

____

____

____

____

Name ______________________________ Date ____________________

Table Hockey

Let's play a game of table hockey! Investigate which materials help the hockey puck slide smoothly and easily across the surface.

MATERIALS:

- baking sheet
- large piece of felt or construction paper
- large piece of sandpaper
- large piece of aluminum foil
- cup of oil
- bottle cap (the "hockey puck")
- sand

PROCEDURE:

STEP 1: Place the piece of felt (or construction paper) on the baking sheet.

STEP 2: Pour sand into the bottle cap. Try to send the bottle cap ("hockey puck") from one side of the pan to the other.

Record your results and observations below. Use the terms *surface*, *force*, and *friction* in your results.

Did the hockey puck glide or slide across the pan?	Why or why not?

STEP 3: Remove the piece of felt.

STEP 4: Place the piece of sandpaper on the baking sheet.

STEP 5: Try to send the hockey puck from one side of the pan to the other.

Record your results and observations below. Use the terms *surface*, *force*, and *friction* in your results.

Did the hockey puck glide or slide across the pan?	Why or why not?

STEP 6: Remove the piece of sandpaper.

STEP 7: Place a piece of aluminum foil on the baking sheet.

STEP 8: Try to send the hockey puck from one side of the pan to the other.

Record your results and observations below. Use the terms *surface*, *force*, and *friction* in your results.

Did the hockey puck glide or slide across the pan?	Why or why not?

STEP 9: Keep the aluminum foil in the pan.

STEP 10: Pour the oil over the aluminum foil, and then spread it out evenly to cover the surface.

STEP 11: Try to send the hockey puck from one side of the pan to the other.

Record your results and observations below. Use the terms *surface*, *force*, and *friction* in your results.

Did the hockey puck glide or slide across the pan?	Why or why not?

STEP 12: Answer the following questions:

Which material(s) created the most friction between the surfaces? Use evidence from your investigation to support your answer.

Which material(s) acted as a lubricant? How did this lubricant affect the friction between the surfaces?

What is the cause-and-effect relationship between different surfaces and friction? Use evidence from your investigation to support your answer.

Name ______________________________ Date ____________________

Activity Page 5.1 Use with Lesson 5

Friction Finder

Friction occurs all around you! Think of one example of the force called friction that you might find in each place noted below. One example has been added for you.

Place	**Examples of the Force of Friction**
Home	Pulling a chair out so you can sit at a table
Classroom	
Outside	

Name ______________________________ Date ____________________

Activity Page 5.2 Use with Lesson 5

Lesson 5 Check

1. Which are characteristics of the force called friction? Circle all that apply.

a. Friction occurs between surfaces in contact.

b. Friction can be helpful or harmful.

c. Friction does not act on objects that are not moving.

d. Friction can make it hard for things to move.

e. Friction opposes (resists) motion.

2. Circle the correct words to complete the sentences below.

One way to reduce friction is to use a [rough surface / lubricant].

Friction [opposes / speeds up] motion.

3. Place a ✓ in the box to tell whether each example of friction is helpful or harmful. In the Reasoning column, explain your reasoning for your answers. The first example has been done for you.

Example	**Helpful**	**Harmful**	**Reasoning or Evidence**
Using the brakes on a bicycle	✓		Friction is useful because it can stop the bike in an emergency.
Gripping the road with tire treads			
On a cold day, rubbing hands together to make heat			
Adding oil to the moving parts of an engine			
Rubbing two sticks together to light a fire and stay warm			

Name ______________________________ Date ____________________

Forces and Patterns

For this activity, you will create a pendulum that swings back and forth exactly 10 times before it stops.

STEP 1: Build your pendulum. Watch your teacher demonstrate, and then copy the steps to make your pendulum.

STEP 2: Hold the pendulum by the end of the string, but do not let it move.

<u>Draw</u> how you think the pendulum will move in the box. Use arrows to show the direction of the pendulum.

STEP 3: Have one person in the group hold and move the pendulum. Another person will count how many times it swings back and forth before it stops moving. Repeat this two times, and record your observations in the table below:

Trial	Number of times it swings before it stops
1	
2	
3	

What is the average number of times that the pendulum swings before it stops?

____

What can you do to make the pendulum swing more or less to get to exactly ten times?

____

____

Was your prediction about how the pendulum moved correct?

____

STEP 4: Make changes to your pendulum. Do you have a different prediction about how the pendulum will move? If so, write it below:

____

STEP 5: Test the pendulum again. This time, switch roles in your group so each person has a chance to hold the pendulum and record the findings. Record your observations in the table below:

Trial	**Number of times it swings before it stops**
4	
5	
6	

Did your changes help the pendulum swing exactly 10 times before it stopped?

____

____

____

If you had a new prediction, was it correct?

____

In your own words, what is a prediction?

____

____

____

Name ______________________ Date ______________

Activity Page 7.1 (Page 1 of 2) Use with Lesson 7

Fishing with Magnets

1. Look through the bowl. List the objects that you observe.

____

____

____

____

2. Make a prediction. Which objects do you think will be attracted to the magnet?

____

____

____

____

It's time to go fishing! Place the fishing pole's "lure" (the magnet) into the bowl of objects, and see which objects stick to the magnet. After you "catch" one object, let your partner try, too.

3. Record your observations.

Which items from the bowl were attracted to the magnet?

____

____

____

Was your prediction from Question 2 correct?

____

4. Summarize your observations.

What do the objects that *are attracted to the magnet* have in common?

____

____

____

____

____

What do the objects that *are not attracted to the magnet* have in common?

____

____

____

____

____

Name ________________________________ Date ____________________

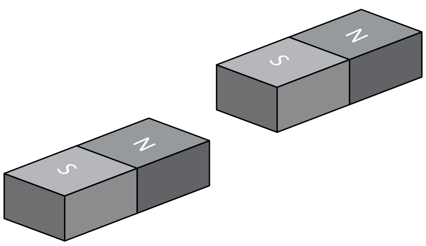
Activity Page 8.1 Use with Lesson 8

Lesson 8 Check

Answer the items below to show what you have learned.

1. Circle the correct words to complete the sentences about magnetism.
   - **a)** Magnetism is [stronger / weaker] when a magnet is closer to magnetic objects.
   - **b)** Magnets [attract / repel] certain types of metals.
   - **c)** Magnetism is a force that is [invisible / visible].
   - **d)** Magnetism acts [never across a distance / often across a distance].
   - **e)** Magnetism attracts [all materials / some materials and not others].

2. What will happen to the magnets in the picture?



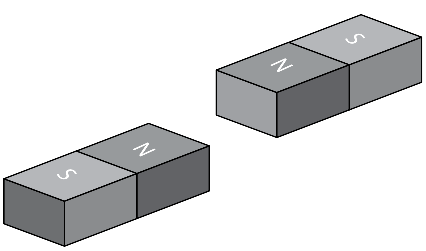
   - **a)** They will attract.
   - **b)** They will repel.

3. What evidence from your reader supports your answer to Question 2?

____

____

4. What will happen to the magnets in the picture?



   - **a)** They will attract.
   - **b)** They will repel.

5. What evidence from your reader supports your answer to Question 4?

____

____

Name ______________________________ Date ____________________

Activity Page 8.2 Use with Lesson 8

Core Vocabulary Review

Complete each sentence with the correct term or phrase. Not every word in the word bank will be used, but any word that you do use will be used only once. For support, review the cards in your Core Vocabulary deck before you begin.

force	push	pull	motion	balanced	unbalanced	pattern	predict
contact	friction	lubricant	magnetism	attract	repel	poles	

1. When several forces are acting on an object that is at rest, and the object does not move, then the forces are ________________.

2. Objects that are changing position are said to be in ________________.

3. You can ________________ a friend on a swing, and you can ________________ on a rope during tug-of-war. Both are types of forces.

4. When you use the brakes on a bike to come to a quick stop, the force that causes the wheel to stop moving is ________________.

5. Friction requires objects to be in ________________, or touching.

6. You can reduce friction by using a ________________.

7. You have two bar magnets. The magnetic poles that are the same will ________________, and the opposite magnetic poles will ________________.

8. You can ________________ what will happen to objects undergoing repeating motion by studying patterns.

9. When five forces are acting on an object, and they cause the object to change its motion, then the forces are ________________.

10. One kind of force that works over a distance without touching is ________________.

Name ______________________ Date ______________

Problem and Solution

1. Describe a simple problem that your team can solve using magnets.

2. Explain the engineering design that your team will use to solve the problem.

3. What are the wants and needs that inspired your engineering design?

4. What are the limitations (time, cost, limits, materials) of the solution you have designed?

5. Sketch your design below. Include labels for the different parts of your design.

6. Why do you think will your design work?

7. How will the size or strength of the magnetic force you use in your solution be impacted by each of the following:

- the properties of objects (what they are made out of)
- the distance between objects

Name ______________________________ Date ____________________

Activity Page UR.1 Use with Unit Review

Big Questions About Forces

The table below contains most of the Big Questions you have explored in the unit Investigating Forces.

Circle the question that was assigned for you to answer.

What is force?	What are balanced and unbalanced forces?
How do forces affect the motion of objects?	How does the force of friction affect motion?
What are the characteristics of the force called friction?	Can we predict the motion of an object that moves in regular patterns?
How do magnets interact with different materials and each other?	What are the characteristics of the force called magnetism?
What problems can be solved with magnets?	How have engineering designers improved trains?

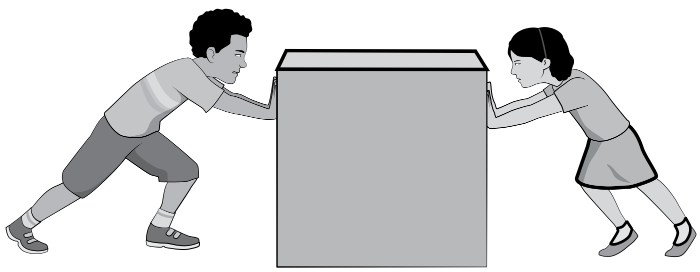
Write three or four sentences to answer the Big Question that was assigned to you and your partner.

Prepare a rough draft of your answer first on scrap paper, and then write your final draft below. Underline any terms in your answer that have a card in your Core Vocabulary deck.

Name ______________________________ Date ____________________

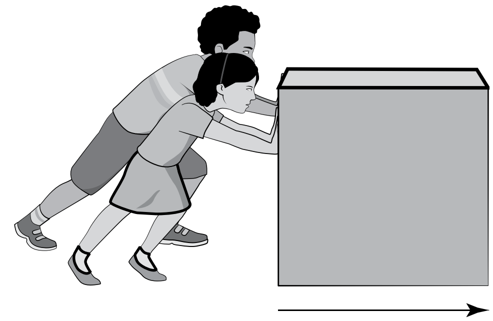
Unit Assessment: What Have I Learned About Forces?

Picture A



The box is not moving.

Picture B



The box's motion is changing.

1. Which of the following words can help you to describe what is happening in Picture A? Circle all the correct answers.

a) at rest

b) in motion

c) pushing force

d) pulling force

e) force from the left

f) force from the right

2. Using what you see in Picture B, complete the sentence below.

The large box changes ____________ by going from a resting position to moving right.

3. In Picture B, the students are applying a force to move a large, heavy box. Use one to two sentences to describe the force they are using. Be sure to use the Core Vocabulary that you have learned during this unit. You can also use the words that describe motion in Question 1.

____

____

____

4. Which of the pictures above illustrate an example of balanced forces acting on the box? Write a sentence to describe how you can tell.

____

____

Patterns in Motion

Friction is a force that acts on surfaces when they come into contact with one another. When the surfaces of two or more objects come into contact, they resist movement or potential movement. The less smooth each surface is, the more resistance occurs. Rub your hands together. What do you feel from the friction between your hands? Think about a ball rolling on a carpeted floor. What happens to the ball?

Based on what you learned in the paragraph above, answer the following question.

5. Which of the following statements describe characteristics of the force of friction? Choose all the correct answers.

a) It opposes motion or potential motion.

b) It speeds up motion.

c) It occurs when objects are in contact with each other.

d) It occurs when objects slide against each other.

e) Its presence can cause motion energy to transform into heat energy.

f) It makes movement easier.

6. Use what you have learned in the paragraph. After each sentence, write the word *harmful* or *helpful* to tell the outcome of the friction.

a) walking on ice while in a hurry ____________

b) starting a campfire by rubbing two sticks together ____________

c) parts wearing down in an engine ____________

d) your bike tires having worn smooth ____________

e) developing a blister on your heel from your shoe ____________

7. Using what you have learned from the paragraph, provide three more examples of friction that have not been used so far in this assessment. Explain the effects of friction in each case.

____

____

____

____

____

____

Patterns in Motion

- If a force pushes an object from one direction, the object will move in the opposite direction.
- If a force pulls something from one direction, the object will move in the same direction.
- On Earth, gravity pulls objects down toward the ground.
- Friction opposes motion.

8. Based on what you have read above, complete the sentence below. Be sure to use the Core Vocabulary that you have learned during this unit.

If you know an object's pattern of movement, you can ____________________ how it will move next.

9. A cat knocks a book off a table, and it falls toward the floor. What forces act on the book during this entire time?

____

____

10. Using what you have learned from the description of patterns above, explain how each force will act on the book in Question 9.

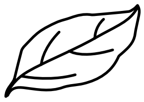
____

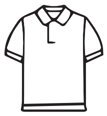
____

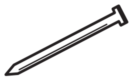
Magnetism

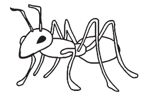
Magnetism is an invisible force caused by the attraction of certain metals to each other. There is a north and a south pole for each magnet. Two poles of the same type repel each other. But the north and south poles are attracted to each other. Magnetic forces can act on objects even when they are not touching. Some metals are magnetic, but other metals are nonmagnetic. Non-metals are never magnetic.

11. Based on the definition of magnetism above, which of the following are **never** magnetic? Circle all the correct answers.

a) 

b) 

c) 

d) 

e) 

f) 

12. Complete the following sentence. Be sure to use the Core Vocabulary that you have learned during this unit.

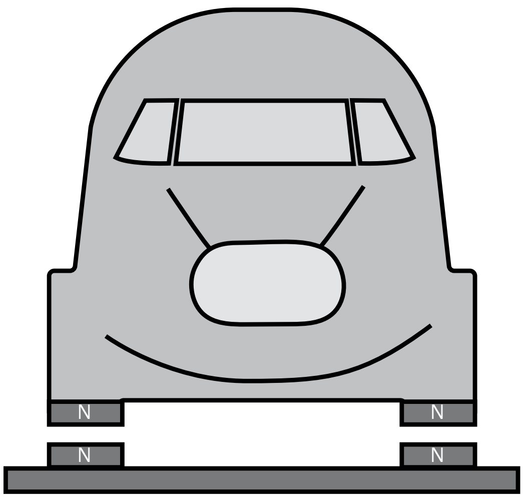
North poles ____________ to south poles, while like or same poles ____________.

13. Based on what you have learned above, how can magnets be used to solve problems? Provide an example in your answer, and use the Core Vocabulary that you have learned during this unit.

___

___

___



14. Study the diagram. Which forces do maglev trains use to levitate?

a) push

b) pull

c) friction

d) gravity

e) magnetism

15. Using the diagram, write two sentences explaining what problem maglev trains solve. Be sure to use the Core Vocabulary that you have learned during this unit.

___

___

___

Activity Pages Answer Key: Investigating Forces

AP 1.1 Push It, Pull It
(page 86)

- Accept all plausible student responses.
- Student draws an object and describes the action or change that makes the object move when pushed.
- Student draws an object and describes the action or change that makes the object move when pulled.

AP 2.1 Lesson 2 Check
(page 87)

1. a, d **2.** b **3.** b **4.** c

AP 3.1 Investigating Forces—Plan (Day 1)
(pages 88–89)

1. Student questions should relate to a specific phenomenon and the forces, balanced and unbalanced, acting during the phenomenon.
2. Student responses should note that balanced forces acting on an object result in no change in motion and unbalanced forces acting on an object result in a change in motion.
3. Accept all plausible predictions to the student questions.
4. Student materials lists should reflect the necessary materials to perform their investigation.
5. Accept all plausible student plans. If student plans require corrections, make notes to them as necessary.

AP 3.2 Investigating Forces—Test (Day 2)
(page 90)

1. Student responses should indicate balanced forces acting on an object at rest or unbalanced forces acting on an object in motion.
2. Student responses should note the object does not move with balanced forces acting on it.
3. Accept all answers about students' predictions.
4. Student explanations should explain why their results do or do not support their predictions.
5. Student responses should indicate attempts to repeat another group's investigation as well as an explanation of how the results were similar or different.

AP 4.1 Table Hockey
(pages 91–92)

Step 2 Student results should indicate if the puck moved across the felted pan and a brief explanation of why or why not.

Step 5 Student results should indicate if the puck moved across the pan with sandpaper and a brief explanation of why or why not.

Step 8 Student results should indicate if the puck moved across the pan with foil and a brief explanation of why or why not.

Step 11 Student results should indicate if the puck moved across the oiled pan and a brief explanation of why or why not.

Step 12
- The felt and sandpaper surfaces make more friction with the puck surface.
- The oiled and foiled surfaces make less friction. Both reduced the friction by making it easier for the puck to slide.
- Students should answer that either the oiled or foiled surface reduced friction the best. Supporting evidence should note that the puck moved faster across the pan.

AP 5.1 Friction Finder
(page 93)

Accept all plausible student responses to the examples students cite.

AP 5.2 Lesson 5 Check
(page 94)

1. a, b, d, e
2. lubricant; opposes
3.
   - Gripping the road with tire treads: Helpful because the tires need to grip the road to move forward and to stop
   - Rubbing hands together to make heat: Helpful when you or your hands get cold
   - Adding oil to the moving parts of an engine: Helpful because it reduces friction in the engine
   - Rubbing two sticks together to light a fire: Helpful when you need some heat to make a fire

AP 6.1 Forces and Patterns (pages 95–96)

Step 2 Accept all plausible student drawings.

Step 3
- Trials 1–3 should show similar results.
- The average should indicate the average of the first three trials.
- Accept all plausible student responses on how to make the pendulum swing exactly 10 times.
- Verify student predictions of the first set of trials to their trial results.

Step 4 Encourage students to write a new prediction based on the changes they made to their pendulum.

Step 5
- Trials 4–6 should show similar results.
- Verify student answers against the results of their trials.
- Verify student predictions of the second set of trials to their trial results.
- Students should accurately paraphrase that a prediction is a claim that something is likely to occur in the future based on present evidence.

AP 7.1 Fishing with Magnets (pages 97–98)

1. Student lists should reflect the contents of the bowl.
2. Accept all student predictions.
3.
   - Student responses should indicate the appropriate metallic objects that were attracted to the magnet.
   - Student responses should indicate if their predictions were correct or not.
4.
   - Student summaries should indicate that all the objects attracted to the magnet were metal or contained metal.
   - Student summaries should indicate that all the objects not attracted to the magnet were not the right type of metal or did not contain metal.

AP 8.1 Lesson 8 Check (page 99)

1. a) stronger

   b) attract

   c) invisible

   d) often across a distance

   e) some materials and not others
2. a) They will attract.
3. Accept plausible student evidence in support of opposite poles attracting.
4. b) They will repel.
5. Accept plausible student evidence in support of like poles repelling.

AP 8.2 Core Vocabulary Review (page 100)

1. balanced **2.** motion **3.** push, pull **4.** friction
5. contact **6.** lubricant **7.** repel, attract **8.** predict
9. unbalanced **10.** magnetism

AP 9.1 Problem and Solution (pages 101–102)

1. Student identifies a simple problem that can be solved by magnets.
2. Student explains the engineering design they would use to solve their problem.
3. Student answers clearly identify wants and needs and differentiate between the wants and needs.
4. Accept all plausible limitations.
5. Student drawings include labels that highlight elements of their design.
6. Student refers to the problem or how the device corrects a want or need.
7. Student notes that the metallic or magnetic objects will be affected by the magnetic force. Student also notes the magnetic force will increase the closer the objects are to each other.

Unit Assessment: Teacher Evaluation Guide

Teacher Directions: The Unit Assessment is not intended to assess student understanding of Next Generation Science Standards (NGSS). Assessment of these standards is done in each unit and lesson through a variety of hands-on and other activities.

The Unit Assessment for students is set as a sixty-point test. Assessment items with simpler answers that test knowledge but not the deeper understandings of the content, such as multiple choice, are worth fewer points. Assessment items that require more complex thinking and a deeper understanding of the content, such as providing short answers that explain phenomena, are worth more points. Assessment items that require more extensive understanding of content—as well as synthesis of that content and other student knowledge—are weighted with more points.

Expected Answers and Model Responses

1. **a)** at rest (1 point for each correct answer)
- **c)** pushing force
- **e)** force from the left
- **f)** force from the right

2. accept either *direction* or *motion* (2 points)

3. (5 points)

Above Average	Student response includes an accurate and detailed explanation of how applying unbalanced forces to objects results in changes in the objects' motion, such as their speed and direction. They should understand that the students are applying unbalanced forces to the large box, pushing it slowly to the right. Response uses at least two Core Vocabulary words or variations thereof.
Average	Student response includes an accurate explanation of how applying unbalanced forces to objects results in changes in the objects' motion, including speed and direction. They should understand that the students are applying unbalanced forces to the large box, pushing it slowly to the right. Response uses no more than one Core Vocabulary word or variations thereof.
Adequate	Student response includes a basic description of how applying unbalanced forces to objects results in changes to one or two of the following: the objects' motion, speed, and direction. It fails, however, to cover all three. They should understand that the students are applying unbalanced force to the large box, pushing it slowly to the right. Response does not include any of the Core Vocabulary words or variations thereof.

Inadequate	Student response includes inaccurate information and does not show an understanding of how applying unbalanced forces to objects results in changes in the objects' motion, including speed and direction. They do not identify the students as applying unbalanced force to the large box, pushing it slowly to the right. Response does not include any of the Core Vocabulary words or variations thereof.

4. Students should identify Picture A as showing balanced forces acting on an object because the object is not moving. (4 points)

5. **a)** It opposes motion or potential motion. (3 points)

c) It occurs when objects are in contact with each other.

d) It occurs when objects slide against each other.

e) It can cause objects to heat up.

6. **a)** helpful (1 point for each correct answer)

b) helpful

c) harmful

d) harmful

e) harmful

7. (8 points)

Above Average	Student response includes an accurate and detailed description of three ways that friction acts on objects. Response includes an accurate explanation of the effects that friction has on the objects.
Average	Student response includes an accurate description of three ways that friction acts on objects, though it is not very detailed. It also includes an accurate but underwhelming explanation of the effects that friction has on objects.
Adequate	Student response includes a fairly accurate description of one or two ways that friction acts on objects, and it includes an explanation, though underwhelming, of the effects friction has on those objects.
Inadequate	Student response does not include an accurate description of the ways that friction acts on objects, nor does it include an explanation of the effects friction has on those objects.

8. predict (2 points)

9. a push

gravity

a pull

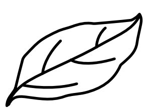
friction

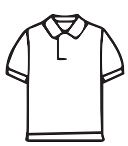
(1 point for each correct answer)

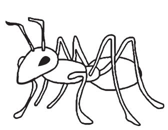
10. (3 points)

Above Average	Student response accurately explains that the cat knocking on the book is a push. Gravity pulls the object down. Gravity is a pull force. Friction from the air acts on the book as it falls.
Average	Student response accurately explains that the cat knocking on the book is a push and that gravity pulls the object down. Friction from the air acts on the book as it falls. Response will not expound on gravity as a pull force.
Adequate	Student response will identify at least two of the following: The cat knocking on the book is a push. Gravity pulls the object down. Gravity is a pull force. Friction from the air acts on the book as it falls.
Inadequate	Student response will identify only one or none of the following: The cat knocking on the book is a push. Gravity pulls the object down. Gravity is a pull force. Friction from the air acts on the book as it falls.

11. (1 point for each correct answer)

a) 

b) 

d) 

e) 

f) 

12. attract, repel (3 points)

13. (5 points)

Above Average	Student response accurately explains the basics of how magnetism works and provides at least three examples of how magnets are used to solve problems. Response also includes at least three Core Vocabulary words.
Average	Student response accurately explains the basics of how magnetism works and provides two examples of how magnets are used to solve problems. Response also includes at least two Core Vocabulary words.
Adequate	Student response explains the basics of how magnetism works and provides one example of how magnets are used to solve problems. Response also includes no more than one Core Vocabulary word.
Inadequate	Student response does not show an understanding of the basics of how magnetism works and does not provide any example of how magnets are used to solve problems. Response does not include Core Vocabulary words.

14. **a)** push (1 point for each correct answer)

e) magnetism

15. (5 points)

Above Average	Student response accurately explains that maglev trains solve the problem of causing a train to go from a resting state to motion and provide an easy solution for using magnetism as both push and pull forces to cause the train to move. Response uses three or more Core Vocabulary words.
Average	Student response accurately explains that maglev trains solve the problem of causing a train to go from a resting state to motion and provide an easy solution for using magnetism as both push and pull forces to cause the train to move. Response uses no more than two Core Vocabulary words.
Adequate	Student response explains one of the following but not both: Maglev trains solve the problem of causing a train to go from a resting state to motion and provide an easy solution for using magnetism as both push and pull forces to cause the train to move. Response uses no more than one Core Vocabulary word.
Inadequate	Student response does not accurately explain either of the following: Maglev trains solve the problem of causing a train to go from a resting state to motion and provide an easy solution for using magnetism as both push and pull forces to cause the train to move. The response does not include any Core Vocabulary.

Appendix A

Glossary

Green words and phrases are Core Vocabulary terms for the unit, and Student Reader page numbers are listed in parentheses. **Bold-faced words and phrases** are additional vocabulary terms related to the unit that you should model for students during instruction and that are often used within the Student Reader, and these latter terms do not have specific page numbers listed. Vocabulary words are not intended for use in isolated drill or memorization.

A

at rest, adj. not moving

attract, v. to pull something closer (22)

B

balanced forces, n. a collection of forces acting on an object that cancel each other out and produce no change in the object's motion (3)

C

cause and effect, n. a relationship between events or objects. When one thing happens, the cause, an effect is created, such as pushing a cart (cause) leads it to roll away from you (the effect).

contact force, n. a push or pull between two objects that are touching each other (8)

D

direction, n. a path along which something moves

distance, n. the space between two or more things

E

engineering design, n. the process by which solutions to a problem are developed

F

force, n. a push or a pull (1)

friction, n. a force that occurs between the surfaces of two objects that are touching (7)

G

gravity, n. a force that pulls objects toward Earth's surface (4)

I

Industrial Revolution, n. a period of rapidly developing technology growth that occurred in the 1800s

L

levitate, v. to float

lubricant, n. a substance that reduces friction between objects in contact (11)

M

magnet, n. a material that applies the force of magnetism (19)

magnetic poles, n. the places on a magnet where the magnetic force is strongest (22)

magnetism, n. a force that can push or pull on some materials without touching them (19)

motion, n. the process of an object changing position (2)

O

oppose, v. to work against (7)

orientation, n. the position of one object in relation to another object

overcome, v. to defeat or conquer

P

patent, n. a government document that gives someone the ownership and rights to an invention

pattern, n. something that keeps repeating (16)

predict, v. to say that something is expected to happen (15)

problem, n. a want or need that requires a solution (25)

pull, v. the application of a force with the intent to move something toward the source of the force

push, v. the application of a force with the intent to move something away from the source of the force

R

repel, v. to push away from (22)

S

solution, n. a plan or object that solves a problem **(25)**

speed, n. the rate at which something moves

strength, n. the amount of force applied to an object

surface, n. the outermost layer of an object

U

unbalanced forces, n. a collection of forces acting on an object that result in a change in the object's motion **(3)**

Underground Railroad, n. a system of roads and hiding places used by slaves in the 1800s to escape to freedom

Appendix B

Classroom Safety for Activities and Demonstrations

In the Core Knowledge Science program (CKSci), activities and demonstrations are a vital part of the curriculum and provide students with active engagement related to the lesson content. The activities and demonstrations in this unit have been selected and designed to engage students in a safe manner. The activities and demonstrations make use of materials and equipment that are typically deemed classroom safe and readily available.

Safety should be a priority when engaged in science activities. With that in mind, observe the following safety procedures when the class is engaged in activities and demonstrations:

- Report and treat any injuries immediately.
- Check equipment prior to usage, and make sure everything is clean and ready for use.
- Clean up spills or broken equipment immediately using the appropriate tools.
- Monitor student behavior to ensure they are following proper classroom and activity procedures.
- Do not touch your eyes, ears, face, or mouth while engaging in an activity or demonstration.
- Review each step of the lesson to determine if there are any safety measures or materials necessary in advance.
- Wear personal protective equipment (e.g., safety goggles, aprons, etc.) as appropriate.
- Check for allergies to latex and other materials that students may have, and take appropriate measures.
- Secure loose clothing, hair, or jewelry.
- Establish storage and disposal procedures for chemicals as per their Safety Data Sheet (SDS), including household substances, such as vinegar and baking soda.

Copy and distribute the Student Safety Contract, found on the next page, for students to read and agree to prior to the start of the first unit, so students are aware of the expectations when engaged in science activities.

Online Resources

For additional support for safety in the science classroom, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Student Safety Contract

When doing science activities, I will

- Report spills, breakages, or injuries to the teacher right away.
- Listen to the teacher for special instructions and safety directions. If I have questions, I will ask the teacher.
- Avoid eating or drinking anything during the activity unless told to by my teacher.
- Review the steps of the activity before I begin. If I have questions I will ask the teacher.
- Wear safety goggles when working with liquids or things that can fly into my eyes.
- Be careful around electric appliances, and unplug them, just by pulling on the plug, when a teacher is supervising.
- Keep my hands dry when using tools and devices that use electricity.
- Be careful to use safety equipment like gloves or tongs when handling materials that may be hot.
- Know when a hot plate is on or off and let it cool before touching it.
- Roll or push up long sleeves, keep my hair tied back, and secure any jewelry I am wearing.
- Return unused materials to the teacher.
- Clean up my area after the activity and wash my hands.
- Treat all living things and the environment with respect.

I have read and agree to the safety rules in this contract.

_______________________________________ ______/______/______/

Student signature and date

____

Print name

Dear Parent or Guardian,

During science class, we want to create and maintain a safe classroom. With this in mind, we are making sure students are aware of the expectations for their behavior while engaged in science activities. We are asking you to review the safety rules with your daughter or son and sign this contract. If you have any questions, please feel free to contact me.

_______________________________________ ______/______/______/

Parent or guardian signature and date

Appendix C

Strategies for Acquiring Materials

The materials used in the Core Knowledge Science program (CKSci) are readily available and can be acquired through both retail and online stores. Some of the materials will be reusable and are meant to be used repeatedly. This includes equipment such as scales, beakers, and safety goggles, but also items such as plastic cups that can be safely used again. Often these materials are durable, can be cleaned, and will last for more than one activity or even one school year. Other materials are classified as consumable and are not able to be used more than once, such as glue, baking soda, and aluminum foil.

Online Resources

The Material Supply List for this unit's activities can be found online. Follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Ways to Engage with Your Community

The total cost of materials can add up for an entire unit, even when the materials required for activities and demonstrations have been selected to be individually affordable. And the time needed to acquire the materials adds up too. Reaching out to your community to help support STEM education is a great way to engage parents, guardians, and others with the teaching of science, as well as to reduce the cost and time of collecting the materials. With that in mind, the materials list can be distributed or used as a reference for the materials teachers will need to acquire to teach the unit.

Consider some of the following as methods for acquiring the science materials:

- School Supply Drive—If your school has a supply drive at any point in the year, consider distributing materials lists as wish lists for the science department.
- Open Houses—Have materials lists available during open houses. Consider having teams of volunteers perform an activity to show attendees how the materials will be used throughout the year.
- Parent Teacher Organizations—Reach out to the local PTO for assistance with acquiring materials.
- Science Fair Drive—Consider adding a table to your science fair as part of a science materials drive for future units.
- College or University Service Project—Ask service organizations affiliated with your local higher education institutions to sponsor your program by providing materials.
- Local Businesses—Some businesses have discounts for teachers to purchase school supplies. Others may want to advertise as sponsors for your school/programs. Usually you will be asked for verifiable proof that you are a teacher and/or for examples of how their sponsorship will benefit students.

Remember: If your school is public it will be tax exempt, so make sure to have a Tax Identification Number (TIN) when purchasing materials. If your school is private, you may need proof of 501(c)(3) status to gain tax exemption. Check with your school for any required documentation.

Appendix D

Advance Preparation for Activities and Demonstrations

Being properly prepared for classroom activities and demonstrations is the first step to having a successful and enriching science program. Advance preparation is critical to effectively support student learning and understanding of the content in a lesson.

Before doing demonstrations and activities with the class:

- Familiarize yourself with the activity by performing the activity yourself or with a team, and identify any issues or talking points that could be brought up.
- Gather the necessary materials for class usage. Consider if students will gather their materials at stations or if you will preassemble the materials to be distributed to the students and/or groups.
- Identify safety issues that could occur during an activity or demonstration, and plan and prepare how to address them.
- Review the Teacher's Guide before teaching, and identify opportunities for instructional support during activities and demonstrations. Consider other support and/or challenge opportunities that may arise as you work to keep students engaged with the content.
- Prepare a plan for postactivity collection and disposal of materials/equipment.

While engaged in the activity or demonstration:

- Address any emergencies immediately.
- Check that students are observing proper science safety practices as well as wearing any necessary safety gear, such as goggles, aprons, or gloves.
- When possible, circulate around the room, and provide support for the activity. Return to the Teacher Guide as students work, to utilize any Support and Challenge opportunities that will make the learning experience most meaningful for your students.

After the activity or demonstration:

- Use your plan for students to set aside or dispose of their materials as necessary.
- Have students wash their hands after any activity in which they could come in contact with any potentially harmful substances.

When engaging students in activities and demonstrations, model good science practices such as wearing proper safety equipment, never eating during an investigation, etc. Good science practices at a young age will lead to students observing good science practices themselves and being better prepared as they move into upper-level science classes.

What to Do When Activities Don’t Give Expected Results

Science activities and experiments do not always go according to plan. Microwave ovens, super glue, and X-rays are just some of the discoveries made when people were practicing science and something did NOT go according to plan. In your classroom, however, you should be prepared for what to do when activities don’t give the expected results or when an activity doesn’t work.

When going over an activity with an unexpected result, consider these points in discussion with your students:

- Was there an error in following the steps in order? You or the student may have skipped a step. To help control for this, have students review the steps to an investigation in advance and make a check mark next to each step as they complete it.
- Did students design their own investigation? Perhaps their steps are out of sequence or they missed a step when performing the activity. Review and provide feedback on students’ investigation plan to ensure the work is done in proper sequence and that it supports the lesson’s Big Question.
- When measurements were taken, were they done correctly? It is possible a number was written down incorrectly, a measurement was made in error, such as wrong unit of measure or quantity, or the starting or ending point of a measurement was not accurate.
- Did the equipment or materials contribute to the situation? For example, chemicals that have lost their potency or a scale that is not measuring accurately can contribute to the success or failure of an activity.

One of the greatest gifts a student can learn when engaged in science is to develop a curiosity for *why something happened*. Students may find it challenging or frustrating to work through a problem during an activity, but guiding them through the problem and figuring out *why* something happened will help them to develop a better sense of how to do science.

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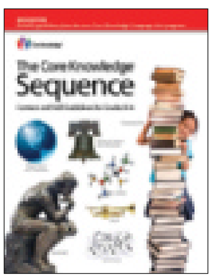
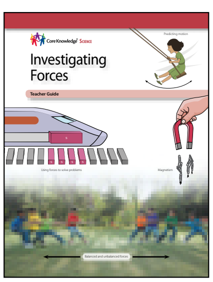


What is the Core Knowledge Sequence?

The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, and the fine arts. In the domains of science, including earth and space, physical, and the life sciences, the *Core Knowledge Sequence* outlines topics that build systematically grade by grade to support student learning progressions coherently and comprehensively over time.



For which grade levels is this book intended?

In general, the content and presentation are appropriate for readers in the middle elementary grades. For teachers and schools following the *Core Knowledge Sequence*, this book is intended for Grade 3 and is part of a series of **Core Knowledge SCIENCE** units of study.

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