Kindergarten Unit 6 Pushes, Pulls, & an Introduction to Magnets

(15–20 days)

Core Knowledge Science Program—Domain Map

Science Content

- Pushes and pulls can have different strengths and directions
- When objects touch, they push on one another even if the objects do not move
- Pushing or pulling on an object can start motion or stop it
- When objects collide they can change the speed or direction of previous motion
- A bigger push or pull makes things speed up or slow down more quickly

- Identify familiar everyday uses of magnets (for example, in toys, in cabinet locks, in "refrigerator magnets," etc.)
- Classify materials according to whether they are or are not attracted by a magnet

This unit contributes to meeting or exceeding the following Next Generation Science Standards:
Standards noted with an asterisk (*) are those that incorporate engineering and design

K-PS2-1. *Plan and conduct an investigation to compare **the effects of different strengths or different directions of pushes and pulls** on the motion of an object.*

K-PS2-2. *Analyze data to determine if a design solution works as intended to **change the speed or direction of an object with a push or a pull.****

K-2-ETS1-2. *Develop a simple sketch, drawing, or physical model to illustrate how **the shape of an object helps it function as needed** to solve a given problem.*

Rationale:

This Kindergarten unit explicitly introduces the core idea of PS2.A: Forces & Motion, as students explore how "objects pull or push each other when they collide or are connected." Students also investigate the effects of different strengths and directions of pushes and pulls relative to the speed/direction of an object's motion (DCI PS3.C). For example, they can explore how changing the motion of toy cars and/or small balls can solve a problem.This unit also contributes directly to the early progression of PS2.B, Types of Interactions and Contact Forces, and provides early, concrete experiences with magnets, which will be explored in more scientific detail in Grades 2 and 4.

The suggested culminating activity for this unit also offers students an opportunity to meet or exceed the engineering standard, ***K-2-ETS1-2***, when students develop and discuss a simple representation of how to solve a problem based on the shape of an object.

This unit offers the opportunity to foreshadow learning that will support the following Next Generation Science Standards	
*2-PS1-1. Plan and conduct an investigation to **describe and classify different kinds of materials by their observable properties.*** *2-PS1-2. Analyze data obtained from testing different materials to determine **which materials have the properties that are best suited for an intended purpose.******	***Rationale:*** Students continue the early progression of PS1.A, started in Unit 5: *Taking Care of the Earth,* as they classify materials according to whether they are or are not attracted by a magnet. In future grades, this progression will continue in G1 U5: Matter & Its Properties; Grade 1 Unit 6: *Introduction to Electricity* (re: conductive versus nonconductive materials); Grade 2 Unit 4: *Magnetism* (re: naturally occurring lodestones versus manufactured magnets); and will then be applied in Grade 2 Unit 5: *Simple Machines* during an engineering design challenge.

Potential Skills & Cross-Curricular Integrations

The connections listed below are intended as ideas for possible integration across this unit. Finding connections in math, in language arts, and in works of poetry, art, and music, may help you as you create meaningful learning experiences for your students. Connections such as these can help your students make links between various disciplines and deepen their understanding of this domain.

POTENTIAL CCSS Math Connections

MP.2 Reason abstractly and quantitatively. (K-PS2-1)

K.MD.A.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. (K-PS2-1)

K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1)

Core Knowledge Sequence Guidelines
Mathematics: Patterns & Classification—Establish concepts of likeness and difference by classifying and sorting objects according to various attributes; define a set by a common property of its elements, and; in a given set, indicate which item does not belong.

POTENTIAL CCSS ELA Connections
RI.K.1 With prompting and support, ask and answer questions about key details in a text. (K-PS2-2) W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS2-1) SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)

Prior Knowledge

Core Knowledge Preschool Sequence
Scientific Reasoning and the Physical World

Goal: Demonstrate an initial understanding of the elements of the material world.

- **Level II:** Observe, describe, and record the effects of magnets on various objects and other magnets.

Core Knowledge Science (previously taught Kindergarten units)
Unit 5: *Taking Care of the Earth*

- Classify objects as recyclable or as garbage *(i.e., this objective supports the growing understanding of the core idea PS1.A, as students continue to classify materials according to observable properties)*.

What Students Will Learn in Future Grades

Core Knowledge Sequence
Grade 2 Simple Machines

- Types of simple machines (e.g., wheel-and-axle, gears: wheels with teeth and notches, how gears work, and familiar uses, such as in bicycles)
- Friction, and ways to reduce friction (lubricants, rollers, etc.)

Grade 2 Magnetism

- Magnetism demonstrates that there are forces we cannot see that act upon objects.
- Most magnets *contain* iron.
- Lodestones: naturally occurring magnets
- Magnetic poles: north-seeking and south-seeking poles
- Magnetic field (strongest at the poles)
- Law of magnetic attraction: unlike poles attract, like poles repel
- The earth behaves as if it were a huge magnet: north and south magnetic poles (near, but not the same as, geographic North Pole and South Pole)
- Orienteering: use of a magnetized needle in a compass, which will always point to the north

Grade 4 Electricity

- Conductors versus insulators
- Electromagnets: how they work and common uses

Core Vocabulary

The following list contains the Core Vocabulary words suggested for purposeful integration across this Kindergarten unit. ***Boldfaced*** *terms can be introduced and/or reviewed with students using a Word Work activity, as modeled by the* [*Core Knowledge Language Arts program*]*(CKLA). The inclusion of the words on this list does not mean that students are immediately expected to be able to use all of these words on their own. However, through repeated exposure across the lessons, students should acquire a good understanding of most of these words and begin to use some in conversation.*

Pushes and Pulls

push, pull, touch, press, force, ***interaction****, connected, tied to, rope, string, wire,* ***balance****, lever, weight,* ***cause****,* ***effect****, strength, size, strong, weak, more, less, direction, way, left, right, up, down, sideways, angle,* ***motion****, movement, slide, roll, move, fall, slip, at rest, motionless, still, unmoved*

Changes in Motion

collide*, crash, hit, propel, bounce, strike, change, alter, divert, different, happen,* ***accelerate****, quick, slow, speed up, slow down, stop, start, friction, contraption, tool,* ***device****,* ***model****, drawing, picture, representation,* ***engineer***

Introduction to Magnets

magnet, magnetism, magnetic, ***phenomenon****, invisible,* ***property****, ability, field,* ***attract****,* ***repel****, hold, stuck, pole, north, south,* ***material****, metal, filings, iron, nickel, cobalt*

Classifying Objects with Magnets

classification, ***classify****, sort,* ***matter****,* ***characteristic****, attribute, size, shape, color, set, group, same, alike,* ***common****, different, unlike, familiar, everyday, objects, type, paper clip, staple, coin, [other everyday objects attracted to magnets]*

Potential Misconceptions

Students have been shown to learn significantly more science when their teachers demonstrate strong knowledge of potential student errors, and when the teacher plans accordingly (Sadler & Sonnert, 2016). The following incorrect statements serve as a sampling of the "intuitive theories" or "alternative conceptions" that students and teachers may actively use to describe their thinking, and which might interfere with the process of learning. The details following each statement are not intended to imply the scope of instruction for this grade, but instead provide a clearer sense of what students (of all ages) often misunderstand and/or overgeneralize when investigating and describing scientific ideas.

Misconception: "Forces only occur when motion is changed," or **"Only moving objects have forces acting on them."**
Students of all ages can fail to recognize that objects at rest experience forces. Activities and discussions using a leveled balance or lever can help to demonstrate that forces exist when motion does not.

Misconception: "Objects in motion within a curved tube/path will continue to curve when the object exits the tube/path."
Students of all ages may believe that a track or path will influence an object's motion even after the track ends (Mayer, 2007; McClosky, Caramaza, & Green,1980). When an object exits the curved path, the force exerted by the path is removed, so the object will actually continue in a *straight line.* To explore this concept with early elementary students, Page Keeley offers a formative assessment probe, the "Marble Roll," in her book *Uncovering Student Ideas in Primary Science* (page 71, 2013).

Misconception: "A large magnet is stronger than a small magnet."
Young students often think a larger magnet will have a larger effect, using a "more of A, so more of B" logic (Keely, 2013). Teachers should be aware of the examples used during instruction, using small, strong magnets as well as larger, weak magnets to draw attention to the differences in size and strength of the forces.

Misconception:"Magnetism is a type of gravity."
Students of all ages may think that gravity and magnetism are related and "interchangeable" terms (AAAS, Volume 2, page 26, 2007). In later grades, for example in CK Science, Grade 2 Unit 4: *Magnetism*, teachers should be especially aware of this misconception when exploring the ideas of orienteering using compasses and the early study of earth's magnetic field.

Misconception: "Magnets don't work where there is no air."
Similar to misunderstandings about gravity, some students believe that magnetism is observable on earth, but not in space. This may be related to misunderstandings of gravity and magnetism as "interchangeable." (Arons, 1997; Driver et al, 1994)

Key Points for Instruction:
Children need to develop the language tools to describe motion appropriately prior to developing an understanding of the principals of motion (Driver, Squires, Rushworth, and Wood-Robinson, 1994). It is highly recommended that teachers scaffold and promote vocabulary development during this unit, using strategies such as Word Walls (Keely, 2013).

Elementary students are usually familiar with the behavior of magnets, but they may not explain that behavior in terms of forces (i.e., they may not recognize that a magnet moving or sticking to an object is the effect of a push or pull). (AAAS, Volume 2, page 26, 2007)

Potential Objectives for This Kindergarten Unit

The organization of the following objectives reflects the order in which they are expected to be addressed.The proposed timing within the unit ("beginning," "middle," or "end") and aligned NGSS are also noted. In addition to daily lessons focused on each objective, days have been built into the unit for review and assessment.

Beginning

- Predict how pushes and pulls affect objects.
- Describe what happens when objects touch.
- Identify whether the force between two objects is a push or a pull.
- Describe the direction of a push or pull.
- Apply your knowledge of forces to balance a lever.

Middle

- Compare the strength of force applied to reach different distances.
- Describe the term 'motion.'
- Identify what causes a change in motion.
- Predict what will happen when two objects collide and push on each other.

End

- Describe different ways magnets are used in everyday life.
- Describe the term 'attract.'
- Classify materials according to whether they are or are not attracted by a magnet.
- Describe the term 'repel.'
- Apply your knowledge of forces and magnets to solve a problem.

Potential Big Guiding Questions

Essential Questions:

- **Can you predict what will happen when objects touch or collide?**
- **Where can we find magnets in our classroom?**
- **What kinds of objects are attracted to a magnet?**

RE: Pushes and pulls

- What is keeping this object at rest?
- How are pushing and pulling similar/different?
- How can you balance this lever?
- What happens when a stronger/weaker force is applied to an object?
- What happens when a force is applied in a different direction?
- How might you push/pull this object to our target?

RE: Magnets

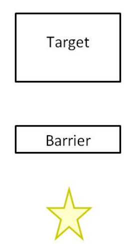
- Can you predict what will be attracted to a magnet?
- What is the difference between the terms ‘attract’ and ‘repel?’
- Can you solve a problem using your knowledge of forces and magnets?

Potential Assessment Opportunities

The following assessment tasks serve as a sampling of how students can demonstrate mastery of lesson objectives. Each aligned objective and NGSS is noted in parentheses. In addition, the proposed timing (“beginning,” “middle,” or “end”) is noted in order to indicate approximately when the assessment should take place.

Culminating Performance Assessment: Applying Pushes & Pulls (End of Unit 6; also see Potential Activity, Example #1)

Advance Preparation:



- You will need to provide students with the following materials:
  - A small ball
  - A barrier (e.g., set of blocks or books)
  - A large flat target (e.g., piece of paper or paper plate)
  - A starting position (e.g., paper circle or star)
  - An array of child-friendly materials that students can use to help direct the ball to hit the target (e.g., a toy car ramp, large blocks, lincoln logs, bins/containers, etc.)
  - Paper on which students can draw model representations of their “contraptions” and illustrate how the contraptions will help the ball to hit the target
- Tape the starting position and target on the floor or large table. Place a small “barrier” in between the two (see sample diagram above at right).

Task Assessment: Challenge your students to be engineers and inventors in this culminating performance task. Explain that they will draw a model illustrating how their contraptions can be used to direct the ball to hit the target. This task assessment will be completed across two days.

Day 1:

Have students sit around the table or area where you have placed the objects (i.e., starting position, barrier, and target). Describe to students that you have a simple problem for them to solve and that they will be engineers as they help you to find a variety of solutions.

T—I want to push this ball so that it rolls and hits this target. Do you think I will be able to do that? After providing students with thirty to sixty seconds of think-time, ask them to share their thoughts. Students should conclude that one would not be able to do this because of the barrier between the ball and the target. Model what happens when one pushes the ball toward the target.

T—What happened? Students should describe the event of the ball bouncing off the barrier.

T—Do you think if I change the amount of force I apply, I can make the ball hit the target? In response to students who say, "Yes," ask, **How much force do you think I should apply?** (Encourage students to use descriptors such as lighter, weaker, less, strong, heavy, or hard). Turning to students who say "No,"ask, **Why don't you think I can hit the target by applying a weaker or stronger force?** Prepare to demonstrate what happens when the ball is rolled toward the barrier with greater/weaker force (based on student feedback). If you are applying a greater force, you may wish to have all students move to the side of the table/floor by the target, to avoid anyone being hit by the ball when it bounces off the barrier. Roll the ball, and discuss why a greater/weaker force will not be an effective way to reach the target behind the barrier.

T—If we can't get through the barrier, how can we reach the target? Through questioning, help students arrive at the idea that they can reach the target by finding a way around or over the barrier.

Display an assortment of materials from your classroom that students can work with (e.g., a toy car ramp, large blocks, bins/containers, etc.).

T—You are going to choose from these materials to build a "contraption" that will help our ball to reach the target. What are two ways that the ball could reach the target? If students suggest that the ball could move over the barrier, say, **Since we can only roll the ball, we will need to build or use something that can roll the ball over the barrier.** You may want to model some non-examples and demonstrate some ideas that will not work, such as building stairs with blocks, so that students understand that to move the ball over the barrier, they will need a smooth surface. If students suggest moving the ball around the barrier, ask, **Can the ball be rolled on a curved surface? Think about what you could build to help get the ball to the target if you rolled it to the side.** Be sure to ask students to use words learned in this unit regarding direction and strength of forces, as well as those regarding changes in motion.

Ask students to return to their individual seats, and pass out paper to them. Explain that they will each draw a picture model that illustrates how to use material(s) to solve the problem (i.e., to help the ball reach the target). Remind students that they can only roll the ball, and leave the starting point, barrier, target, and materials visible as they work. Rotate around the room, and ask students to describe their models, making note of keywords or phrases used by each student. Ask how much force they would apply to the ball, in which direction, and why. Encourage students to think about the relationship between their contraption's shape and their solution (e.g., a ramp is slanted to help carry the ball over the barrier). If possible at the end of the day, photocopy their picture modes so you have a copy of their first drafts.

Day 2:

Explain to students that you would like them to share their models from Day 1 with one or two partners. Encourage students to tell their partners how they think their contraptions will help the ball hit the target. Remind students to use descriptions of the amount of force they think is needed and in which direction. As students share, walk around the room, making note of their ideas. Identify at least two to three models that you believe will solve the problem when tested and, while students continue to discuss, gather the materials that these students will need to build their contraption.

One at a time, ask these two or three students to share their picture models with the class. Assist (or encourage several other students to assist) each student with building/positioning his or her contraption as the model is described. Once built, have students stand around the starting point, barrier, and target. (**Safety Note:** As students test their models, it may be best to move other students back a safe distance so they are not accidently struck by the ball.) As each child tests his or her model, ask him or her to describe the amount of force he or she is applying, the direction of that force, and why. For example: **"Why wouldn't you want to apply a very strong force when rolling the ball up the ramp?"** or **"Why wouldn't you apply a weak force when rolling your ball toward the wall you made out of building logs?"**

After the two to three demonstrations, ask students to return to their seats and to compare their own picture models with what they have just seen.

T—A part of an engineer's job is finding ways to improve her or his original model. Look at the model you drew yesterday. Think about what your classmates just showed us, and how you can change your model to solve our problem in a better way. It can be a big change or a small change. For example, do you think using different materials would be better? Or, do you think you can make your drawing better with more details?

Give students a minute to think about what they should do. After signaling that they can begin drawing, rotate around the room, asking students to describe how and why they are adjusting their models. If some students wish to create very different models compared with their original drafts, it may be helpful to provide them with another piece of paper.

Potential Activities & Procedures

The following activities or procedures serve as a sampling of what instruction could look like in this unit. Each example was specifically designed to contribute to one or more of the aforementioned objectives. In addition, the proposed timing ("beginning," "middle," or "end") is noted in order to indicate approximately when the activity should be conducted during this unit. Aligned NGSS are noted in parentheses.

Example #1: (Middle of Unit 6)

{Objective: Compare the strength of force applied to reach different distances.}

Advance Preparation:

- This activity requires direct teacher supervision of a small group. It is most effective when used as a station or part of a series of small group activities.
- Provide two targets (e.g., small hoops, plastic cups, or paper plates) that are labeled 'A' and 'B' that you will use to mimic a mini golf game.
- Provide a small ball (e.g., a plastic or foam ball). One to two extra balls may help facilitate the activity as well.
- Provide one object that can be used to push the ball toward a target (e.g., a toy golf club or any child-safe object that can be used to propel the ball toward the targets). **Safety Note:** It is

recommended that only one toy golf club or other object is used and that it is monitored closely by the teacher as groups rotate to complete this activity.

- In a relatively open area of your classroom, set the targets in two locations at different distances (in approximately the same direction). Depending upon your classroom space, you may wish to complete this activity in an alternate location, such as outdoors or in a gymnasium.
- Identify a good “starting position” from which you believe students will be able to successfully hit a ball onto/into each target. Be sure that the targets are at different distances so that your students can discuss differences in the amount of force needed to successfully hit their target.
- Before conducting this activity, consider any extenuating circumstances that may require adjustments in order for students to successfully and safely complete the activity.

Activity: Through this activity, students will investigate and discuss the concept of “bigger” and “smaller” forces through concrete experiences.

Explain to students that they will work as part of a small group to propel a ball to hit two targets. [**Safety Note:** It is recommended that the teacher sets ground rules for how the toy golf club or other object is to be used safely and that the teacher closely monitors the student attempting to hit the ball towards the targets.] Identify the first target (‘A’ or ‘B’), and ask a volunteer from the group to aim the ball and hit it. If the student hits the target, ask him or her to describe the force he or she applied. If he or she misses the target, ask the group to describe what could be done next time to hit the target from the starting position (e.g., apply more/less or stronger/weaker force). (If applicable, you can also discuss the direction of the force, however, help students to address the amount of force and the direction each separately.) In addition, looking at the ball’s new position, you may ask the group to think about the amount of force that would need to be applied since the ball is now closer to or further from the target. When aiming for the second target, ask group members to predict whether more or less force should be applied to hit it and to explain their prediction. After a different child from the group attempts to hit this target, ask the students if their predictions were correct. You can add a layer of challenge by asking students to compare the forces they used to push the object to “hit the mark” when aiming at target ‘A’ versus target ‘B.’

Time permitting, consider extending this activity by setting the targets in opposite directions but at the same distance. Engage students in a conversation about applying a push force in different directions.

Example #2: (End of Unit 6)

{Objective: Classify materials according to whether they are or are not attracted by a magnet.}

Advance Preparation:

- Prepare your room so that students will have easy access to various objects that are and are not attracted to a magnet. For example be sure that classroom supplies, such as paper, pencils, toys, paper clips, coins, etc., are accessible for students to complete a small-group “scavenger hunt” around your room. Their goal will be to collect six items, in groups of two to three, including three items that are attracted to magnets and three that are not.

- Ensure that you have enough child-safe magnets, one for each student, so that all students can participate and demonstrate their reasoning through nonverbal responses, as you also probe for verbal answers to your questions.

Activity: Ask students to share what they have learned about magnets so far (e.g., ways that magnets are used in everyday life and/or a working definition of the term "attract" that was developed in an earlier lesson). Then, invite your students to participate in a "magnetic scavenger hunt" for items around your classroom. Their goal, in groups of two to three students, is to collect at least three objects that are attracted to a magnet as well as three objects that are not. [**Safety Note:** It is recommended that the teacher sets ground rules for behavior during the scavenger hunt. For example, that all students should walk and be courteous of others and that groups should stay together while searching for items around the room.] Before starting the scavenger hunt, provide time for all groups to brainstorm ideas of what they might collect to meet your challenge, for example, using the Think-Pair-Share protocol. Give student groups thirty to sixty seconds to discuss possible objects that they could collect, and then provide all students with a child-safe magnet. Also ask your students to think about the following question as they complete the hunt: "How will I know whether an object is attracted to a magnet or not?" Setting a time limit, such as three to five minutes, invite each group to collect a variety of classroom objects that match your challenge.

Periodically provide students with a time check, letting them know, for example, that they have two minutes left to complete the challenge, etc. When the time limit is up, ask students to sit with their groups at tables or on the carpet. Provide at least two to three more minutes for students to organize their items and to come to a consensus about why each item fits your challenge/criteria.

Then, ask each group to pair with another set of students to share what they found and to discuss why it fits your challenge. (Hint: to spur productive listening, consider asking your students to share what the partner group found before sharing what they found themselves.) Rotate through the groups as they share, probing for more information about what they were thinking about each object and why (e.g., "How do you know that this item is/isn't attracted to a magnet?"). When groups are finished sharing, ask for volunteers to share another group's examples first and then to share their own.

Websites & Media

PBS Kids—Sid the Science Kid's Balancing Game: http://pbskids.org/sid/balancingact.html

Consider using this interactive game to introduce or support your discussion of balances, levers, and the forces that objects exert/experience even when they are at rest.

How Stuff Works:

The web pages below can help you to enhance your background knowledge of magnets and magnetism. They may also be useful for teaching about magnets during future domains, such as astronomy, geology, and matter.

- **Magnets** http://science.howstuffworks.com/magnet.htm
- **Compasses** *(Foreshadowing Grade 2)* http://adventure.howstuffworks.com/outdoor-activities/hiking/compass.htm
- **Stuff to Blow Your Kid's Mind: Magnets** *(Foreshadowing Grades 1, 2, and 4)* http://shows.howstuffworks.com/stuff-to-blow-your-mind/51304-stuff-to-blow-your-kids-mind-magnets-video.htm

Supplemental Trade Books

- *What Magnets Can Do,* by Allan Fowler (Children's Book Publisher, 1995) ISBN 051646034X
- *What Makes a Magnet,* by Franklyn Branley and True Kelley (HarperCollins, 1996) ISBN 0064451488

Recommended by the National Science Teachers Association:

- *Magnetic and Nonmagnetic* (My World of Science), by Angela Royston (Heinemann Educational Books, 2003) ISBN 140343168X
- **Teacher Reference:** *Stop Faking It! Force & Motion*, by William C. Robertson (NSTA Press, 2002) ISBN 9780873552097