Non-Contact Forces Unit Grade 3

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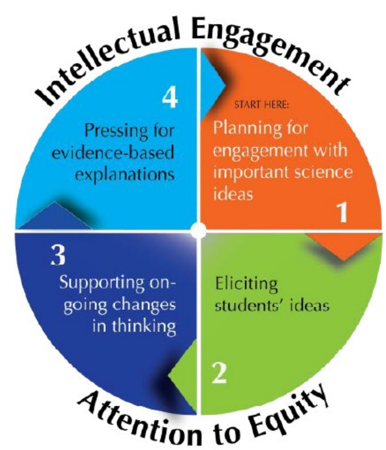
Ambitious Science Teaching Framework



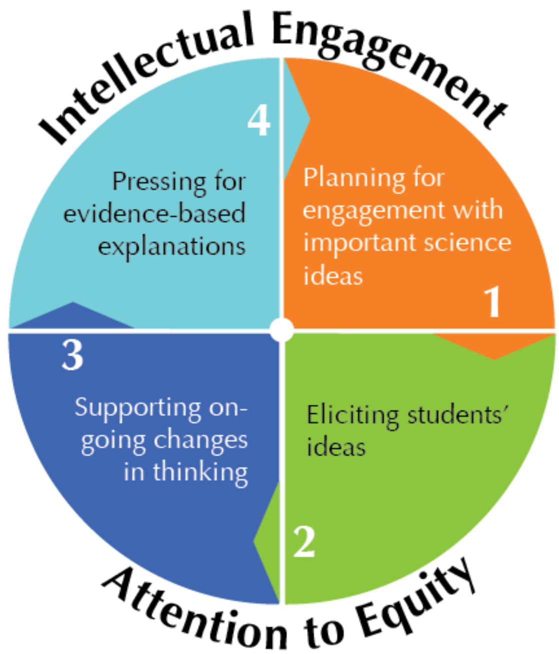
Unit Synopsis:

Students investigate a phenomenon of how the magnets on a magnetic ring toy appear to levitate and how, after compressing and releasing them, the magnets spring up into the air. Over the unit, students learn about balanced and unbalanced forces to work towards explaining how and why the gaps between magnets are different sizes and how the magnets move or 'float' in particular ways.

This unit is structured into two sets of lessons. First, students learn about pushes and pulls, material properties, magnetic fields, and how multiple forces can act on one object to explain how the magnetic ring toy works. Then, students ask questions, design and conduct their own investigations, and write an informational text to answer their testable questions about magnets and magnetism. Ultimately, students develop and revise evidence-based models to explain how the magnetic ring toy works and then apply these ideas to explain their investigation data and other magnetic force-related phenomena that we use in everyday life.

Ambitious Science Teaching

We provide here a vision of ambitious teaching—teaching that is effective, rigorous and equitable. But more than that, we provide a framework of research-based teaching practices that are consistent with this vision and a wide range of tools that can transform how students learn in your classroom. The vision, practice, and tools will furnish a common language about teaching for a group of science educators committed to the improvement of teaching. You will be able to identify “what we will get better at” and how to get started.



Ambitious teaching aims to support students of all racial, ethnic, and social class backgrounds in deeply understanding science ideas, participating in the talk of the discipline, and solving authentic problems. This teaching comes to life through four sets of teaching practices that are used together during units of instruction. These practices are powerful for several reasons. They have consistently been shown through research to support student engagement and learning. They can each be used regularly with any kind of science topic. And finally, because there are only four sets of practices, we can develop tools that help both teachers and students participate in them, anyone familiar with the practices can provide feedback to other educators working with the same basic repertoire, teachers can create productive variations of the practices, and everyone in the science education community can share a common language about the continual improvement of teaching.

The four Ambitious and Equitable Science Teaching Practices are summarized in the below.

Practices	What does it LOOK like?
Planning for engagement with important science ideas	• Planning a unit that connects a topic to a phenomena that it explains (Chemical Reactions – Bike Rusting, Photosynthesis – Seed Becoming a Tree) • Teaching a topic within a real-world context
Eliciting students’ ideas	• Asking students to explain HOW and WHY they think a phenomena happens (How did the bike change? Why did it change? What is happening at the unobservable level?)
Supporting on-going changes in thinking	• Using ALL activities/lessons to explain the phenomena. • Giving students opportunities to revise their thinking based on what they’re learning
Pressing for evidence-based explanations	• Allowing students to create a final model or explanation about the phenomena • Pressing students to connect evidence to their explanation

Many teachers want to know what their classrooms should look like and sound like—they want to understand how to interact with their students about science ideas and students' ideas. This is especially true now that the *Next Generation Science Standards* are being used in many states.
As a result of the last 30 years of classroom research, we know enough about effective instruction to describe in clear terms what kinds of teaching practices have been associated with student engagement and learning. This research tells us that there are many ways that teachers can design and implement effective instruction, but that there are common underlying characteristics to all these examples of teaching that can be analyzed, described, and learned by professionals. These practices embody a new form of "adaptive expertise" that EVERY science educator can work towards. Expert teaching can become the norm, not reserved for a select few. Ambitious teaching is framed in terms of practices that any teacher can learn and get better at over time. What would we see if we entered classroom of a science educator using ambitious teaching? To give you a sense of what ambitious teaching looks like, we have described below some features common to all science classrooms where ambitious teaching is being implemented (listed on right). These features address everyday problems with learning and engagement that teachers face (listed on left).

Common problems in supporting student engagement and learning	**What you'd see in a science classroom where ambitious teaching is the aim**
The problem: *Students don't see how science ideas fit together.* Each day is perceived by students to be the exploration of ideas that are unconnected with previous concepts and experiences.	At the beginning of the unit, students are focused on developing an evidence-based explanation for a complex event, or process. Students know that throughout unit, most of the activities, readings and conversations will contribute to this explanation.
The problem: *An oversimplified view of what it means "to know."* Science ideas perceived to be straightforward and learnable within a lesson—either you get it or you don't."	An idea is never taught once and for all, but revisited multiple times. Students' science explanations are treated as partial understandings that have to be revisited over time to become more refined and coherent.
The problem: *Lack of student engagement.* Students' experiences and interests not elicited or seen as relevant. Student ideas treated as "correct" or "incorrect."	Students' ideas and everyday experiences are elicited and treated as resources for reasoning; students' partial understandings are honored as a place to start. They are made public and built upon.
The problem: *Students reluctant to participate in science conversations.* Teachers dominate the talk, ask primarily for right answers, get brief responses from students.	Teachers use a varied repertoire of discourse moves to facilitate student talk. Guides and scaffolds for talk help students feel comfortable interacting with peers.
The problem: *Some students have little support for accomplishing tasks that would otherwise be within their grasp.* Little or no guidance for students' intellectual work. Giving "clear directions" is seen as enough to ensure participation in activities.	There is scaffolding that allows students to participate in science-specific forms of talk, in group work, and in science practices.
The problem: *Invisibility of student ideas and reasoning.* Teacher does not know what students think—their heads are a black box. Cannot then work on students' ideas. Students cannot take advantage of the ideas or ways of reasoning by their peers.	Students' thinking made visible through various public representations (tentative science models, lists of hypotheses, question they have, etc.). The teacher can see how students think and how that thinking could change over time. Students benefit from seeing and hearing the reasoning of others.
The problem: *Illusion of rigor.* Students reproduce textbook explanations, lean on vocabulary as a substitute for understanding. Talk of evidence and claims are rare.	The teacher presses for complete, gapless explanations for unique real-life events or processes, and press for the use of evidence to support claims.

As you will see, ambitious teaching is not a "method," and the teaching practices are not scripts. It is a set of principled practices that must be adapted to your classroom needs. Coaches and other teachers can work with you to do this ambitious work.

Forces & Motion Unit Overview - Grade 3 - Magnetism

In this unit, students consider: *How can non-contact forces acting over a distance on an object cause the object to start moving, stay moving, stop moving, or remain still?* To address this, students learn about science ideas to explain how a magnetic ring toy works. They ask questions, determine which questions are testable, and, with guidance, conduct investigations to collect data that helps answer their questions about magnets and the effects of non-contact forces and the motion or position of objects.

Phenomenon

A magnetic ring toy has a magnetic base and a plastic stick to hold donut-shaped magnets. These magnets have different distances between them and move in different ways depending on how they are oriented and if we push or pull on them.

- Why are there sometimes spaces between the donut-shaped magnets? Do the gaps change size when adding/removing magnets? Why do you think this happens?
- Push the magnets down and then let go. What happens? Why do the magnets separated by gaps seem "bouncy"?

Next Generation Science Standards*

Below are performance expectations targeted in this unit. The three dimensions—Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Cross-cutting Concepts (CCC)—should be combined in a variety of ways to support student sensemaking in three-dimensional learning experiences.

- **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.** [Clarification Statement: Examples include an unbalanced force on one side of a ball makes it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]
- **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.** [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [Assessment Boundary: Assessment does not include technical terms such as period and frequency.]
- **3-PS2-3. Ask questions to determine cause & effect relationships of electric or magnetic interactions bet. two objects not in contact with each other.** [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; 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 the 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.]
- **3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.** [Clarification Statement: Examples of problems could include constructing a latch to keep the door shut and creating a device to keep two moving objects from touching each other.]

Science & Engineering Practices	Disciplinary Core Ideas	Cross-cutting Concepts
Asking Questions and Defining Problems Ask questions that can be investigated based on patterns such as cause and effect relationships. Define a simple problem that can be solved through the development of a new or improved object or tool. ***Developing and Using Models*** Use models to describe phenomena. ***Planning and Carrying Out Investigations*** Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	***PS2.A: Forces and Motion*** ● Each force that acts on one object has both strength and direction. An object at rest typically has multiple forces acting on it, but they add up to give a zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction. ● The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. ***PS2.B: Types of Interactions*** ● Objects in contact exert forces on each other. ● Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	***Cause and Effect*** ● Cause and effect relationships are routinely identified,tested, and used to explain change. ***Patterns*** ● Patterns of change can be used to make predictions

* *Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor lead states & partners that developed Next Generation Science Standards were involved in the production of this product, and do not endorse it.*

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Big Science Ideas

1. **Objects exert forces on each other.**
   Objects that touch each other can put force on each other (contact force), like a foot pushing a soccer ball. However, electric, magnetic, and gravitational forces between objects do not require objects to touch to exert forces on each other (non-contact forces). We can classify forces as pushes or pulls.

2. **Forces between objects can cause changes in motion.**
   Forces can cause objects to start moving, stay moving, change direction, change speed, stop moving (unbalanced forces). Forces are always present even if there is no detectable motion (balanced forces). Motion is relative -- a comparison between the object in motion and a reference point.

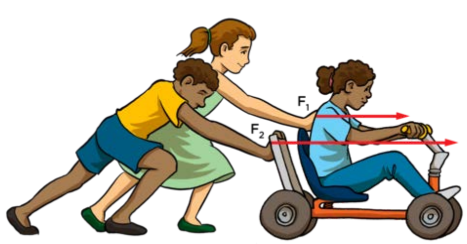
3. **The strength of a force acting on or between objects depends on several factors.**
   Properties of the objects (i.e. mass, size, or material), initial speed of the objects, distance between the objects, orientation of objects relative to each other can affect how much force is needed to change the object's motion or position.

4. **Forces transfer energy from one place to another.**
   When two objects interact, each one exerts a force on the other, transferring energy between the objects which often manifests as a change in motion, sound, light, electric current, or if the forces are equal and opposite, the system remains stable. For non-contact forces, the energy is often described as stored in a force field around an object, like a magnet (magnetic force field) or planet (gravitational force field). *[This idea is beyond standard for grades 3-5 but could be introduced if students bring up language of energy.]*

Big Idea Statement for Student Understanding

***If** students can* identify multiple forces acting on and between objects in the given scenario AND represent the relative strengths and directions of these forces…

*…**then** students will be able to* justify their predictions about the motion and position of the objects in the given scenario.

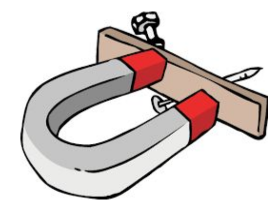


Contact Forces: A Pushing Example

Two people pushing a cart in the same direction add their forces together (net force on the cart) motion in one direction. Typically, scientists use the length of an arrow to represent the strength of the force. There is friction in the opposite direction between the wheels and the ground but the rolling of the wheels helps overcome friction, hence the forward motion moving the cart.

Non-contact Forces: Gravitational Force

One example of non-contact forces is the gravitational attraction between a parachute jumper and the Earth. The gravitational force pulls the parachute jumper towards the Earth because the Earth is much more massive than the person. The jumper uses a parachute to "catch air" and slow down creating a drag force (contact force) in the opposite direction. The force of drag is not equal to gravity but it is strong enough to slow the parachuter to land safely.



Non-contact Forces: Magnetic Force

Magnetic force is a non-contact force; A magnet can pull or push on objects without touching them. Magnets are only attracted to a few 'magnetic' metals and not all matter. Magnets are attracted to and repel other magnets. The force of magnetism acts at a distance without touching the magnetic object or other magnet. Stronger magnets cause motion from farther away than weaker magnets. Like with gravity, magnetism acts through other materials and cannot be blocked. Unlike with gravity, every object has mass and therefore has a gravitational pull (even a tiny one); however, not all objects have a magnetic field.

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Teacher Background Content Knowledge

The purpose of this unit is for students to develop their understanding of how forces between objects change or maintain the motion of objects. The motion of the donut magnets with the magnetic ring toy is an engaging anchoring event focusing on *non-contact* forces. The magnet toy should not be the only context within which students consider forces and motion. Therefore, this unit contains other real-world examples alongside developing the explanation of how and why the magnetic ring toy works (e.g., sometimes has gaps of different sizes, can “launch” the top magnet off the top, bouncy like an ‘invisible spring’.)

When do objects start moving?

Objects need a push or pull to start moving. For example, a soccer ball remains still until it is kicked (pushed) by someone’s foot. The foot makes contact with the ball. Scientists call these *contact* forces. Students observe objects touching if they see or feel the contact with an object.

There are also forces that can push or pull objects *without* touching them, such as magnetic force and gravitational force. If a magnet is moved close enough to a magnetic object, like a paperclip, it will attract or pull that object to the magnet. This is a *non-contact* force because the pull and subsequent motion of the paperclip happens without the magnet touching the paperclip. Scientists call these forces *non-contact* forces because there is no contact needed to change the motion of the object.

In the case of the magnetic ring toy, the donut magnets exert magnetic forces on each other if they get close enough to be within their magnetic fields. If the same poles (sides) of the magnets are facing/oriented towards each other, the force will push apart the magnets until the forces are balanced between the downward gravitational pull and the repulsive magnetic force such that the magnets stop moving, leaving a visible gap. If the opposite poles (sides) of the magnets are facing each other and the magnets are close enough (within their magnetic fields), the magnets attract and pull towards each other until they touch, leaving no gap. Magnetism works at a distance but the limits of this distance are due to the strength of the magnetic field of a given magnet.

When do objects stay moving?

Objects that are moving on a surface, like a pencil rolling on a desk, a soccer ball rolling across a field, or a paper airplane gliding across the room will stay moving for some period of time depending on the strength of the initial push/pull AND on the mass of the object. *Example: One pencil will roll farther than another pencil if it’s pushed with more force.*

Objects only stay moving if there is a continued push or pull on the object. A soccer ball stays in motion if the player keeps kicking it. Pushing a shopping cart full of groceries (more mass) needs more force to get it moving than an empty shopping cart (less mass). The full shopping cart won’t stay moving as long unless the person keeps applying a force (pushing it). Without this constant push or pull the object will slow down and stop moving relative to the Earth as other forces slow down and stop the moving object.

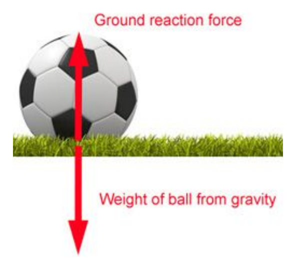
When do objects stop moving?

Objects stop moving because there is a force applied in the opposite direction to the object’s motion. For example, Player A kicks the soccer ball to Player B who stops the ball with her foot by stepping down on the ball. If Player B misses the ball, the ball will eventually roll to a stop because the friction between the grass and the ball slows the ball down to a stop.

Balanced & Unbalanced Forces

One way scientists describe forces acting on an object is whether forces are balanced or not. If the forces on an object change (and do not cancel each other out), then the object’s motion changes (direction and/or speed).

Example: At first, the ball is still. It is pulled to Earth by the gravitational force between the ball and the Earth. These forces are in *balance,* the pull of gravity between the ball and the Earth is equal to the force supporting that weight (reaction force or also called a normal force). There are no horizontal forces on the ball.



When a soccer player kicks the ball (horizontal push), it moves in a given direction with a certain speed. The kick force is greater than the opposing frictional force between the ball and grass. These forces are unbalanced, showing a change in motion.

For the magnetic ring toy, students may notice that the donut magnets bounce, jiggle, or move a bit on their own before stopping. The magnets move when they get within the distance of their respective magnetic fields. There is a “tug-of-war” between the magnetic attraction or repulsion between the donut magnets and the downward pull of the Earths’ gravitational force until a balance between these forces is achieved and the magnets stop moving.

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Unit Roadmap

- **Pacing**: This unit takes about 7 weeks if lessons happen 3-4 times per week (+1 week if using extensions). Lessons span multiple days (1 day = 45 mins).
- **Unit organization**: The order of lessons as written is intended to help students build on their understanding over time. Below, lessons are organized into two sets of lessons plus some ideas for extensions. To support your students' learning, you should make adjustments to the lessons suggested below using your formative assessment observations from student talk, models, and explanations to best support your students' sensemaking about magnetic forces and motion.

Set 1: Explaining a toy *How does the magnetic ring toy work?* *Timeframe: 14-15 days, 4 weeks*

	Lesson	Question	Phenomena/Problem	What students figure out
1	Introduce phenomenon	How does the magnetic toy work?	*[Introduce the magnetic ring toy. How does it work? What are students curious about?]*	Students compare observations and ideas about how the magnetic ring toy works. Students come up with ways to represent the 'invisible cushion' or 'force field' that they observe.
2	Non-contact force: Magnetism	When do magnets push? When do magnets pull?	Students noticed in L1 that donut magnets sometimes snapped together or flipped themselves over to snap together. Why does that happen?	Magnets must be oriented in particular ways to either repel each other (push apart) or attract each other (pull together). This idea helps contribute to explaining why there are sometimes gaps between magnets in the toy and sometimes not.
3	Non-contact force: Gravity	What's going on with the gaps between magnets?	Students noticed in L1/L2 that gaps between magnets are different sizes. *Why are the gaps on the bottom smaller than on the top of the magnetic ring toy?*	Students consider the interactions of two forces (gravity and magnetism) to explain the size of the gaps. The gaps are smallest on the bottom because the Earth's gravity is pulling down so the bottom gap "feels" the weight of the upper magnets. When the toy is horizontal, all the gaps are equal because gravity is perpendicular to magnetic forces and does not "pull sideways."
4	How Unbalanced Forces Cause Motion	Which force "wins"? How do we know?	Students build on their thinking from L3 about how different forces act on an object and how that might result in changes in motion. *How do unbalanced forces cause motion?*	Students figure out how the strength and direction of forces (both magnetic force from the magnet and gravitational force from the earth) affect the movement of an object (in this case, a stack of paper). Students learn about balanced and unbalanced forces.
5	Material Properties of Objects	What kinds of things do magnets attract?	From L1 students noticed that the magnetic toy ring magnets are plastic ("probably with a magnet inside") and that magnets don't attract to the plastic pole or wooden pencil. Why not?	Students figure out that some, but not all, metals are attracted by magnetic forces and that other materials are not affected by the magnetic field. This attraction can happen at some distance away from the object. Why do they think toy designers used plastic?
6	Magnetic force extends through a field	How do magnets work without touching objects?	Students have noticed that magnets can make other magnets or magnetic objects move without directly touching them. *How does this work?*	Students observe evidence of magnetic fields and figure out that the distance at which a magnet can attract a magnetic object is at the edge of that field.
7	Update Models using evidence	How does the magnetic ring toy work?	Students use what they have observed and learned to explain the parts of the toy, the materials, and how the toy works.	Students figure out ways to give constructive feedback to partners to improve their models and explanations using evidence from many sources (readings, videos, experiments).

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Set 2: Investigating & Solving Problems *What questions do we still have? How can we answer our questions?* *Timeframe: 10-12 days, 3 weeks*

	Lesson	*Question*	*Phenomenon/Problem*	*What students figure out*
8	Investigate a common question together	Which magnet is the strongest?	The class figures out different ways to collect evidence to support a claim of "strongest magnet". *How can we collect and display data to convince others of the strongest magnet?*	Students conduct tests collaboratively in groups to test the strength of magnets. They graph their results and write evidence-based conclusions to argue for which magnet is strongest.
9	Investigating student-generated testable questions	What else do you still wonder about magnets?	Students sort their questions and then choose one testable question to investigate with their group. Groups develop a plan for an experiment and then revise their plan to make sure their test is valid, fair, and reliable. Finally, groups collect and display their data in graphs.	Students use results from their investigations to answer their testable questions in the form of a written essay or report to convince readers that their conclusion is based on data or evidence.
10	Solving Simple Problems with Magnets	What are simple problems we could solve with magnets?	Magnets can be used to solve simple problems because of their properties and how they interact with other magnets and magnetic materials.	Students examine some example solutions to sample problems and then choose a problem to design a solution. Compare plans. If time permits, build and test the solution. There can be many ways to solve the same problem.

Extensions: More about Magnetism *Timeframe: 3-4 days, 1 week*

	Lesson	*Question*	*Phenomenon/Problem*	*What students figure out*
A	Force(s) at work: Mysterious Motion	Is it magnetism or something else that causes the balloon to move and stop?	It appears from the video (or demonstration) that the inflated latex balloon is controlling the motion of an empty aluminum can. *Suggested placement: Use after Lesson 7.*	Students use evidence from the unit to explain a new puzzling event involving non-contact forces to argue for whether or not magnetic force, gravitational force, or some other force is responsible for the motion of the aluminum can.
B	The Earth is a Big Magnet: Make-your-own compass	The Earth has a magnetic field, why does that matter?	Not all planets have a magnetic field, but the Earth does and we can infer there is a magnetic field using a compass.	Students use what they know about magnetic forces to understand how compasses work, identify how a magnetic field is useful, and how objects can become magnetized.
C	Using magnets to store data (Computer Science Integration)	How do people use magnets to store information?	The poles of a magnetic object can be reversed using electricity. This flips the north/south to south/north. Why is this useful?	The north/south poles of a magnetic object are like the ones and zeros computers use to store information (binary). Hard drives can store data, and rewrite data by flipping the poles of magnets to encode messages (example: binary bracelet encodes a message).

Lesson Outlines with Links to Resources

The table below shows NGSS 3-dimensions combination foregrounded in the lesson but learning opportunities can include others.

Set 1, Lessons 1-7: Explain a toy *How does the magnetic ring toy work?* *Timeframe: 14-15 days, 4 weeks*

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
1	Introduce phenomenon: Elicit Students' Ideas & Experiences 2 days *How does this magnetic ring toy work?*	**Introduce the phenomenon:** What do you notice? Wonder? **Exploring donut magnets on a pencil:** What did you try or figure out? What do you notice about the gaps? Can you make the gaps different heights and sizes? **Model-to-Explain initial ideas:** You wrote/talked about __. How could you show that on your model? We can't see that ___between magnets that we feel. How are you going to show it in the picture? What's going on that we can't directly observe that you think could be causing _____? *For more on eliciting student thinking, visit: Ambitious Science Teaching*	magnet push pull	**SEP: Develop and use models** *Develop a model to describe phenomena* **SEP: Asking Questions** *Ask questions that can be investigated and/or researched* **DCI: PS2.B: Types of Interactions** *Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified, tested, and used to explain change*	Teacher Guide L1 (link) Lesson Slide Guide (GoogleSlide) Chart paper, markers, sticky notes *Ideal, but optional: 1 magnetic ring toy (Amazon) or 1 game set (Amazon) per table group* Per student pair: - 4 donut magnets (Amazon) - 1 pencil Per student: - Science notebook and/or - *Optional: Model Scaffold (choose options)*
2	When do magnets push? When do they pull? 2 days	**Reading**: What information does this text give us about magnets? Are there a few new science words to add to our word wall? How will these words help us communicate with each other? **Exploring magnets interacting:** What did you notice as you moved one magnet near the other? Where have you observed pushing? pulling? Do different magnet shapes push or pull in the same places? What do you think might cause ____ to happen? **Making Connections:** How do the readings help you explain your observations? How can your observations and the readings explain how the magnet toy works?	magnet attract repel north pole south pole magnetic force	**SEP: Planning and carrying out investigations** *Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation* **SEP: Obtaining, Evaluating, and Communicating Information** *Obtain and combine information from books and other reliable media to explain phenomena.* **DCI: PS2.B: Types of Interactions** *Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified, tested, and used to explain change*	Teacher Guide L2 (link) Lesson Slide Guide (GoogleSlide) Chart paper, markers, sticky notes 1 copy each magnetism books: - *Rookie Read About Science: What Can Magnets Do?* By Allan Fowler (Amazon) - *Magnets Pulling Together Pushing Apart* by Rosinsky and Boyd (Amazon) - *All about Magnetism* by Angela Royston (Amazon) Per student: - Science notebooks - half-sheet reading (*reading*)
3	More on pulling: Introducing Gravity 2 days	**Reading**: What information does the reading share about gravity? How does this info about gravity help us think about the toy? **Exploring the magnetic toy:** Compare the gaps when the pencil/stick is vertical compared to horizontal. Why do you think causes a difference in gap size? When we add more magnets on vertical, why do gaps get smaller? If we push and release, why do magnets eventually stop moving? **Model-to-explain:** How can we show forces we can't see in a drawn model?	gravitational force	**SEP: Developing and using models.** *Develop models to explain phenomena.* **DCI: PS2.A: Forces and Motion** *Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified.* ***CCC: Patterns*** *Patterns can be used to make predictions*	Teacher Guide L3 (link) Lesson Slide Guide (GoogleSlides) Chart paper, markers, sticky notes For the class: - At least 2 Magnetic Ring Toys - Copy of: *Rookie Read About Science: What Can Magnets Do?* By Allan Fowler (Amazon) Per student: - Science notebooks - *Optional: note-taking half sheet* - 4 donut magnets

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
4	Magnetic versus gravitational force: Who wins? 3 days	**Part 1: What does it mean for a force to win or lose?** Modeling forces with arrows; balanced/unbalanced forces **Part 2: Challenge:Making the biggest gap between magnets** Collect & analyze data: How will you measure the gaps? What do you notice about the gaps? What patterns do you see when we see small gaps? Big gaps? Model-to-explain: Why are gaps different sizes? **Part 3: Challenge: How high can the magnet "fly"?** Design a magnet configuration whereby the top ring magnet will launch the farthest into the air off the top of the magnet toy when compressed. Decide how to measure heights of each launch to determine which design gets the top ring magnet highest into the air	balanced forces unbalanced forces claim data	**SEP: Develop and use models** *Develop a model to describe phenomena* **SEP: Planning and carrying out investigations** *Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation* **DCI: PS2.A: Forces and Motion** *Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in object's speed/direction of motion.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified.* ***CCC: Patterns*** *Patterns can be used to make predictions*	Teacher Guide L4 (link) Lesson Slide Guide (GoogleSlides) Chart paper, markers, sticky notes Class demo: - 1 horseshoe magnet - 1 donut magnet - 40+ sheets of paper Per group: - 1 magnetic ring toy or 10 ceramic donut magnets + pencil Per student: - Science notebooks - *Optional data sheet: Part 2: Gap Height; Part 3: Launch Height*
5	What kinds of things do magnets attract? 2 days	**Part 1: Identify materials with magnetic properties** Discuss a real-world problem (separating recyclable materials) to set a purpose for testing magnetic properties of objects. Conduct a simple test using a magnet and the list of objects on the data sheet or objects from the classroom. Analyze patterns in the data to make general claims about what kinds of materials have magnetic properties. **Part 2: Summarize Learning + Art Extension** Summarize learning from Part 1 and add to summary table Use a combination of magnets and magnetic objects to build character sculptures. Use understanding of balanced forces to make the sculpture free-standing.	attract magnet magnetic balanced forces unbalanced forces	**SEP: Develop and use models** *Develop a model to describe phenomena* **SEP: Plan and carry out investigations** *Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation* **DCI: PS2.A: Forces and Motion** **CCC: Cause and Effect** *Cause and effect relationships are identified.* ***CCC: Patterns*** *Use patterns to make predictions*	Teacher Guide L5 (link) Lesson Slide Guide (GoogleSlides) Chart paper, markers, sticky notes Per pair/group: - Bag or bin of items to test - Magnet Per student: - Science notebooks - Optional: Data table
6	Making Magnetic Fields Visible: How do magnets work? 2 days	**Reading**: What does the text say about magnetic force fields? What does the image show? Why do you think the author included this image and caption? **Explore**: Use iron filings in a plastic box (or bag) and/or Etch-a-Sketch to locate the field of differently shaped magnets. What do you notice about the filings? What patterns do you see? Does the shape of the magnet change what the field looks like? **Model-to-explain**: **Notebook Writing** How can magnets move magnetic objects without touching them? How does information from the text help us explain this? How can we use the idea of magnetic fields to explain observations of the magnetic ring toy? **Summarize Learning + Art Extension** Summarize learning from Part 1 and add to summary table. Art: Create a Wooly Willy Toy. Place small amount of iron filings in a plastic bag.Tape shut. Draw a character. Place bag over drawing. Move a magnet over the outside of the bag to position filings to place hair/fur.	magnetic field distance	**SEP:Ask Questions and Define Problems** *Ask questions that can be investigated based on patterns such as cause and effect relationships.* **PS2.B: Types of Interactions** *Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified.* ***CCC: Patterns*** *Patterns can be used to make predictions*	Teacher Guide L6 (link) Lesson Slide Guide (GoogleSlides) Chart paper, markers, sticky notes Per student: - Half sheet reading (link) Per table group: - 4 plastic boxes w/iron filings (link) *and/or* sealed/taped clear bags w/1 TBSP iron filings* (link) - 4+ small compasses (link) - 1 etch-a-sketch (optional) - 1 pair of horseshoe magnets - 1 par of donut/circle magnets - 1 pair of bar/rectangle magnets *Never put iron filings directly on magnets

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
7	Revise models with evidence 2 days	**Part 1: Review & Update Models** Orient to prior learning: What was your favorite experience? Create a "gotta have" checklist together. Revise/update models using "gotta have" checklist and write a few explanatory paragraphs using evidence. **Part 2: Incorporate feedback and finalize explanations** Give feedback on models. Incorporate and/or address feedback. Finalize explanation of how the magnetic ring toy works.	claim evidence source	**SEP: Constructing Explanations and Designing Solutions** *Use evidence (e.g., observations, patterns) to support an explanation.* **DCI: PS2.A: Forces & Motion PS2.B: Types of Interactions** **CCC: Cause and Effect** *Cause and effect relationships are routinely identified.* **CCC: Patterns** *Patterns can be used to make predictions*	Teacher Guide L8 (Link) Lesson Slide Guide (GoogleSlides) Summary charts from prior learning experiences (L2, L3, L4, L5, L6) Per student: - Science notebook - Blank paper, writing paper, or *model scaffold (choose options)*

Set 2, Lessons 8-10: Investigate & Solve Problems ***How can we answer our questions?*** *Timeframe: 10-12 days, 3 weeks*

Lsn	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
8	Which magnet is strongest? 3 days	**Part 1: Simple test** Groups investigate the same testable question: *Which magnet is the strongest?* Decide on what tests would show the strength of a magnet given the materials available. **Part 2: Revising tests and comparing results** Students revise their investigation procedure. **Part 3: How do scientists display data in graphs?** Students create a bar graph or pictograph to display results.	bar graph pictograph	**SEP: Plan & carry out investigations** **DCI: PS2B Types of Interactions** **CCC** ***Patterns*** ***CCSS math connection***: *Draw a scaled picture graph and a scaled bar graph to represent a data set. Solve one- and two-step "how many more" "how many less" problems using info presented in scaled graphs.*	Teacher Guide L8 (Link) Lesson slide guide (GoogleSlides) *Optional: Extra practice (Slides)* Per student: - one 5"x8" index card - ruler or straight edge - Science notebooks
9	Test Your Question 6 days	**Part 1: Figuring out your question** What makes a question testable vs researchable? **Part 2: Planning your test.** What will you do with magnets to collect data to help you answer your question? Make a plan. Tinker with materials (mini-tests) to make revisions to the plan. **Part 3: Collecting data.** Draw conclusions and discuss your results with your group. If time permits, what would you do next if you did your test again? Write about your test and the results. **Part 4: Publish your results.** Write about your investigation with organized, logical flow, including background information, procedure, data/result, and an evidence-based conclusion.	testable question variable	**SEP: Plan & carry out investigations** *Make observations and measurements to produce data to serve as basis for evidence for an explanation of a phenomenon* **DCI: PS2B Types of Interactions** *Electric and magnetic forces do not require objects to be in contact. The size of the forces depend on the properties, distance apart, and orientation.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified, tested, and used to explain change.*	Teacher Guide L9 (Link) Lesson slide guide (GoogleSlides) Per student: - graph paper - Science notebooks - *Optional: colored pencils/crayons* On a materials table: - Rulers, string,scissors, tape - graph paper - boxes of 100 metal paper clips - 100 metal, magnetic washers - various magnets, different shapes
10	Solving simple problems with magnets 2-3 days	**Part 1: Brainstorming a list of simple problems and solutions**. Brainstorm: What are some simple problems around our classroom or school that we could solve using magnets? Students choose one and draft a plan. Have students match up based on the problem they selected and compare plans. ***Optional*** **Part 2: Prototype and test solutions** Group students by the problems they selected in Part 1 to build and test solutions as a group. Compare solutions.	criteria constraints problem solution	**SEP: Asking Questions and Defining Problems** *Define a simple design problem and include several criteria for success and constraints on materials, time, or cost* **SEP: Construct Explanations & Design Solutions** *Generate and compare multiple solutions to a problem based on how well they meet criteria and constraints.* **DCI: PS2.A: Forces and MotionDCI: PS2B Types of Interactions** **CCC: Cause and Effect**	Teacher Guide L10 (Link) Lesson Slide Guide (GoogleSlides) Per student: - Science notebook - Pencil, colored pencils, crayons *Optional, part 2, assorted materials::* - *various magnets* - *other supplies (paper clips, rulers, rubber bands, string, etc).*

Extensions: More about Magnetism

These extension ideas do not have accompanying lesson plans. Resources are linked below.

	Purpose	Questions/Prompts in this Lesson	Key Terms	Next Generation Science Standards	Materials
A	Forces at work: Mysterious Motion 1 day	**Hands-down conversation** Watch the video clip and/or do the demo shown in the video showing motion between a balloon and empty aluminum can. Have students make observations, and then discuss: **Systems**: How is the motion of the can-balloon system similar/different than the motion of a paperclip-magnet system? **Cause-and-effect:** Could the force between the aluminum can and latex balloon be a magnetic force? Why or why not? How do you know? What else would you need to know? Defend your position with evidence from prior activities.	attract repel magnetism force gravity	**SEP: Engaging in Argument from Evidence** *Construct an argument and justify claims by citing relevant evidence* **DCI: PS2B Types of Interactions** *Electric and magnetic forces do not require objects to be in contact. The size of the forces depend on the properties, distance apart, and orientation.* **CCC: Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change.	Lesson Slide Guide (GoogleSlides) If conducting the demo, you need: - Empty aluminum soda can - Balloon - Magnet - Paper clip *Directions:* Inflate balloon. Rub it on your hair in one direction repeatedly. Hold balloon near can to see if can moves. If not, rub more times. Works best in low-humidity.
B	The Earth is a Big Magnet 1+ day	**Reading: The Earth is a Big Magnet** What is the main idea of this reading? What does the Earth's magnetic field do for us? What do you think would happen if the Earth was not a magnet? **Video: How Compases Work** Compare the information from the reading and the video: What information is repeated? What is new information? **Hands-on: Make a compass** Follow the video guide to make-your-own compass; Use the thimble to protect fingers while magnetizing the needle. **Video: Magnetizing materials** Examine a model presented in the video of how materials become magnetized. How does this apply to our compasses?	magnetic north magnetic south compass	**SEP Obtaining, Evaluating, and Communicating Information**: *Obtain and combine information from books and other reliable media to explain phenomena.* **DCI: PS2B Types of Interactions** *Electric and magnetic forces do not require objects to be in contact. The size of the forces depend on the properties, distance apart, and orientation.* **CCC: Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change.	Lesson Slide Guide (GoogleSlides) Per pair or group: - Water in a non-metallic bowl - 1 needle - 1 thimble (to protect finger) - 1 piece of cork - 1 magnet - 1 compass Per student: - Copy of reading (link) - Science notebook
C	Manipulating magnets: Using magnets to store data 1 day	**Video: How Magnets Store Data** What did the video say about how magnets store data? What are some uses for magnets shared in this video? **Discuss: Real-world Problem - Hotel Card Key** How do you think the magnetic strip on the card key works? What would help keep the card key working? **Extension: Make a Binary Bracelet** What patterns do you notice about the binary alphabet? If we added another letter to the alphabet after Z, what do you think the binary translation would be? Justify your thinking. Decode each others' binary bracelets using the alphabet code.	binary encode decode	**Computer Science**: *1A-DA-05 Store, copy, search, retrieve, modify, and delete information using a computing device and define the information stored as data.* **SEP Obtaining, Evaluating, and Communicating Information**: *Obtain and combine information from books and other reliable media to explain phenomena.* **DCI: PS2B Types of Interactions** **Connections to ETS**:*Discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process.***CCC: Patterns** *Patterns can be used to make predictions*	Lesson Slide Guide (GoogleSlides) Per student: - Binary Bracelet sheet (link) - marker

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Unit Materials List

This list assumes a class of 32 students, 8 groups of 4 students. Multiple classes can share non-consumables (which would reduce the cost) by teaching at different times of the day or staggering lessons on different days. This list does not include common school supplies like notebooks, paper, sticky notes, rulers, pencils, colored pencils, pencil boxes, tissues, paper towels, etc. Pricing estimates as of 11/10/19. Nearly all materials for this unit are non-consumable or reusable. Some funds will be necessary to replace broken or missing parts (e.g. if ceramic magnets break/shatter throw them out and replace them) and replace any consumable supplies. *This list does **not** include materials for all of the "Extension" lesson ideas.*

Item	*Sold in Qty*	*Price/Vendor*	*Need*	*Qty to order*	*Cost*	*Subtotal*
❏ Magnetic Ring Toy	pk of 1	$12/ea. Amazon	1 per group	8 pkgs	$84	**Magnet supplies $325**
❏ Horseshoe magnets	pk of 5	$24/ea. School Specialty	1 per group	2 pkgs	$48	
❏ Ceramic donut magnets	pk of 40	$15/ea. Amazon	4 per pair	2 pkgs	$30	
❏ Rectangular magnets	pk of 12	$15/ea. Amazon	1 per pair	2 pkgs	$30	
❏ Bar magnets	pk of 10	$5/ea. School Specialty	1 per pair	2 pkgs	$10	
❏ Iron filings in clear plastic cases	pk of 10	$22/ea. Amazon	1 per group	1 pkg	$22	
❏ Iron filings, jar of powder	pk of 1 (12 oz)	$10/ea. Amazon	1 per class	1 jar	$10	
❏ Magnadoodle toy, small	pk of 15	$30/ea. Amazon	1 per pair	1 pkg	$30	
❏ Compasses, small	pk of 50	$16/pk. Amazon	1 pkg per class	1 pkg	$16	
Magnetic items for Art extension:						
❏ Large magnetic bolts *(must be magnetic)*	pk of 25	$11/pk. Amazon/Hardware	25 items per class	1 pkg	$11	
❏ Large magnetic washers *(must be magnetic)*	pk of 100	$15/pk. Amazon/Hardware	50 items per class	1 pkg	$15	
❏ Small magnetic bolts *(must be magnetic)*	pk of 25	$9/pk. Amazon/Hardware	25 items per class	1 pkg	$9	
❏ Small magnetic washers *(must be magnetic)*	pk of 100	$6/pk. Amazon/Hardware	50 items per class	1 pkg	$6	
❏ Book: *Rookie Read About Science: What Can Magnets Do?* By Allan Fowler		$5/ea. Amazon	1 per class	1 copy	$5	**Books $30**
❏ Book: *Magnets Pulling Together Pushing Apart* by Rosinsky and Boyd		$8/ea. Amazon	1 per class	1 copy	$8	
❏ Book: *All about Science: All about Magnetism* by Angela Royston		$8/ea. Amazon	1 per class	1 copy	$8	
❏ Book: *Let's Read and Find out: What Makes a Magnet* by Franklyn Branley		$7/ea. Amazon	1 per class	1 copy	$7	
❏ Metal paper clips	10 pks of 100	$8/set Amazon	1 box of 100 per group	1 set	$8	**Other supplies $50**
❏ String or ribbon	1 spool	$7/spool Amazon	1 spool per class	1 spool	$7	
❏ Graph paper	50 sheets/pkg	$6/pkg Amazon	3 sheets per student	2 pkgs	$12	
❏ Resealable plastic zip-top bags, 3"x4"	300 bags/pkg	$10/pkg Amazon	1 bag per student	1 pkg	$10	
❏ Index Cards, 5x8	500 cards/pkg	$12/pkg Amazon	4 cards per student	1 pkg	$12	
❏ Lego or plastic brick	n/a borrow	n/a borrow	1 per group	n/a borrow	$0	
❏ Brass paper fastener (brad)	n/a borrow	n/a borrow	1 per group	n/a borrow	$0	
❏ Wooden block (or craft stick)	n/a borrow	n/a borrow	1 per group	n/a borrow	$0	
❏ Aluminum foil (small square)	n/a kitchen	n/a kitchen	1 per group	n/a borrow	$0	
❏ Hair clip or barrette, metal	n/a borrow	n/a borrow	1 per group	n/a borrow	$0	
❏ Puzzle piece (cardboard)	n/a borrow	n/a borrow	1 per group	n/a borrow	$0	
❏ Wooden block (or craft stick)	n/a borrow	n/a borrow	1 per group	n/a borrow	$0	

Approximate start-up cost total, before taxes/shipping **$405**

Estimated annual restocking/replacement cost for missing, used, or broken pieces < $50

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Tracking Depth of Student Understanding

Note: Assessing student understanding happens within three-dimensional tasks. Examine evidence from within a practice (like modeling) to see how students express a content understanding (DCI) using a cross-cutting concept (CCC). The rubric may be useful to identify and track growth over the unit. Start with initial models to plot initial understanding. Then pick a few assignments throughout the unit to plot on the rubric to see how students' understanding of those ideas and practices are changing. (See also NGSS Evidence Statements)

Disciplinary Core Ideas (DCI)	1 - Below	2 - Approaching	3 - Meets Standard	4 - Exceeds Standard
PS2.A: Forces and Motion ● Each force that acts on one object has both strength and direction. An object at rest typically has multiple forces acting on it, but they add up to give a zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction. ● The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.	No attempts at describing or labeling forces (as pushes or pulls on an object) or the motion of the object.	Recognizes that pushes and pulls are forces that can start, maintain, or stop an object's motion.	Identifies the relative strength and/or direction of a force on or between objects and uses this information to predict or explain a change in the speed or direction of an object's motion. Labels and describes multiple forces acting on an object and recognizes that: (1) if these forces are equal but opposite, the object will not move or (2) if these forces are not equal but opposite, the object will move in the direction from which the stronger force is applied. Observes and analyzes patterns of an object's motion in various situations and uses this analysis to justify predictions of future motion.	*Measuring and summing the forces acting on an object*: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The patterns of an object's motion in various situations can be measured; when past motion exhibits a regular pattern identified in collected data, students predict future motion using that pattern.
PS2.B: Types of Interactions ● Objects in contact exert forces on each other. ● Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	No attempts at explaining the interaction of objects on changes in motion of the objects.	Recognizes that when objects touch or collide, they push on one another. Labels "magnetism" or "gravity" with no attempts to use non-contact forces to explain motion.	Describes and labels the orientation of magnets and connects this to the cause of motion at-a-distance between two magnets or between a magnet and a magnetic object. Identifies the gravitational force of Earth acting on an object near Earth's surface pulling that object toward the planet's center Identifies patterns in material properties to predict if a new object could be influenced by magnetic force Uses ideas about orientation, distance, material, magnetic force, magnetic field, and/or magnetic poles to explain that magnets can change the speed or direction of motion of another magnet or magnetic object without touching the object (non-contact force).	Explanations include interactions of multiple non-contact "invisible" forces, like gravitational forces and magnetic forces, shown as fields that can be mapped by their relative strength and effect on an object.
Cross Cutting Concepts (CCC)	**1 - Below**	**2 - Approaching**	**3 - Meets Standard**	**4 - Exceeds Standard**
Cause and Effect -- Cause and effect relationships are routinely identified,tested, and used to explain change. ***Patterns*** -- Patterns of change can be used to make predictions	No attempts to describe data or identify patterns.	Describes data (observations, measurements) they have collected.	Identifies patterns in data (observations, measurements) or the relationships between different quantities in data (e.g. strength of magnets compared to magnet shape/size). Students begin to consider what might cause these patterns and relationships. Use patterns in data to make and justify predictions.	Analyzes patterns in data, suggests what might cause these patterns and relationships, and designs tests and/or plans research to gather evidence to support or refute their ideas.

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Science & Engineering Practices* (SEP)	1 - Below	2 - Approaching	3 - Meets Standard	4 - Exceeds Standard
Developing and Using Models Building and revising simple models and using models to represent events: ● Use models to describe phenomena. ● Develop a model using an analogy, example, or abstract representation to describe a scientific principle.	No attempts to model forces or motion.	Some attempts to label or describe forces acting on an object in a model.	Labels and describes interactions of forces on objects to explain their current position and/or change in position (motion). Shows relative strengths of forces from different magnets on magnetic objects. Uses evidence to revise or update models.	Identifies limitations of their model by justifying parts of the phenomenon they included and excluded from their model. Critiques credibility of evidence used in revising a model.
Constructing Explanations Using evidence to construct explanations, describe and predict phenomena. ● Construct an explanation of observed relationships ● Identify the evidence that supports particular points in an explanation	Makes claims without attempts to supply evidence or examples.	Supports claim with general connections to evidence source without specifics	Recognizes and uses a pattern in data to predict, describe, explain phenomena. Supports a claim in a larger explanation with appropriate and specific evidence such as numerical data points or quotes from text	Recognizes and uses data patterns to predict, describe, or explain phenomena, and relates it to science concepts. Supports a claim (or more than one claim) with specific and appropriate evidence AND critiques the reliability or validity of the source of the evidence.

* These 2 SEPs were selected to track growth over this unit and over several units in the school year. You may wish to assess/track different SEPs. Students will engage in multiple SEPs at various points in the unit so there are opportunities to notice how students are engaging in other practices as well.

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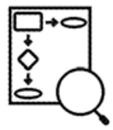
Lesson 1 Developing initial models of non-contact forces

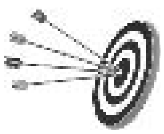


Purpose

This lesson introduces students to a new unit focused on forces. Students will be able to explain why objects start moving, stay moving, stop moving, or remain still. This series of lessons focuses on non-contact forces, like magnetism and gravity. In this first lesson, students make observations of a magnetic ring toy, and hypothesize about how the toy works and why gaps between magnets are not the same size.

- Students make observations and share hypotheses and wonderings about how magnetism works in the magnetic ring toy.

Information gathered by eliciting students' initial observations and hypotheses about a phenomenon, and making a public record of these inform instructional decisions for upcoming lessons. For more about eliciting students' ideas, see [http://AmbitiousScienceTeaching.org]



Learning Target

Focus question

How does this magnetic ring toy work? Why are there gaps of different sizes?

Learning Target

I can share my hypotheses to explain how I think the magnetic ring toy works.

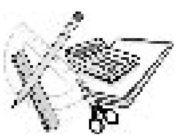
**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Develop and use models *Develop a model to describe phenomena* **SEP: Asking Questions** *Ask questions that can be investigated and/or researched*

DCI: PS2.B: Types of Interactions *Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.*

CCC: Cause and Effect *Cause and effect relationships are routinely identified, tested, and used to explain change*



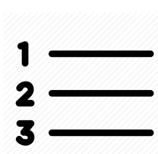
Materials

For the class:
- Lesson Slide Guide (GoogleSlides)
- Chart paper and markers
- Sticky notes

For each table group:
- *Optional: 1 magnetic ring toy (Amazon)*

Per student pair (if you have enough magnets, per individual student)
- 4 donut magnets (Amazon)
- 1 pencil

Per student:
- Science notebooks
- *Optional: Model Scaffold (options)*



Lesson Step Summary

1. **Introduce the phenomenon:** Introduce the magnetic ring toy and elicit observations. Students partner-share what they notice.
2. **Explore the phenomenon in partners and small groups**: *How does this magnetic ring toy work? What did you figure out?* Students explore and talk about the magnet ring toy using donut magnets on their pencil. Elicit hypotheses about what might be going on. *Why are there gaps sometimes, but not all the time? Why are gaps different sizes?*

[To break this lesson into two parts, have students jot down observations and stop here for now.]

3. **"Just-in-time" instruction (mini-lesson):** Review modeling. *How do we represent what we can't see? What could arrows/color communicate?*
4. **Pressing for explanations**: Students sketch their initial models of how they think the magnetic toy works. *What might be going on that we can't see? How will you show that? Why do you think it happens this way?*
5. **Summarize (whole-group):** Share ideas and wonderings. Make a class list of hypotheses about the magnetic toy and questions about magnetism.

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[Could complete this step at the start of lesson 2 if time is short.]

Lesson Steps

Purpose

Visual Demo

Turn-and-Talk

1. Launch: Introduce phenomenon.

a) State the purpose for this new unit and introduce the magnetic ring toy.

b) Ask students to watch your demonstration of the magnetic ring toy silently (teacher is silent, too, just move the magnets to show a few different arrangements) and students should be ready to share with a partner: *What do you notice? What do you wonder?*

c) Have students turn and talk about what they notice and wonder.

This might sound like: *We are starting a new unit about forces and motion. To help us learn, we will work together to figure out how this magnetic ring toy works. Let me show you all a few of my favorite patterns. What do you notice? What do you wonder?* [Show demo and give thinking wait time.] *Turn and listen to your partner's observations and wonderings.* [Spend about 2 mins. Listen in.] *I heard that some scientists noticed the magnets are bouncy, like this* [jiggle the toy]. *They bounce without touching. Other people noticed the magnets weren't touching and some magnets were farther apart. Now you will have time to explore this toy yourself using a pencil and 4 donut magnets* [and/or can pass around the magnetic ring toy].

2. Explore the phenomenon in partners and small groups

a) Tell students they will have time to explore this magnetic ring toy. You likely will not have a toy for everyone but each pair of students can use 4 donut magnets on their pencil (eraser side down please so as not to accidentally draw on the table). *Optional: If you have multiple toys, each table group gets 1 magnetic ring toy. Then after students share and explore together, pass out ceramic donut magnets + pencil set-up if needed.*

Safety Alert

b) Give a brief safety warning to students:
- Magnets can pinch so be careful!
- Wash hands after touching/working with ceramic magnets.

Make Observations

c) Students gather materials and return to their desks to explore. Encourage students to talk with partners or others at their tables. Students explore how magnets interact on and off their pencil *(and/or using the magnetic ring toy if you have a set for each group)*.

Back-pocket questions:
- *What have you tried?*
- *What did you notice?*
- *What do you think causes ____?*
- *What might happen if we added/removed ring magnets?*

Teacher Move:
Circulate & Listen

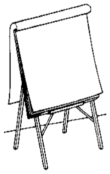
Teacher focus: Noticing and eliciting student ideas

Circulate the room as students explore. Listen and watch:

★ What *language* are students using to describe what they are seeing/feeling?
★ What *experiences* are they bringing up?
★ Are they making any *connections* or *explaining* how/why they think it works?
★ Are they *showing* and *sharing* each others' configurations?

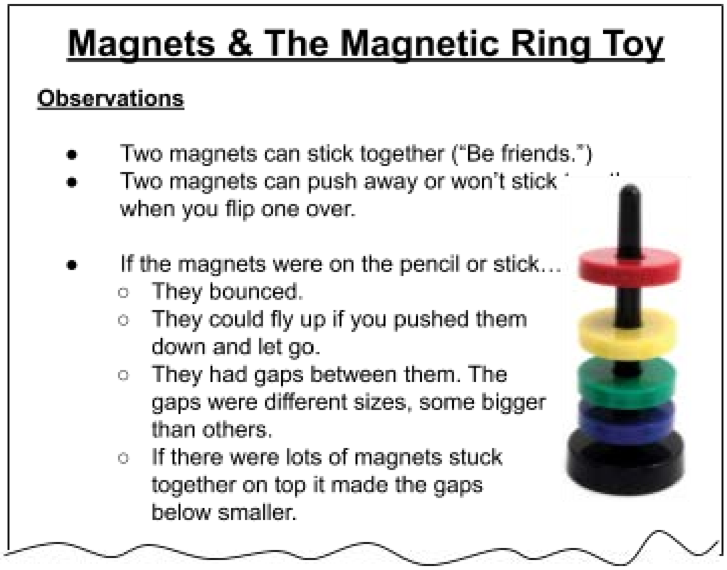
Jot notes as you circulate and listen, you could use blank paper or you might find this Rapid Survey of Student Thinking organizer helpful.

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools



Public Record

d) Have students share some observations and list them on a chart. This list of observations can come in handy as students work on their models *(e.g. You noticed ____. Why do you think it happens like that? How could you show or add that to your model?)*



Magnets & The Magnetic Ring Toy

Observations

- Two magnets can stick together ("Be friends.")
- Two magnets can push away or won't stick together when you flip one over.
- If the magnets were on the pencil or stick…
  - They bounced.
  - They could fly up if you pushed them down and let go.
  - They had gaps between them. The gaps were different sizes, some bigger than others.
  - If there were lots of magnets stuck together on top it made the gaps below smaller.

If you're looking for another facilitation option for students to share their observations with less teacher involvement, try one of these:

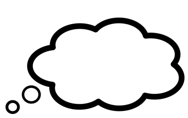
- Invite each student to write their observations on the chart after sharing with the class and checking to see if others observed it, too (if no one else made a similar observation, invite the student to show it to the class)
- Have students jot each observation on a separate sticky note. Put up observations on sticky notes and cluster observations by similarity, giving each cluster a name or phrase title, under the heading "Observations" on the chart.

[If you need a stopping place for today, pause here and pick up tomorrow. Keep the magnets available for students to manipulate when developing models.]

Mini-Lesson

3. "Just-in-time" instruction (Mini-Lesson): Developing models

a) Tell students it is time to get our ideas on paper so we can remember the ideas and questions we have. Students develop their models including explanations in their science notebooks, on paper, or let students choose to use a copy of one of these [model scaffolds].



Think Time

b) Remind students that models are not just labeled pictures. Models show what happened or what is going on, so labels are helpful but not the only part. Models go deeper to show how or why we think something happens.

c) Ask students to think about that invisible cushion, zone, bubble they felt between magnets *(use whatever language students used to describe the magnetic field when two magnets repel)*. How might you show that in a drawn model? Think about how you might use symbols, arrows, and color to communicate about things you felt but can't see.

Turn-and-Talk

d) Turn-and-talk with a partner. Share out a few ideas (there are many!) of how we can use arrows, colors, and symbols in our model today.

Model to Explain

4. Model-to-Explain

Allow students at least 10 minutes of quiet thinking, writing, and work time to develop their models of how the magnetic ring toy works, why there are sometimes gaps between magnets, and why the gaps are sometimes different heights or sizes. As students work, look at their work and try some of the back-pocket questions to push their thinking and get students to write down their ideas and questions.

Back-pocket questions:

- *You observed ___. What do you think made that happen?*
- *You wrote/talked about ___. How could you show that on your model?*
- *We can't see that air cushion that we feel, so how are you going to choose to show it in the picture?*
- *What's going on that we can't directly observe that you think could be causing _____?*

5. Summarize: Listen to Others' Observations and Ideas

Turn-and-Talk

a.) Partner share/rehearsal: Students pick one favorite part of their model, question, idea, or observation to share with a few partners. Have students pair up, share, listen to 2-3 partners before coming to sit on the carpet for a class discussion. *Optional: "Add an idea you agree with to your model."*

Share & Connect Circle

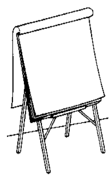
b.) Share-and-connect circle: *How does the magnetic ring toy work?*
- Have students bring notebooks/models and sit in a large circle.
- The purpose of this conversation is to surface what our scientists have been noticing, thinking, and wondering about. Tell students to speak loudly and clearly when they share. Listen carefully and closely.
- Try a 'hands-down' conversation. Do not raise your hand. Find a time and place to slide an idea or question into the conversation that connects with a prior idea. The conversation keeps going without teacher intervention. The teacher sits outside the circle taking notes. If there is a 20 second silence, you could try asking a follow-up question based on a trend in ideas you heard or try one of these:
  - *We noticed there are gaps between magnets. Why are there gaps sometimes? What makes some gaps bigger or smaller than others?*
  - *We noticed that if you compressed all the magnets down and let go, they sprung up into the air and sometimes the top one popped off. What do you think causes that to happen? What would we have to do differently to be able to get the top magnet to hit the ceiling?*

Teacher Move:
Be Curious, Listen & Notice

Teacher role: Noticing student ideas

★ Step back. Jot notes about what you hear from students. This will help inform changes to future lessons to support students' developing ideas.

★ You may need to pause the conversation and intervene. Here are some occasions that warrant and intervention:
- *If students start a scientific argument,* pause the conversation and remind students to keep today's discussion about surfacing all ideas and questions.
- *If only a few students are talking,* pause the conversation and this noticing OR whisper to one of the 'talkers' and ask them to recognize this and/or invite others in by asking questions
- *If students are not following the expectations,* remind them of no hand raising, one voice at a time, and listening to understand each other.



Public Record: Observations, Hypotheses, & Questions

c.) Listing observations, hypotheses, and questions:

Based on the discussion, the teacher can summarize common hypotheses after class and add them under the list of observations. Show students this list at the start of the next lesson to see if anything needs to be added or changed. This list of ideas and questions can be used to introduce future lessons by targeting specific ideas.

It may also be helpful to generate a list of words that students used today (student language) that students can refer to in part 2 as they work on their models. This is likely a mix of "science" words as well as everyday, descriptive words.

Hypotheses about how the toy works...

- All the pieces are magnets except the stick part and magnets sometimes stick and other times have an air cushion (gravity? force field?)
- The gaps get smaller when there are more magnets because many magnets push down and are heavier than only one magnets.
- Magnets have two different sides. When the right sides touch they stick, when the wrong sides touch they push away. The gaps are made by pushing away.
- If we had 8 donut magnets, not 4, the gaps would be teeny tiny but still there. We tried it and then they bounced off like if there was a spring.

Words we used...

- force
- push
- pull
- gravity
- magnet
- magnetic
- magnetism
- flip
- opposite
- side
- not touching
- floating
- bouncy
- bouncing
- floating

Lesson Closing

Lesson Closing

Ask students to jot questions on sticky notes. Then, stack model scaffold papers or keep science notebooks open to their models and make a stack (so they are easy for the teacher to look through).

It might sound like this:
Now you have some ideas going about how you think the magnet toy works. Let's end today generating some questions. Jot each question on a different sticky note and put them up here. After placing your sticky note, return all the magnets to the materials tub and make a stack of your models.

Teacher reflection: Examining Student Thinking

Teacher Move:
Observe & Interpret

There are many ways to analyze student work. For initial models, it is helpful to do a quick 3 pile sort by the amount of information on the page. Then spend more time examining the contents of each pile asking these questions:

★ What ideas do you see and understand in students' work?
★ What do you understand about each students' current thinking? What are you unsure of and could you ask a follow-up/clarification?
★ How are students showing ideas with modeling conventions such as how they chose to use arrows, symbols, colors?
★ Which students are represented in each pile? What does this make you wonder about the modeling task and how to support all students?

Optional Teacher Reflection: Considering Commonly-Held Alternative Conceptions

Add some notes from your observations to the Rapid Survey of Student Thinking from lesson 1. Read over students' models to examine student thinking at this starting place for the unit.

List of Commonly-Held Alternative Understandings about Magnetism and Gravity

Below is a list of alternative ideas students may have about the non-contact magnetic and gravitational forces. *(We, as adults, may have these misconceptions, too, particularly if we have not studied or taught this content before!)* Based on lesson 1, see which ideas you heard or saw evidence of so far. Also, reflect on your own understanding of these ideas.

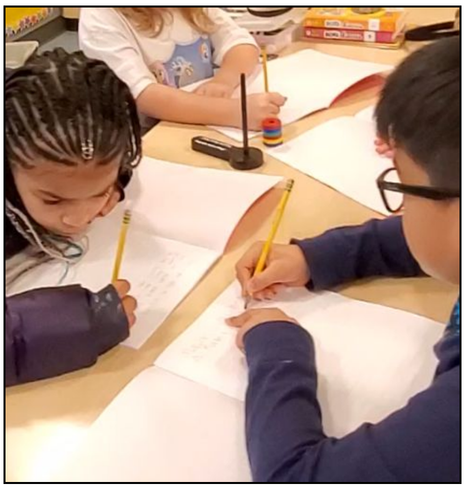
★ Which of these did you hear from your students and/or see in their initial models?
★ Which of these surprise you as an adult learner?

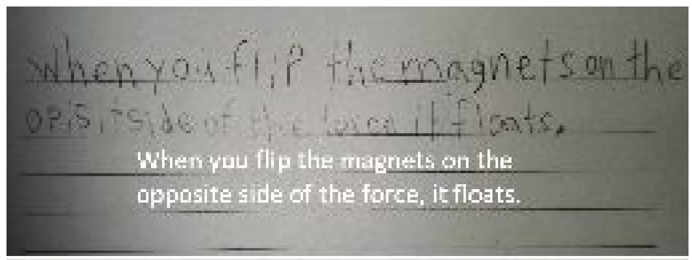
Observed from students	Surprised me as an adult	Some Commonly-Held Alternative Understandings about Magnetism and Gravity *(Lesson(s) that starts and/or continues to work on the idea in this unit.)*
❏	❏	Magnetic poles are always at the ends of a magnet. *(Lesson 2)*
❏	❏	Magnetism only works through air but not other materials like wood or water. *(L2)*
❏	❏	Magnets are attracted to each other because of gravity. *(Lesson 3)*
❏	❏	Gravity turns on/off. Gravity is 'on' when an object falls, 'off' when it lands. *(L3)*
❏	❏	Gravity only affects heavy things. *(Lesson 3)*
❏	❏	Gravity works one direction, just towards large objects -- The Earth's gravity attracts the person but the person's gravity does not attract Earth. *(L3)*
❏	❏	All metals are attracted to a magnet. *(Lesson 5)*
❏	❏	Magnetic field lines are *really* there, a pattern of actual lines *(Lesson 6)*
❏	❏	Larger magnets are *always* stronger than smaller magnets *(Lesson 8)*
❏	❏	All materials that can be magnetised are magnets. *(Lesson 13)*
❏	❏	Things fall naturally – no forces are involved; barriers stop things falling.
❏	❏	There is "more gravity the higher up you go" because things dropped from higher up suffer greater damage when they hit the floor.

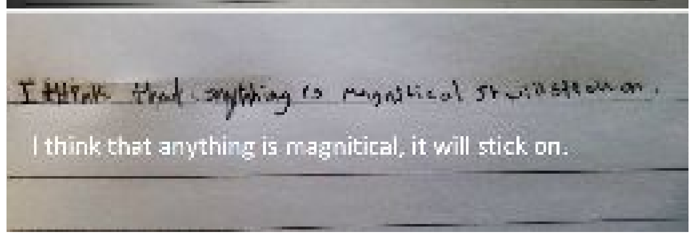
Sources for this list: Magnetism misconceptions; Teaching Forces Misconceptions; Physics misconceptions;

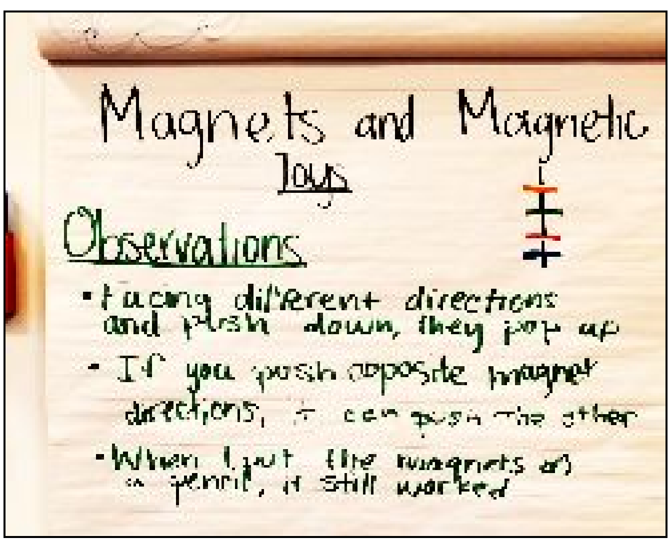
**Not all ideas listed are fully addressed in this Grade 3 unit. Lessons in this unit will work to lay the groundwork for continued learning in future grade levels. Misconceptions are stepping stones to developing understandings so they take time to shift. See this article to read about the usefulness of surfacing, acknowledging, and using misconceptions.

Photos from Lesson 1







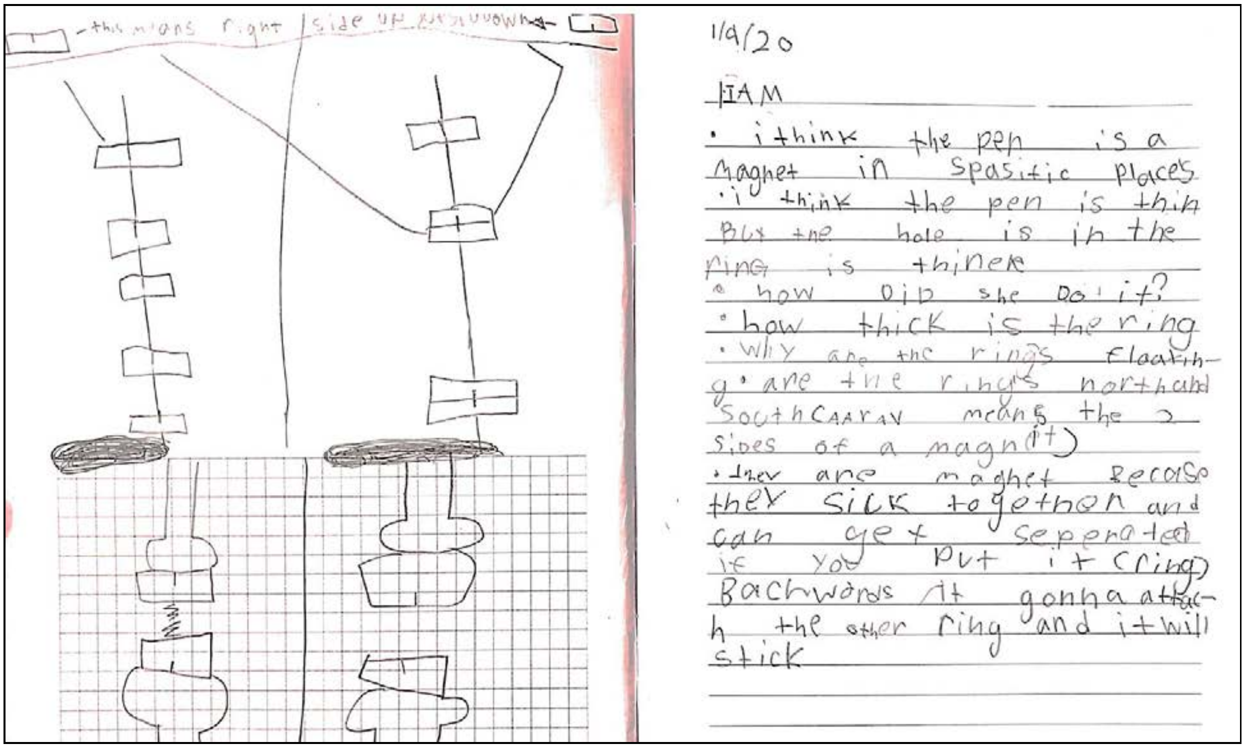


Students explored the Magnetic Ring Toy and, as they explored, jotted a few observations, claims, and sketches in their notebook.

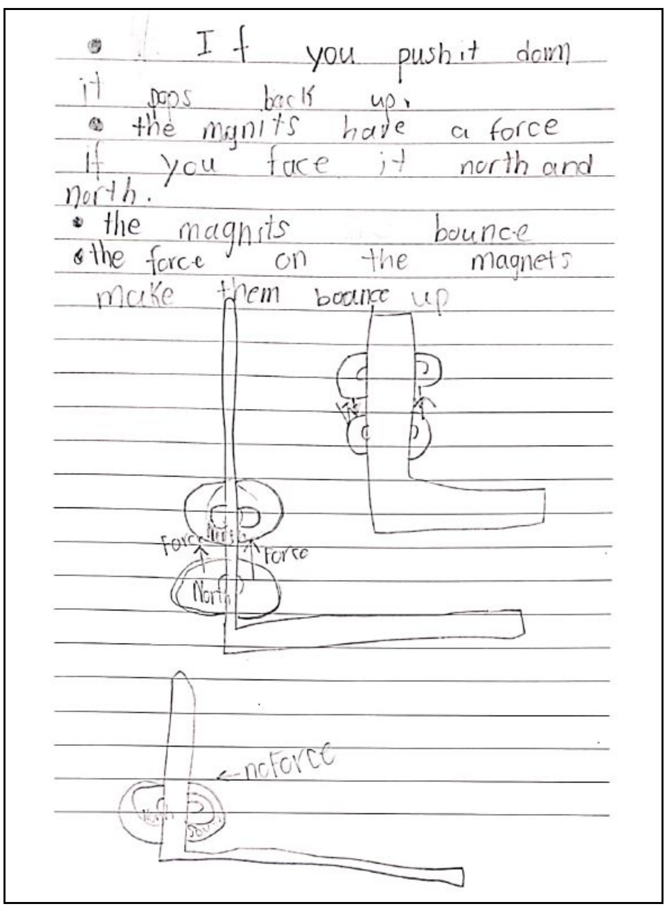
In Part 2, students can refer back to these quick notes and sketches to work on their initial model about how the magnetic ring toy works. They may also have items to add to the class chart of observations and ideas in Lesson 1, Part 2.

Example Initial Models

Student A:



Student B:



Student A has ideas that certain places of an object (the pole) are more magnetic than others and that the thickness and orientation (backwards/ forwards) of the magnets matters. Student A has background knowledge that magnets have two sides, north and south. Student A does not bring up any explicit ideas about forces or motion. However, in the lower part of the model sketch it seems the student is comparing two situations, the left has some kind of zig-zag symbol coming from both magnets and the right does not.

Student B notes a relationship between forces (push) and motion (bounce). Student B, like A, also has background knowledge that magnets have sides, writing that if magnets are north-and-north facing they have a force. Presumably, then this student thinks that there are conditions where there would NOT be a force. In the sketch, students point to a one magnet situation as “no force” present.

WHAT DO YOU NOTICE? WONDER?

Lesson 1

MAKE ONE: WHAT DO YOU NOTICE? WHAT CAN YOU FIGURE OUT?

<u>You need:</u>
1 pencil
4 donut magnets

Safety Note: These magnets can pinch so be careful with your fingers.

<u>Your task:</u>

1. Place the pencil through the magnets. Explore.
2. Talk with a partner or group about what you:

Notice: What happens with the magnets? What do you notice about the gaps?
Think: What did you figure out about the gaps? Why might that happen?
Wonder: What are you wondering now?

MODEL TO EXPLAIN YOUR THINKING

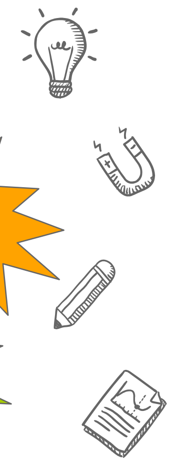
Models help us communicate our thinking about a phenomenon or event.

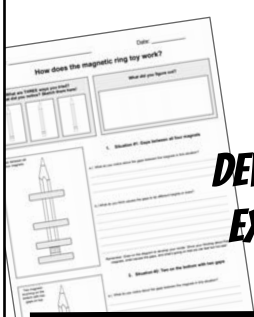
- Sketch *what* happened
- Add *how* or *why* you think it happened
- Use symbols, colors, and arrows to show what we can't see

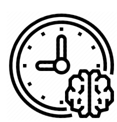
How will you draw something you felt but could not see?

What might you use arrows for?

What else will you include to help communicate your thinking to others?







DEVELOP YOUR MODEL & EXPLANATION OF HOW THE TOY WORKS

My model:

How will you draw something you felt but could not see?

What might you use arrows for?

Magnet Toy 01/13/20

I noticed...
I think that happened because...

I also observed...
So I figured out that...

Now, I'm wondering...
Another question I have is...

1. What did you **notice** or observe about the gaps?

2. What do you **think** causes the gaps?

3. How can you make the gaps bigger? smaller?

4. What else did you figure out? What are you **wondering** now?

Share & Listen

Share and listen to the ideas and questions from at least 3 other scientists.

Then, come together as a whole class to summarize what we did and figured out.

Summarize

Who did you just listen to?
What did they share with you?

SCIENCE HOMEWORK:

Go on a magnet hunt.

Where can you find magnets?

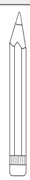
What do we use magnets for?

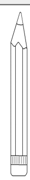
Page 29

Name: ___________________________ Date: ___________

How does the magnetic ring toy work?

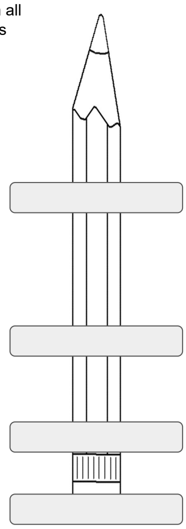
What are THREE ways you tried? Sketch them here!





What did you figure out?

Gaps between all four magnets



1. Situation #1: Gaps between all four magnets

a.) What do you notice about the gaps between the magnets in this situation?

____

____

____

b.) What do you think causes the gaps to be different heights or sizes?

____

____

____

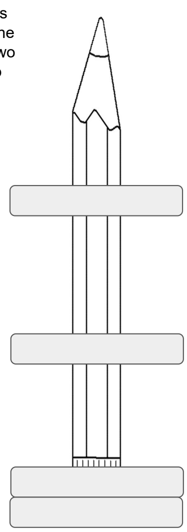
____

____

____

Remember: Draw on the diagram to develop your model .Show your thinking about these magnets, what causes the gaps, and what's going on that we can feel but not see!

Two magnets touching on the bottom with two gaps on top



2. Situation #2: Two on the bottom with two gaps

a.) What do you notice about the gaps between the magnets in this situation?

____

____

____

b.) What do you think causes the gaps to have the height or size that they do?

____

____

____

____

____

____

Remember: Draw on the diagram to develop your model .Show your thinking about these magnets, what causes the gaps, and what's going on that we can feel but not see!

Name: ____________________________ Date: ___________

How does the magnetic ring toy work?

What are TWO ways you tried? Sketch them!

What did you notice about the magnets?

What did you figure out?

What do you wonder? What questions do you have?

<table>
<tr><th>Rapid Survey of Student Thinking

(RSST)</th><th>Students' Ideas

What facets/fragments of understanding do students already have? What ideas do students have that are inconsistent with the scientific explanation? How are students reasoning about the phenomenon or question?</th><th>Students' Language

What terms, language, phrases, or gestures did you hear/see students use that you might connect to academic language in upcoming lessons?</th><th>Students' everyday experiences or connections

What familiar experiences did students describe during the elicitation activity?</th></tr>
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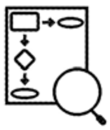
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">What can you do with this information? Choose 1-2 from these options to try in an upcoming lesson.</td></tr>
<tr><td colspan="2">• Do further eliciting of initial hypotheses to clarify your understanding of students' partial understandings
• Do further eliciting about experiences or frames of reference students are using
• Do 10-minute whole class whole class conversation of 2-3 key ideas elicited to find out more as a class about these ideas.
• Write multiple hypotheses on board and/or develop an initial consensus model
• Pose "what if" to create conceptual conflict about validity of alt. Ideas
• Challenge students to think further/give them a piece of evidence to reason with</td><td>• Use language to reframe essential question in students' terms
• Use as label in initial models that you make public. Work in academic versions of these words into public models and discussions later.</td><td>• Re-write the essential question to be about this experience
• Make their prior experiences a central part of the next set of classroom activities
• If kids cannot connect science ideas to familiar experiences they've had, provide a shared experience all kids can relate to</td></tr>
</table>

Modified by C.Colley with permission from Tools for Ambitious Science Teaching, University of Washington, 2011, www.AmbitiousScienceTeaching.org

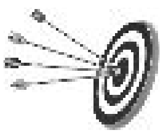
Lesson 2 When do magnets push? When do they pull?



Purpose

In this lesson, students observe two magnets interacting to figure out under what conditions (distance, orientation) the magnets pull towards each other (attract) or push away (repel) to cause two different kinds of motion (pull=move towards or push=move away). This lesson also helps students understand that poles do not always have to be on the ends of magnets depending on the magnet's shape.

- Students make observations and predictions about when magnets push and pull other magnets causing motion.



Learning Target

Focus question

When do magnets push?
When do magnets pull?

Learning Target

I can predict the motion of one magnet when it is near another magnet.

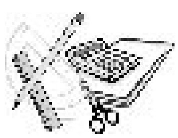
**You do not need to post a target statement. Instead, pose a question on the board.*

NGSS 3-D

SEP: Develop and use models *Develop a model to describe phenomena.* **SEP: Obtaining, Evaluating, and Communicating Information** *Obtain and combine information from books and other reliable media to explain phenomena.*

DCI: PS2.B: Types of Interactions *Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.*

CCC: Cause and Effect *Cause and effect relationships are routinely identified, tested, and used to explain change*



Materials

For the class:

- Lesson Slide Guide (GoogleSlides)
- Chart paper and markers
- Sticky notes

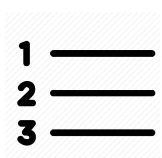
Per student:

- Science notebooks
- half-sheet reading (*reading*)

Per table group -- in a bag/box:

- 1 pair of horseshoe magnets
- 1 par of donut magnets
- 1 pair of bar magnets
- 1 pair of circle magnets*
- 1 pair of rectangle magnets*

**Each student needs a pair of magnets to manipulate and observe. Students can share at tables to observe different shapes of magnets.*



Lesson Step Summary

Part 1

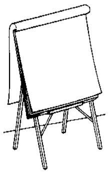
1. **Orient students to an idea or question:** Use an observation, idea, or question from L1 related to how magnets push/pull to introduce today's lesson.
2. **Provide new information:** Read a short text to give students new vocabulary they might find helpful as they observe magnets.
3. **Engage students in activity for sensemaking**: Students explore and talk in pairs/table groups about what they notice about magnets. *What did you notice? What did you figure out?* Students sketch and write about what they figured out.
4. **Summarize**: Share observations as a class to identify patterns.

Part 2

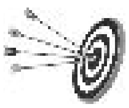
1. **Orient students to a question:** When do magnets push or pull on each other?
2. **Provide new information:** Read selected pages from books on magnetism about when magnets push or pull. Do they share information in similar ways?
3. **Making sense of information:** Write about connections. *How does the information from the readings help explain part of how the magnet toy works?*
4. **Summarize: Coordinate ideas and questions (whole-group)** Share ideas and wonderings. Make a summary table or chart for this question about magnets pushing and pulling to help us remember.

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

Part 1: Making Observations & Identifying Patterns



Public Record



Purpose

Turn-and-Talk

1. Launch: Introduce today's lesson

a) Revisit the list of hypotheses and questions from lesson 1. Provide an opportunity for students to add anything else before moving on.

b) Open with a statement of purpose for this lesson related to a hypothesis or questions students had from Lesson 1 related to how magnets push or pull. Show the focus question: *When do magnets push? When do magnets pull?* or use a question from your class that is similar (e.g. *How do magnets know when to move towards or away from each other?*)

This might sound like: *Last time you had some time to think about how this magnetic ring toy works. Before we get into today's learning, let's take a moment and look over the list of ideas and questions. If you have something you'd like to add, show a quiet thumb.* [Take additions or amendments to the public records from L1.] *Look over here on out list. Some of you were doing some thinking yesterday around how magnets move towards each other or that they can to push away* [insert idea/question from your class here related to pushing/pulling]. *Today you'll have some time to do some careful observations to see if we can answer this question together: When do magnets push on other magnets? When do magnets pull on other magnets?*

2. Introduce new ideas: Short reading

Read for information

Science Word

a) Students may have used words in L1 (poles, sides, top/bottom) or shared ideas (magnets stick one way but push the other way). Today's reading builds on student language and observations from L1.

b) Read the short reading about magnetic poles. Make decisions about what structure or scaffolds students might need to access this half-sheet text:
   - Will students read it as a class, in partners, or individually?
   - How will students interact with the text? Here are some ideas:
     1) Students may find it useful to be able to use magnets to act out what they are reading, have them available and encourage students to use magnets to understand the reading.
     2) Circle up to 3 words you don't know but want to know.
     3) Highlight the most important thing to you. Then share with a partner: *"The most important thing to me was ____ because…"*

c) Add 3-4 new words to a word wall or jot them on the board for student reference today: attract, repel, north pole, south pole.

3. Engage students in an activity for sensemaking:

Safety Alert

a) Tell students they will explore different shapes of magnets to see where they can feel or see where magnets attract, repel, or have no effect on each other. Remind students about using magnets safely:
   - Magnets can move quickly and pinch, so be careful.
   - Wash hands after touching/working with ceramic magnets.

Make Observations

Turn & Talk

Sketch & Jot

b) Each group needs pairs of magnets at their table (paired by shape) to pass around and observe to find out where the magnets attract, repel, or have no effect on each other. Once they observe two of the same magnets interacting (moving closer to each other, farther away, flip over, turn around, etc), pass the pair to the next person so students observe different shapes of magnets.

c) Encourage students to talk with each other to show and describe where magnets attract, repel, or have no effect on each other.

d) Notebook writing: Have students take a few moments to sketch what they tried out today and use arrows, symbols, labels, and captions to capture observations.

Back-Pocket Questions

<u>Getting Started:</u>
- *What are you trying out?*
- *What have you done so far?*
- *What did you notice as you moved one magnet near the other?*
- *Where have you observed pushing? pulling?*

<u>Pressing & probing:</u>
- *Do different shapes push or pull the same ways or in the same places?*
- *What do you think might cause ____ to happen?*
- *How can your observations help us explain how the magnet toy works?*

<u>About notebook writing/drawing:</u>
- *I heard you say___. How might you show that in pictures?*
- *You noticed the poles are not labeled or marked on the magnets. How could you label that in your sketch to show the same or opposite poles?*

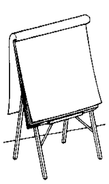
Teacher moves: Circulate, watch, listen, select, and sequence

Teacher Move:
Select & Sequence

Circulate as students make observations. Listen and watch. After doing some silent attending to what students are saying and doing, try some back pocket questions to help students look for patterns in where on the magnets they feel the attraction, repulsion, or no force between magnets.

As students wrap up their observations and work on their notebook sketch and jot, circulate again to identify students who could help with one of these roles in a class discussion:

1. Show where magnets repel, attract, and have no effect,
2. Describe or label where on the magnets their “strong spots” (kid language) or poles (science language) are and how they know.
3. Generalize a pattern making a statement about magnetic poles and interaction between magnets generally.



Summary Table: Observations & Patterns

e) *Summarize observations and identify patterns*: Gather as a class to summarize observations. Start off by asking some students to show and describe magnets interacting to identify places they attract, repel, feel strongest, weakest, or no effect. Ask students if they can come up with any claims that work for all, or almost all, magnets.

Claims could sound like some version of these:
- On each magnet, we found two poles but they might be in different places like top/bottom, ends, or sides.
- All magnets had some ‘weak spots’ or ‘dead spots’ in the middle (between poles) where pushes/pulls aren’t as strong or none at all.

Part 2: Building Explanations & Making Connections

Purpose

1. Orienting students

Remind students of the question they are working towards answering: *When do magnets push? When do magnets pull?* or use a similar question (e.g. *How do magnets know when to move towards or away from each other?*)

Read for information

2. Provide new information

a) Listening task: Have students listen closely and notice illustrations as you read selected pages from books about interactions between magnetic poles and think about how this text can help us answer our focus question. Suggested pages/texts:
   - pg 12-16, Rookie Read About Science: What Can Magnets Do?
   - pg 10-13, Magnets Pulling Together Pushing Apart
   - pg 4-5 & pg 20-21, All about Science: All about Magnetism

Turn-and-Talk

b) Turn-and-talk: What information did you hear that helps answer our question: *When or where do magnets push or pull each other?*

c) *Optional: Compare how authors/books presented the same information. Why do you think authors chose different ways to communicate this concept? Which author do you think did the best job? Why?*

3. Making sense of new information

Quick Write

a) Have students write their response to the lesson question: *When or where do magnets push or pull each other?* Encourage students to use ideas from the books and their observations from part 1. They can make labeled sketches and full sentences.

Teacher Move

Teacher role: Noticing student understanding

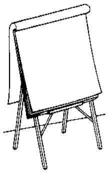
As students work on writing, circulate and examine what they are writing. What are you seeing from the class around these content ideas?

1. that magnets have two different poles
2. where poles are located on different magnet shapes -- not just the ends
3. how poles cause a change a magnets position/motion when magnets are oriented to other magnets in particular ways

Depending on what you notice, you may offer individual students or pause the class to offer a reminder or provide scaffolding.

Turn-and-Talk

b) After about 5-7 minutes of writing, pause the class. Have students turn their attention back to the magnetic toy and have a table/group discuss and then continue writing about: *How does learning about magnetic poles, attraction, and repulsion help us explain the gaps in the magnetic ring toy?* As students write, look for the 3 ideas above in addition to *4. how understanding poles explains gaps in the magnetic toy.*



Summary Table: Explain & Connect

4. Summarize: Explain & Connect (whole-group)

Share ideas and wonderings. Make a summary table or chart for this question about magnets pushing and pulling to help us remember.

Activity	Observations & Patterns	Learning & Explanation	Connections to the phenomenon
When do magnets push? When do magnets pull?	Each magnet has two poles in different places like top/bottom, ends, or opposite sides. The donut magnets can move the other magnet through the table and pages of a book but not the whole book. To get a magnet to move the other, it had to get close to it. All magnets had some 'weak spots' or 'dead spots' between poles where pushes/pulls aren't as strong.	* opposite poles = attract/pull * same poles = repel/push * magnets have two poles even if you broke a magnet, the pieces have poles	Each donut magnet has two magnetic poles on the top and bottom. The side going around the donut doesn't seem to have any strength to push or pull other magnets. When two donut magnets are on top of each other they will push away or repel if their poles on the sides are opposite.

Lesson Closing

5. Lesson Closing

a. Check in with students using a thumb-mometer: *Do you think we have answered the question about when do magnets push and pull?* If lots of side or down thumbs, ask a follow-up about what other information or investigations they need to help answer this question.
b. Tell students that next time they will keep thinking about what causes these gaps between magnetic rings and why they are different heights.
c. Have students stack their notebooks open to the pages from today's lesson so they are easy to skim and sort.

[If time permits, there are optional extension tasks at the end of the SlideGuide for this lesson.]

Teacher reflection: Examining Student Thinking

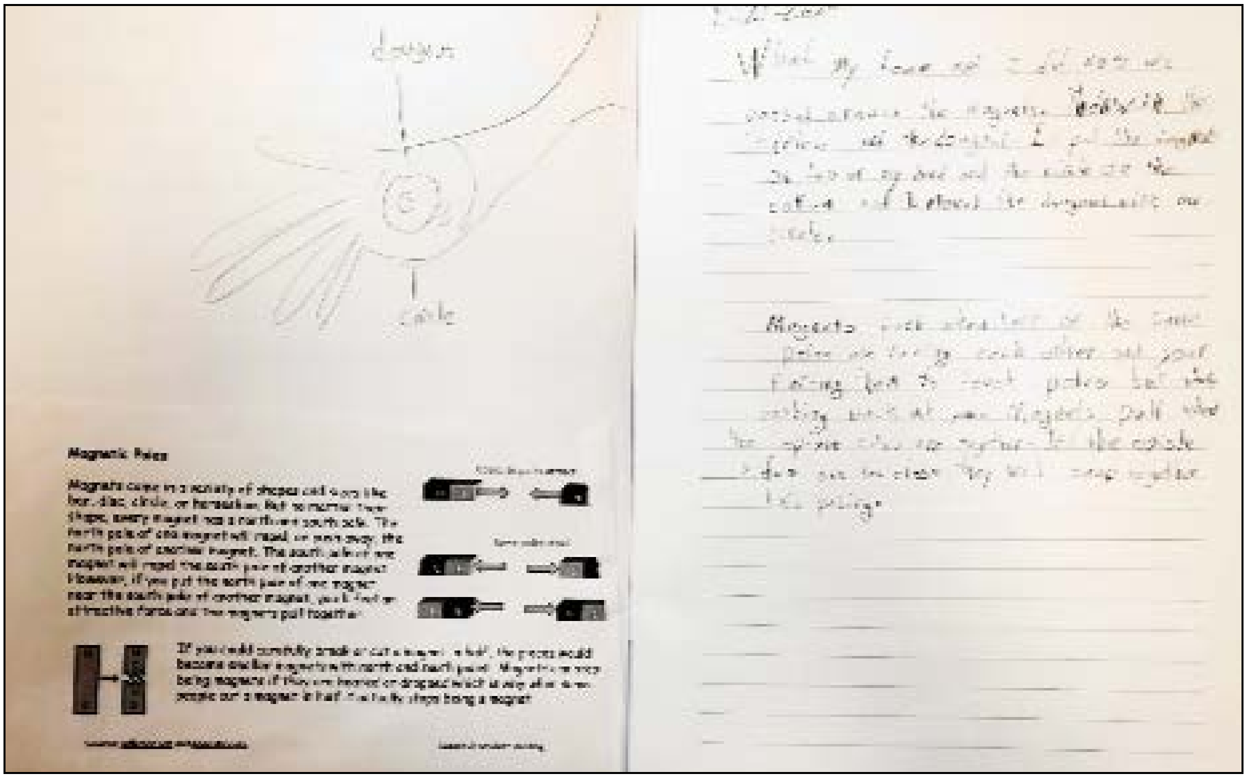
Teacher Move: Examine & Interpret

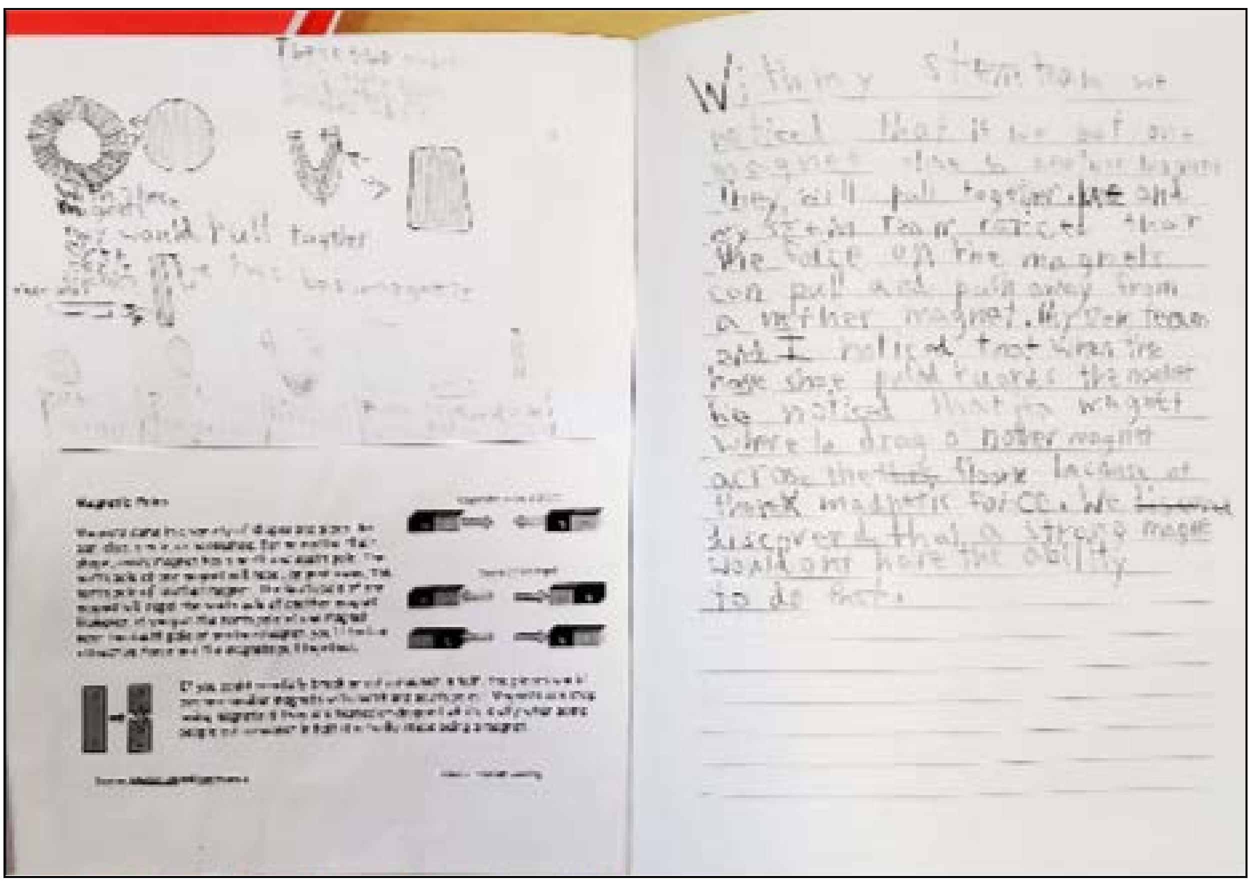
Do a quick 3 pile sort of notebooks by the amount of information on the page (none/very little, some, a lot). Then spend more time tackling each pile, reading more closely, to get a better sense of students' current thinking.

★ What ideas do you see and understand in students' work? Specifically, for this lesson, what information did students include about the importance of magnetic poles?
    1. *That* magnets have poles
    2. *Shere* poles are located on different shapes of magnets -- not just at the ends of a magnet
    3. *How* poles cause a change a magnets position/motion when magnets are oriented to other magnets in particular ways
    4. *Connect* knowledge about magnetic poles to explain gaps in the magnetic toy

★ Whose notebooks are in each pile? What does this make you wonder about how to support all students recording their current thinking?

Photos from Lesson 2





When do magnets push? When do they pull?

Part 1

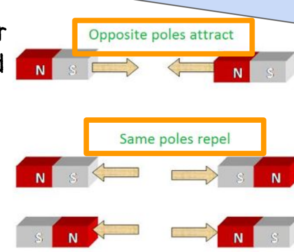
A Short Reading...

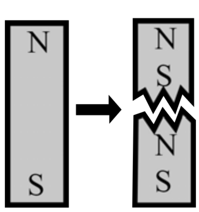
Magnetic Poles

Try it!

Use your magnets to act out paragraph 1. What can you figure out about poles?

Magnets come in a variety of shapes and sizes like bar, disc, circle, or horseshoe. But no matter their shape, every magnet has a north and south pole. The north pole of one magnet will repel, or push away, the north pole of another magnet. The south pole of one magnet will repel the south pole of another magnet. However, if you put the north pole of one magnet near the south pole of another magnet, you'll feel an attractive force and the magnets pull together.





If you could carefully break or cut a magnet in half, the pieces would become smaller magnets with north and south poles! Magnets can stop being magnets if they are heated or dropped wh
some people cut a magnet in half it actually stops be

Quick Question:
Modeling using arrows

How did the author use arrows in the diagrams? What do the arrows show or mean?

Sources: Jefferson Lab and Apex Magnets

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

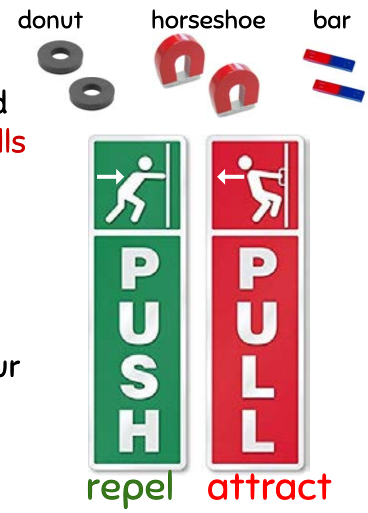
MAKE OBSERVATIONS

You need: 2 of the same magnets at a time

Your job: Move the 2 magnets around (same kind of magnet). Observe the pushes and pulls between the magnets.

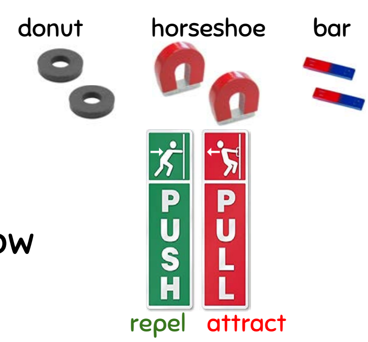
- ❏ Can you push one magnet with the other magnet?
- ❏ Can you pull one magnet with the other magnet?
- ❏ What do you notice about the distance or strength?

Next step: Compare with another scientist at your table. Does your magnet shape push and pull the same as another shape? What do you notice?

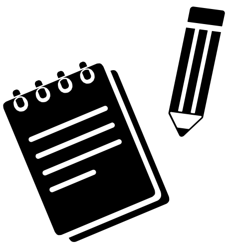


SUMMARY TABLE: OBSERVATIONS & PATTERNS

- ➢ What did you do?
- ➢ What did you observe or notice?
- ➢ What claims can we make about how magnets interact with each other?



Activity	Observations & Data Patterns	Explaining our observations and data	Making Connections
When do magnets push? When do magnets pull?	*What did you observe or notice?*	*What did we learn that helps explain our observations?*	*How does this activity help us explain how the magnetic toy works?*



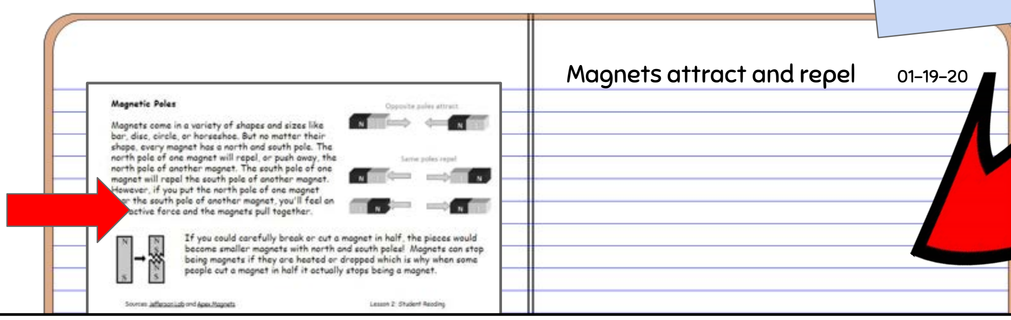
NOTEBOOK

- ❏ Open to a new page.
- ❏ Glue your reading.
- ❏ Write title and date.
- ❏ Sketch what you did with magnets.
- ❏ Explain what you figured out today.

Helpful Words:

magnet	poles
attract	pull
repel	push

Modeling using arrows:
How could you use arrows in your sketch? What do the arrows show or mean?



Magnetic Poles

Magnets come in a variety of shapes and sizes like bar, disc, circle, or horseshoe. But no matter their shape, every magnet has a north and south pole. The north pole of one magnet will repel, or push away, the north pole of another magnet. The south pole of one magnet will repel the south pole of another magnet. However, if you put the north pole of one magnet r the south pole of another magnet, you'll feel an active force and the magnets pull together.

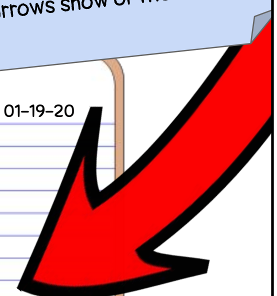
Opposite poles attract

Same poles repel

If you could carefully break or cut a magnet in half, the pieces would become smaller magnets with north and south poles! Magnets can stop being magnets if they are heated or dropped which is why when some people cut a magnet in half it actually stops being a magnet.

Sources: Jefferson Lab and Apex Magnets

Lesson 2: Student Reading



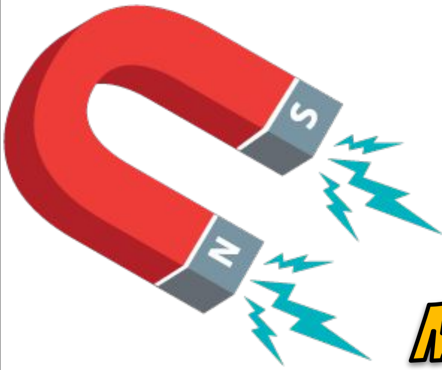
THINK & DISCUSS

What have we figured out about:

WHEN DO MAGNETS PUSH EACH OTHER?
WHEN DO MAGNETS PULL EACH OTHER?

Anything else we want to know, research, or figure out?

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

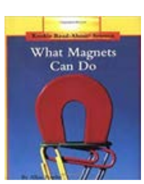


WHEN DO MAGNETS PUSH? WHEN DO THEY PULL?

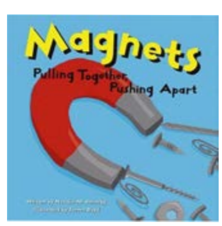
Part 2

HOW DO THESE TEXTS SHARE SIMILAR IDEAS?

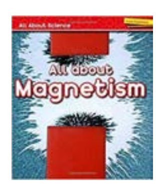
Refer to the pages below for the book(s) you have available.



pages 12-16



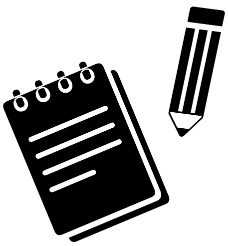
pages 10-13



pgs 4-5 & 20-21

Does the information help us answer today's question:

WHERE OR WHEN DO MAGNETS PUSH OR PULL?



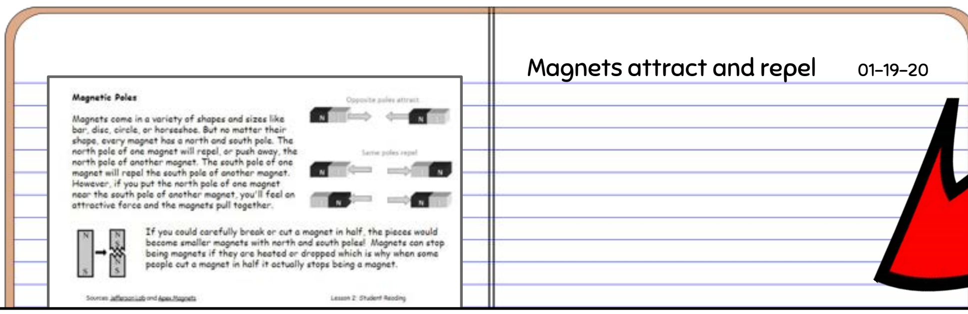
NOTEBOOK

Helpful Words:

magnet, attract, repel, poles, pull, push

Below what you wrote yesterday…

- [ ] Add more about when or where magnets push and pull on each other.



Magnetic Poles

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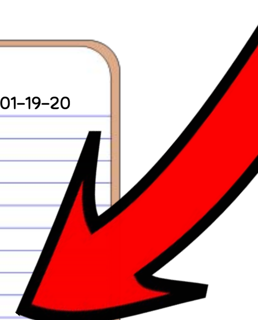
Same poles repel

If you could carefully break or cut a magnet in half, the pieces would become smaller magnets with north and south poles! Magnets can stop being magnets if they are heated or dropped which is why when some people cut a magnet in half it actually stops being a magnet.

Sources: Jefferson Lab and Apex Magnets — Lesson 2: Student Reading



SUMMARY TABLE: EXPLAIN OUR OBSERVATIONS

donut horseshoe bar

repel attract

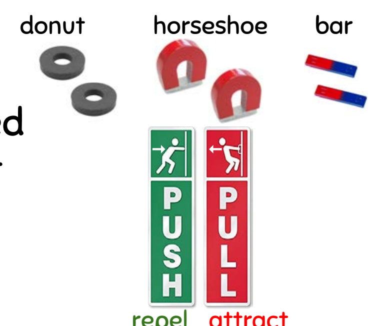
What did we learn from the texts that helps us explain how magnets interact with each other?

Our Question	Observations & Data Patterns	Explaining our observations and data	Making Connections
When do magnets push? When do magnets pull?	*What did you observe or notice?*	*What did we learn that helps explain our observations?*	*How does this activity help us explain how the magnetic toy works?*

APPLY WHAT WE KNOW: MAGNETIC RING TOY

How does learning about magnetic poles, attraction, and repulsion help us explain how the magnetic ring toy works?

SUMMARY TABLE: MAKING CONNECTIONS



How can what we observed and learned help us explain part of the story about how the magnetic ring toy works?

Our Question	Observations & Data Patterns	Explaining our observations and data	Making Connections
When do magnets push? When do magnets pull?	*What did you observe or notice?*	*What did we learn that helps explain our observations?*	*How does this activity help us explain how the magnetic toy works?*

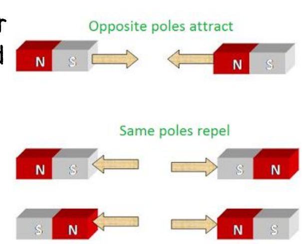
OPTIONAL EXTENSIONS

Optional

EXTENSION: CLASS DISCUSSION

Magnetic Poles

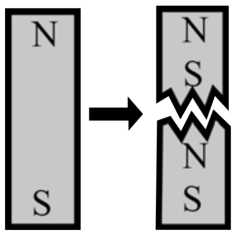
Magnets come in a variety of shapes and sizes like bar, disc, circle, or horseshoe. But no matter their shape, every magnet has a north and south pole. The north pole of one magnet will repel, or push away, the north pole of another magnet. The south pole of one magnet will repel the south pole of another magnet. However, if you put the north pole of one magnet near the south pole of another magnet, you'll feel an attractive force and the magnets pull together.



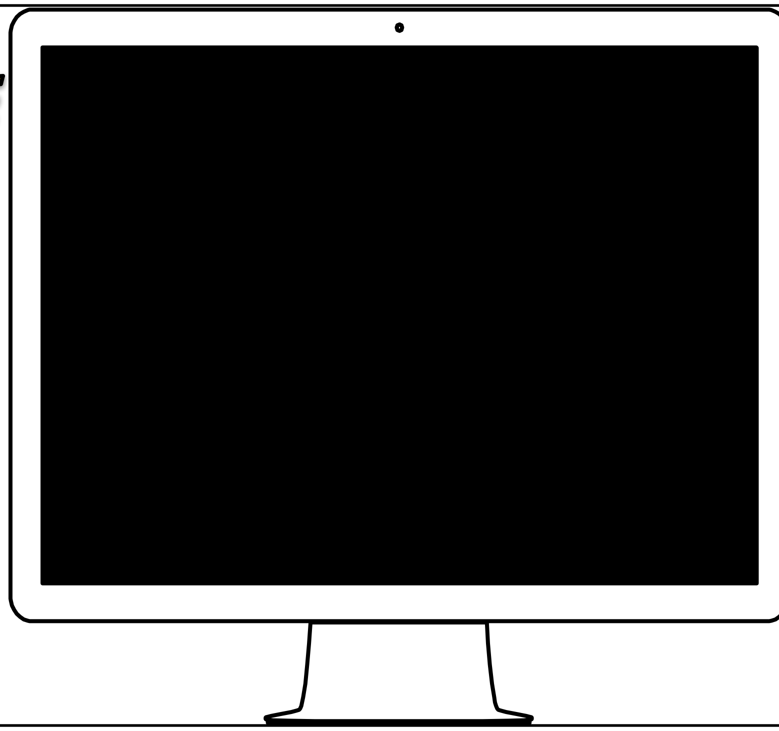
What if a magnet does not have its poles labeled? How could you figure out which pole is north and which is south?

Sources: Jefferson Lab and Apex Magnets

EXTENSION: MORE INFORMATION...

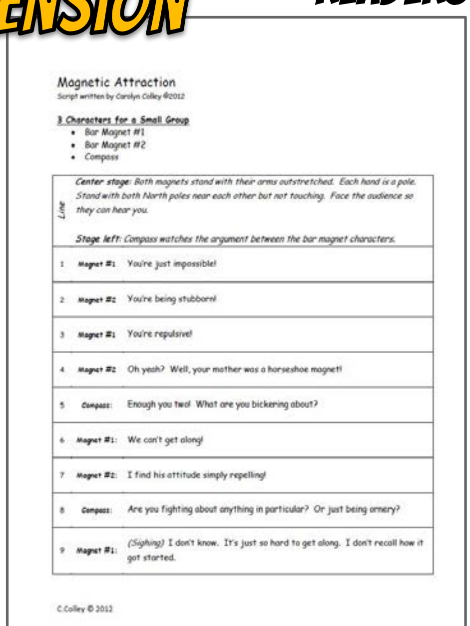


WHY CAN'T WE JUST HAVE ONE POLE IF WE BREAK A MAGNET?



EXTENSION

READERS' THEATRE



Magnetic Attraction

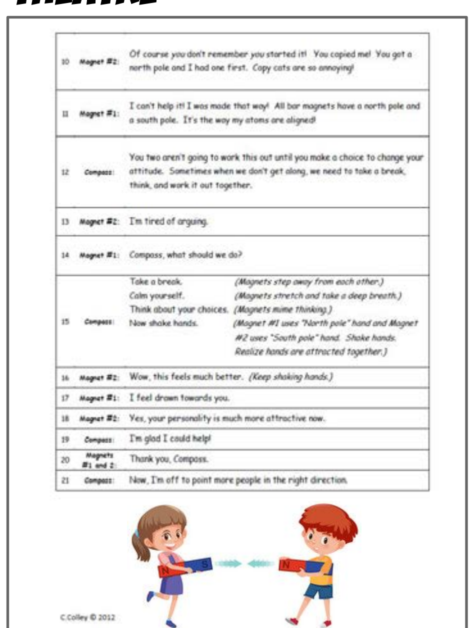
Script written by Carolyn Colley ©2012

3 Characters for a Small Group

- Bar Magnet #1
- Bar Magnet #2
- Compass

Line		
		Center stage: Both magnets stand with their arms outstretched. Each hand is a pole. Stand with both North poles near each other but not touching. Face the audience so they can hear you. *Stage left: Compass watches the argument between the bar magnet characters.*
1	Magnet #1	You're just impossible!
2	Magnet #2	You're being stubborn!
3	Magnet #1	You're repulsive!
4	Magnet #2	Oh yeah? Well, your mother was a horseshoe magnet!
5	Compass:	Enough you two! What are you bickering about?
6	Magnet #1:	We can't get along!
7	Magnet #2:	I find his attitude simply repelling!
8	Compass:	Are you fighting about anything in particular? Or just being ornery?
9	Magnet #1:	*(Sighing)* I don't know. It's just so hard to get along. I don't recall how it got started.

C.Colley © 2012



10	Magnet #2:	Of course you don't remember you started it! You copied me! You got a north pole and I had one first. Copy cats are so annoying!	
11	Magnet #1:	I can't help it! I was made that way! All bar magnets have a north pole and a south pole. It's the way my atoms are aligned!	
12	Compass:	You two aren't going to work this out until you make a choice to change your attitude. Sometimes when we don't get along, we need to take a break, think, and work it out together.	
13	Magnet #2:	I'm tired of arguing.	
14	Magnet #1:	Compass, what should we do?	
15	Compass:	Take a break. Calm yourself. Think about your choices. Now shake hands.	*(Magnets step away from each other.)* *(Magnets stretch and take a deep breath.)* *(Magnets mime thinking.)* *(Magnet #1 uses "North pole" hand and Magnet #2 uses "South pole" hand. Shake hands. Realize hands are attracted together.)*
16	Magnet #2:	Wow, this feels much better. *(Keep shaking hands.)*	
17	Magnet #1:	I feel drawn towards you.	
18	Magnet #2:	Yes, your personality is much more attractive now.	
19	Compass:	I'm glad I could help!	
20	Magnets #1 and 2:	Thank you, Compass.	
21	Compass:	Now, I'm off to point more people in the right direction.	

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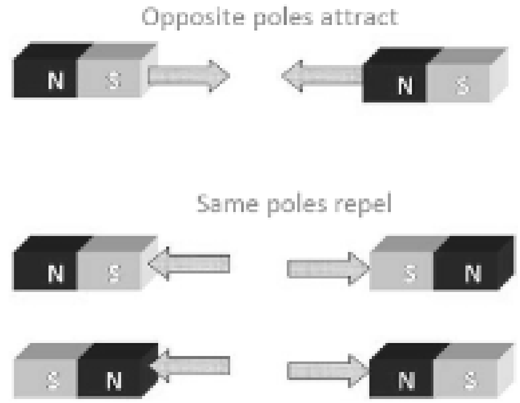
Magnetic Poles



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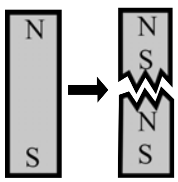
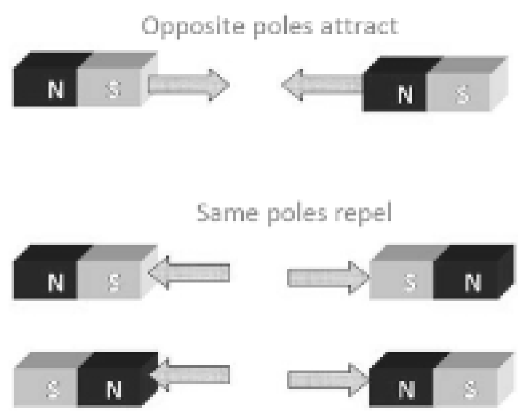
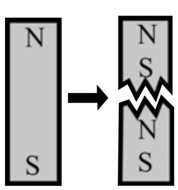


If you could carefully break or cut a magnet in half, the pieces would become smaller magnets with north and south poles! Magnets can stop being magnets if they are heated or dropped which is why when some people cut a magnet in half it actually stops being a magnet.

Magnetic Poles



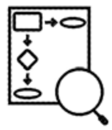
Magnets come in a variety of shapes and sizes like bar, disc, circle, or horseshoe. But no matter their shape, every magnet has a north and south pole. The north pole of one magnet will repel, or push away, the north pole of another magnet. The south pole of one magnet will repel the south pole of another magnet. However, if you put the north pole of one magnet near the south pole of another magnet, you'll feel an attractive force and the magnets pull together.



If you could carefully break or cut a magnet in half, the pieces would become smaller magnets with north and south poles! Magnets can stop being magnets if they are heated or dropped which is why when some people cut a magnet in half it actually stops being a magnet.

Sources: Jefferson Lab and Apex Magnets   Lesson 2: Student Reading

Lesson 3 More on Pushes and Pulls: Introducing Gravity

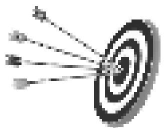


Purpose

In this lesson, students continue learning about how forces can cause or change motion by learning about gravitational force.

- Students will use ideas about forces (gravity and magnetism) that act between objects to make predictions about motion (or no motion) of an object.

For more about supporting on-going changes in student thinking, see [http://AmbitiousScienceTeaching.org]



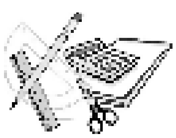
Learning Target

Focus question
How does the magnet float in-place without moving? What's going on with the gaps?

Learning Target
I can obtain information about gravity and use it to explain and predict motion.

**You do not need to post a target statement. Instead, pose a question on the board.*

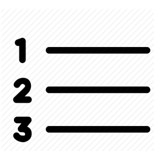
NGSS 3-D
SEP: Developing and using models. *Develop models to explain phenomena.*
DCI: PS2.A: Forces and Motion
Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.
CCC: Cause and Effect *Cause and effect relationships are routinely identified.* ***CCC: Patterns*** *Patterns can be used to make predictions*



Materials

For the class:
- Lesson Slide Guide (GoogleSlides)
- 2 magnetic ring toys (or more)
- Chart paper and markers
- Sticky notes
- Book: Forces Make Things Move by Kimberly Bradley

Per student:
- Science notebooks
- half-sheet student notes (*scaffold*)
- 1 set of 4 donut magnets
- 1 pencil



Lesson Step Summary

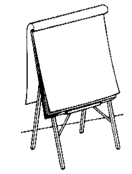
Part 1

1. **Orient students to an idea/question:** Use a student idea/question related to ideas about gravity or pressure to introduce today's lesson. Have students notice/wonder about the magnetic ring toy oriented vertically versus horizontally.
2. **Provide new information:** Read selected pages to give students information about gravitational force they might find helpful as they explain the behavior of magnets in the next activity. *(Option: Students use note-taking scaffold.)*
3. **Engage students in activity for sensemaking**: Students explore and talk about what they notice about the gap size between magnets.
4. **Revisit the concept of gravitational force**: Revisit the idea of gravity as a force using a short video clip and add the term to the science word wall.

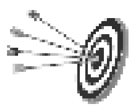
Part 2

5. **Model-to-Explain**: Students model-to-explain the changes in gap size between magnets using ideas they have heard about so far magnetic and gravitational forces. *How can you develop a model that explains what's going on with the forces?* Circulate and press students to talk about how they are showing magnetic and gravitational forces in their models.
6. **Class discussion**: Choose 2 models to launch a class discussion about what's going on in the gaps between magnets and how students showed forces. At the end of the discussion, summarize any "take-aways" or "most-important points."

Part 1



Public Record



Purpose

1. Launch: Introduce today's lesson

a) Refer back to an observation, idea, or question from L1 or L2 related to gravity or pressure to introduce the lesson. It is helpful to directly point to the idea or question that is on a public chart so students see what your lessons are following-up on ideas or questions that they, or others in their class, have about magnets and the magnetic toy.

Photo: Notice & Wonder

Turn-and-Talk

b) Show the focus question: *How does the magnet float in-place without moving? What's going on with the gaps?*

c) Do a notice and wonder about images or observe the actual magnetic ring toy oriented vertically compared to horizontally. This is meant to get students focused on today's question and not turn into a long discussion right now. There is time later in the lesson for a class discussion about this phenomenon.

This might sound like:
As we have been exploring magnets, some of you have been using words like gravity and pressure along with ideas about repelling and attraction, or how magnets push and pull on each other. We have a wondering on our question chart about *<u>why magnets seem to squish together, making gaps smaller and some gaps bigger</u>* [or insert related question from your students].

Today we'll have some time to learn more about gravity as a force and what job the force of gravity has in helping us think about how magnets interact. A question to work on answering today is: What's going on with the gaps between the magnets on our magnetic ring toy? Why are some gaps bigger than others?

Let's look at this image (see slide) *that shows the magnetic ring toy laying horizontal and compare it to vertical. What do you notice about the gaps? What do you think caused that to happen? Think for a few silent seconds* [give 10-15 silent seconds] *and now turn and talk with a partner.* [No need to share out whole group here. There will be time later.]

Read for information

2. Introduce new ideas: Short reading

a) Tell students that they build on the language that some were using around gravity, pressure, pushing, and pulling. To help focus on what the text says, suggest students jot some notes as they listen in their notebook *(optional: preview the [half sheet notetaking scaffold](#) so students know what to listen and look for in the text.)*

Note-taking

b) Read pages 22-29 to the class from the book *Forces Make Things Move* by Kimberly Bradley. Pause once or twice for about 15-20 seconds to allow students to jot or sketch a note about what they heard/read so far.

Turn-and-Talk

c) Ask students to prepare a thought to share with a partner to answer the question: *What did you find out about gravity from this book?*

d) Slowly do a picture walk back through pages 22-29 and students can signal a part or page to pause on to reread/revisit now. Give students a silent minute to add notes about gravity as a force.

Safety Alert

3. Engage students in an activity for sensemaking:

a) Tell students they will use the donut magnets on their pencils like the magnetic ring toy to compare vertical and horizontal orientations to figure out what makes gaps bigger or smaller.

Make Observations

b) Remind students about safely:
- Magnets can pinch so be careful.
- Wash hands after touching/working with these magnets.

PartnerTalk

c) Each student needs 4 donut magnets and their pencil. If you have multiple magnetic ring toys, have those available if students have questions they would like to test using the toy compared to donut magnets.

d) Encourage students to talk with each other to share their models and ideas about the sizes of gaps between magnets.

Back-Pocket Questions

Getting Started:
- Materials: *Do you have what you need to observe gaps between magnets?*
- Observations: *What did you notice about the size of the gaps?*
- Patterns: *When are the gaps small? When are the gaps bigger?*

Pressing & probing:
- Cause-and-effect: *What do you think might cause ____ to happen?*
- Explain using science concepts:
  - *What information helps you explain what you noticed?*
  - *How can ideas about magnetic poles or gravity help you explain why or how that happens?*

Teacher Move: Listen & Confer

Teacher moves: Circulate, attend, elicit, and confer

Circulate as students make observations. Listen and watch. After doing some silent attending to what students are saying and doing. Try some back pocket questions to help students look for patterns and push students to try-out using science concepts like magnetic forces and gravitational force in their verbal explanations.

Video Clip

4. Revisit ideas:

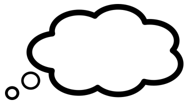
Return materials to the tub and rejoin at the carpet to take a moment as a class to revisit the concept of gravity using the short video clip. *What else did you hear about gravity?*

Science Word

Optional: Student understanding about gravity as a force is still under construction so students may not feel confident yet about revising the definition. Use teacher discretion to decide if you want to use the slide with the definition draft for gravitational force and have students turn-and-talk about how they would revise or reword the description provided. Add to the science word wall for future reference.

[Depending on timing, pause here and start with models in Part 2. If you have time remaining today, students can start their models, and finish them at the beginning of part 2.]

Part 2



Think Time

Turn-and-Talk

Re-orient students to science ideas: Return to the image of the magnetic ring toy gaps (vertical vs horizontal) and have students think about what they've learned about magnetic forces and gravitational forces so far.

Might sound like: *We've been thinking about why gaps between magnets are different sizes and how magnets can hover without moving. What have we learned about magnetic forces or gravitational force that could help us explain this?* [Think. Turn-and-talk.]

Model to Explain

5. Model-to-Explain:

a) Prepare students model-to-explain the gaps, comparing horizontal vs vertical, using ideas they have heard about so far magnetic poles and gravity as a force. Remind students that scientists use arrows to represent things, that we can't see but we know are there, like forces. Also, tell students to try using recent ideas they have learned about magnetic poles, attraction, repulsion, and gravitational force.

Turn-and-Talk

a) Give time for students to sketch models explaining the gaps in magnetic ring toy using ideas they have learned about so far.

b) Have students share models and get ideas by sharing with an elbow partner or do a stand-up-hand-up-pair-up to share and compare how they chose to show magnetic and gravitational forces. This is a rehearsal for participating in the whole-class discussion next.

Back-Pocket Questions

Getting Started:
- Clarify Task: *What will you explain in your model?*
- Observations: *Start by sketching what you noticed first.*

Pressing & probing:
- Modeling: *You said___. What's one way you could show that with symbols, colors, or arrows on your model?*
- Compare: *What forces are the same between the vertical and horizontal toys? Do you think the forces change? How could you show that?*

Teacher Move:
Select & Sequence

Teacher moves: Circulate, watch, listen, select, and sequence

Circulate and attend to what students are saying, writing, and drawing. Try back pocket questions (above) to help students get started or to represent forces they can't directly see (using color, symbols, arrows). Look for students who show the following and would be willing to show that part of their model to the whole class:

1. Show that magnets repel or attract using arrows, symbols, or colors.
2. Show a difference between gravitational force and magnetic force.
3. Using ideas about different forces to explain why gaps on the horizontal toy are equal but gaps on the vertical toy were different sizes.

Share & Discuss

6. Class discussion *(or try Hands-Down Conversation , see next page)*

a. Have 3-4 students quickly show how they represented forces: *What were some different ways we showed forces? How did we show the magnetic forces? How did we show the gravitational force?*

b. Direct the discussion to the original question. *Why are the gaps more evenly spaced in the horizontal toy and vary in size in the vertical toy*? If you want, try a hands-down conversation (see next page for more detail).

Hands-Down Conversation Opportunity: Gaps between magnetic rings

Purpose

Use a [hands-down conversation] structure for about 10 minutes about today's question about the horizontal versus vertical image of the magnetic toy. This could be during a shorter science time or in another part of the day. The goal for this discussion is building on each others' ideas.

Micro-lesson

This discussion also acts like a rehearsal of ideas before students go model-to-explain these ideas on their own in their notebooks. *(Alternative sequence: Have students model-to-explain first to prepare for the discussion.*

Think Time

1. **Micro-lesson: Build ideas together**
   a. Tell students the focus of this discussion is to build ideas together, which goes beyond just sharing your idea.
   b. Provide a list of what they can say to build ideas together.
   c. Have students move into a large circle so everyone can see each other and has space.

Discuss

2. **Getting started:** After students are in a circle, and can see everyone, ask who would like the first word in the discussion explaining what's going on with the gaps..

3. **Teacher role**: Intervene, only when needed, to remind students of the expectations or of today's challenge. Let awkward silences happen.

Feedback & Follow-up

4. **Getting feedback**: In the last minute, choose a student to give the last word. Then, check in to get feedback from students. *How do they think they did today in building ideas?* Add any new specific moves to the list to try next time when building ideas is the discussion purpose.

Say something to students like,
"Let's take some time to do some deeper thinking together to build our understanding of forces together. Your challenge for this conversation is not only to share your thinking but to connect it to another students' idea or to something we read or observed. What could building ideas sound like? [Jot some ideas on the board.] *You could try building ideas by saying:*

- "Yes, and…"
- "Can anyone say more about ___?"
- "I think ___ which connects to…"
- "I agree that ___ but what if…"
- "I disagree that __ because…"
- "___ makes me think about..."

We can add more to this list later.

Remember, your challenge is to build off each other while following the expectations of (1) no hands, (2) one voice at a time, (3) listening to understand, and (4) responding. I'll give you the prompt and some silent think time before we move into our circle.

[Teacher role: Provide question/prompt, then step out and have students start the hands-down conversation. Intervene when needed. After several minutes, invite one student to share the last word/contribution to end the discussion. Then do a quick debrief about the discussion experience.]

Let's check in on our challenge today. Show your thumb-mometer. How did you do personally today at trying to build ideas together? [Look at thumbs] *Would anyone like to share something you tried out to build ideas?* [Share a few.] *Are there any moves we want to add to our list? We will have a chance to improve and rise to this challenge later in this unit."*

Teacher reflection: Examining Student Thinking

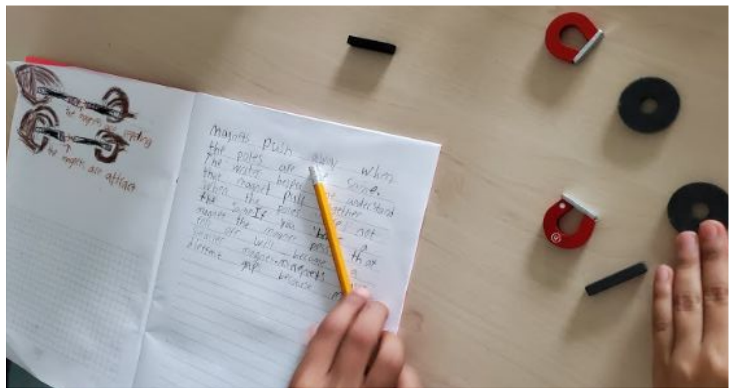
Teacher Move:
Observe & Interpret

There are many ways to analyze student work. For this lesson, look through students' notebook entries about explaining the gaps in the magnetic ring toys.

Look for how students modeled with forces. This will help you launch lesson 4:

★ How are students using arrows and labels to show forces?
★ Which students tried out using gravity or gravitational pull? How did they show this? Did they use arrows or labels or color?
★ Which students used ideas from lesson 2 about magnetic poles, attraction and repulsion between magnets? How did they show this? Did they use arrows or labels or color?

Lesson Photos



Optional Teacher Reflection: Considering alternative conceptions

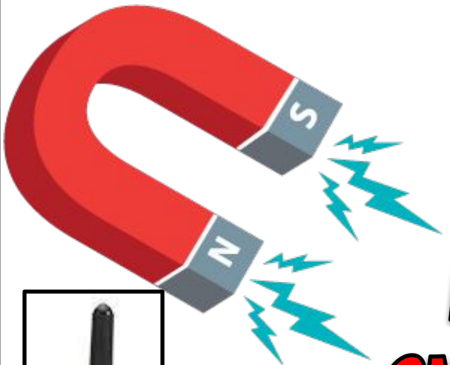
Below is a list of commonly-held alternative ideas students may have about gravity. Take a moment to consider which students shared these understandings through talk or writing. Remember, the expectation in grade 3 is that students recognize and describe how gravitational force can cause changes to the motion of objects. Students continue developing their conceptual understanding over the next few years, and can start working on them now.

Approx # of students showing this idea in L3	Some commonly-held alternative understandings about magnetism and gravity that could surface in Lesson 3
_____ _____ _____ _____	1. Magnets are attracted to each other because of gravity. 2. Gravity turns on/off. Gravity is 'on' when an object falls, 'off' when it lands 3. Gravity works one direction, just towards large objects -- The Earth's gravity attracts the person but the person's gravity does not attract Earth. 4. Gravity only affects heavy things. *(Least likely to come up, but might.)*

Not all ideas listed are fully addressed in this Grade 3 lesson or unit. Lessons in this unit lay the groundwork for continued learning in future grades. Misconceptions are stepping stones to developing understandings and take time to shift. See this article to read about the usefulness of surfacing, acknowledging, and using misconceptions.

What could you do with this information? It is more important to push students to consider for themselves how their ideas align or not with other sources, including video, text, and peers.

★ *How does your idea compare with... what the text or video says? What your partner says?*
★ *In what places do you and the text/video/partner agree? disagree?*
★ *What makes sense or doesn't make sense to you?*
★ *What do you need more information about to help grow your thinking?*

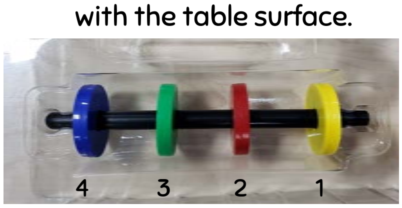


WHAT'S GOING ON WITH THE GAPS?

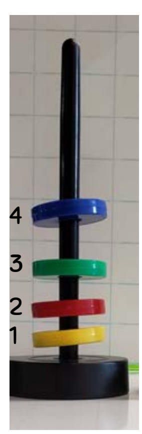
Part 1

WHAT'S GOING ON WITH THE GAPS?

This is the magnetic ring toy in a horizontal position, parallel with the table surface.



horizontal



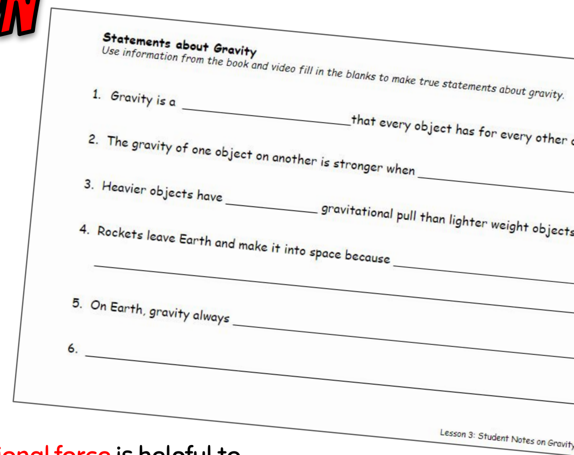
vertical

This is the magnetic ring toy in a vertical position, perpendicular on the table.

READ FOR INFORMATION

pages 22–29

What does this book say about gravity as a force?


Statements about Gravity
Use information from the book and video fill in the blanks to make true statements about gravity.

1. Gravity is a ____________ that every object has for every other ob
2. The gravity of one object on another is stronger when ____________
3. Heavier objects have ________ gravitational pull than lighter weight objects.
4. Rockets leave Earth and make it into space because ____________
____
5. On Earth, gravity always ____________
6. ____________

Lesson 3: Student Notes on Gravity

- ➢ What did you find out about gravity?
- ➢ Do you think knowing about gravitational force is helpful to explaining the gaps between magnets? Why or why not?

WHAT'S GOING ON WITH THE GAPS?

COMPARE GAP SIZES: HORIZONTAL VS VERTICAL

<u>You need:</u>
1 pencil
4 donut magnets

Safety Note: These magnets can pinch so be careful with your fingers.

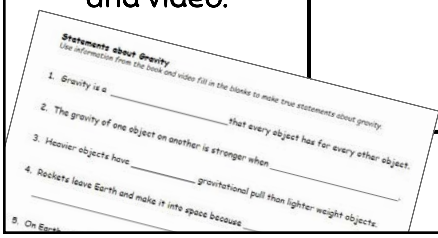
<u>Your task:</u>

1. Place the pencil through the magnets. Try horizontal and vertical. Change the number of magnets. Explore and observe.
2. Talk with a partner or group about what you:
   Notice: What happens with the magnets? What do you notice about the gaps?
   Explain: How can you use your knowledge of magnetic poles and gravitational forces to explain what you observe?

WATCH

What else can we learn about the Earth's gravitational force?

Compare info from the book and video.


Statements about Gravity
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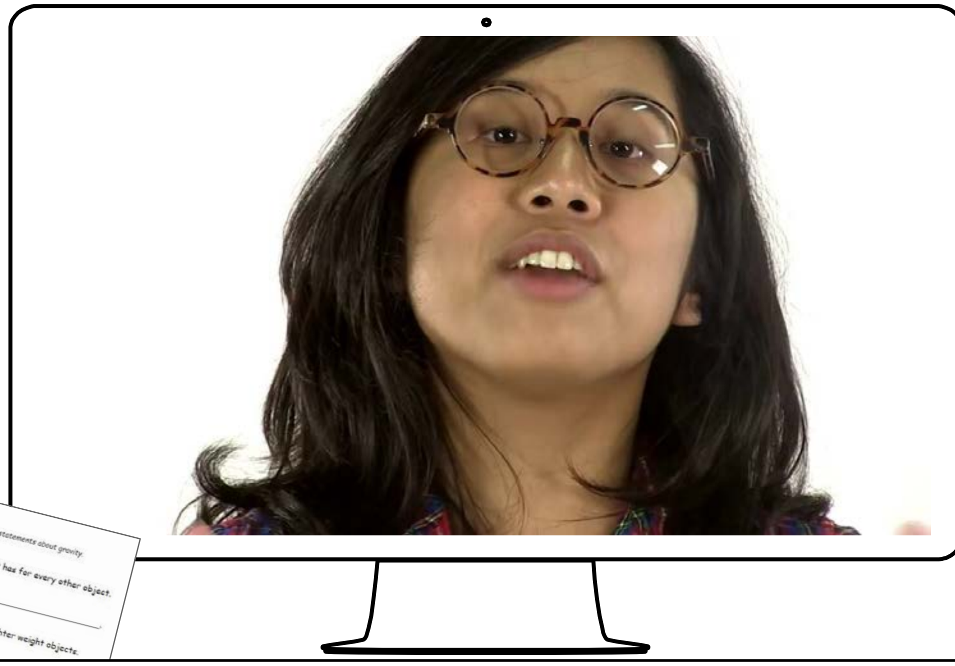
1. Gravity is a ____________ that every object has for every other object.
2. The gravity of one object on another is stronger when ____________
3. Heavier objects have ____________ gravitational pull than lighter weight objects.
4. Rockets leave Earth and make it into space because ____________
5. On Earth



NEW SCIENCE WORD

What would you add or change to make this description of gravity more complete or easier to understand?

Gravitational force

Gravity is an attractive force between objects.

The strength of the pull depends on the masses of the objects and how far apart they are.

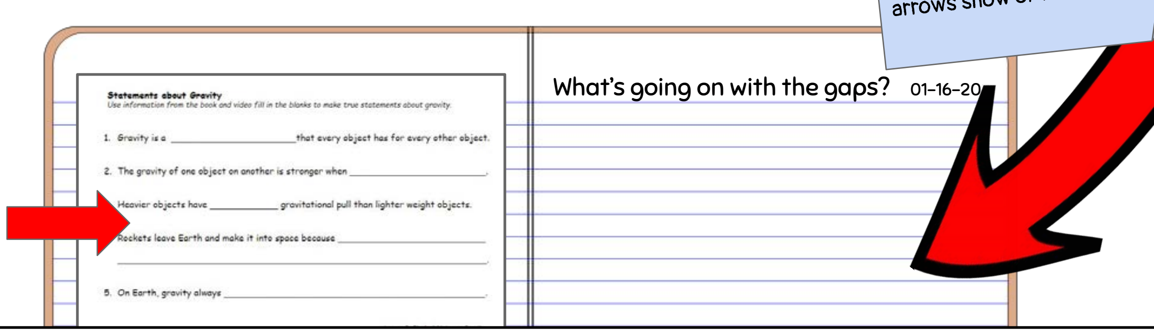
NOTEBOOK

- ❏ Open to a new page.
- ❏ Glue your reading.
- ❏ Write title and date.
- ❏ Sketch a model to show your ideas.
- ❏ Jot your explanation about today's question.

Helpful Words:

magnet poles
attract pull
repel push
gravitational force
magnetic force

Modeling using arrows:
How could you use arrows in your sketch? What do the arrows show or mean?



PARTNER CONFERENCE

What forces did you show in your model?

How did you show them?

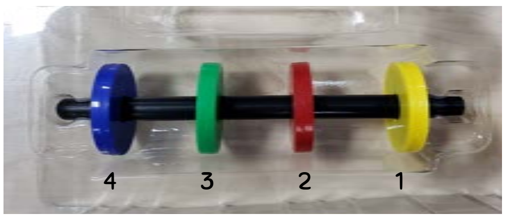
What felt easy for you to make this model?

What felt hard for you to make this model?

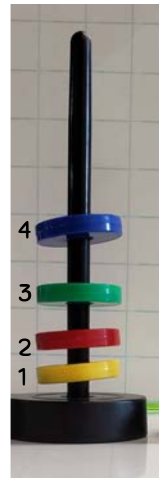
CLASS DISCUSSION

How does the information about gravitational force and what we know about magnetic force help us explain the sizes of gaps in these photos?

Bonus: What if this toy were in outer space? Do you think the gap sizes would be different?



horizontal



vertical

Lesson 3 Slides

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

Statements about Gravity
Use information from the book and video fill in the blanks to make true statements about gravity.

1. Gravity is a ________________________that every object has for every other object.
2. Gravitational force of one object on another is stronger when ____________________.
3. Heavier objects have _____________ gravitational pull than lighter weight objects.
4. Rockets leave Earth and make it into space because ____________________________

   ____.
5. On Earth, gravitational force always ____.
6. ____.

Statements about Gravity
Use information from the book and video fill in the blanks to make true statements about gravity.

1. Gravity is a ________________________that every object has for every other object.
2. Gravitational force of one object on another is stronger when ____________________.
3. Heavier objects have _____________ gravitational pull than lighter weight objects.
4. Rockets leave Earth and make it into space because ____________________________

   ____.
5. On Earth, gravitational force always ____.
6. ____.

Lesson 4 Balanced and unbalanced forces: Which force wins?

Purpose

In this lesson, students continue learning about how forces can cause or change motion by identifying the strength and direction of forces.

- Students will identify strength and direction of forces acting on an object to predict whether or not the object will move or stay still.

For more about supporting on-going changes in student thinking, see http://AmbitiousScienceTeaching.org

Learning Target

Focus question

Magnetic force versus gravitational force: Who's the winner? What does it mean for the motion of an object if forces pushing or pulling on it "win" or "lose"?

Learning Target

I can identify the strength and direction of forces acting on an object to explain or predict if it will move or stay still.

NGSS 3-D

SEP: Develop and use models *Develop a model to describe phenomena* **SEP: Planning and carrying out investigations** *Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation* **DCI: PS2.A: Forces and Motion** *Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified.* **CCC: Patterns** *Patterns can be used to make predictions*

Materials

For the class:

- Lesson Slide Guide (GoogleSlides)
- Chart paper and markers, sticky notes
- 40 sheets of paper
- 1 horse shoe magnet
- 1 donut magnet

Per student:

- 4 donut magnets + pencil
- Science notebooks
- *Optional: data table (handout)*

Per group:

- 1 magnetic ring toy
- ruler, tape measure, meter stick
- graph paper

Lesson Step Summary

Part 1: Forces can 'win' and 'lose': Introduce balanced/unbalanced forces

1. **Orient students to an idea:** Read and discuss the quote (win/lose).
2. **Engage students in activity for sensemaking**: Whole class demo of holding sheets paper on the magnetic whiteboard with magnets. Introduce new terms.
3. **Just-in-time instruction:** Mini-lesson about modeling forces with arrows
4. **Model-to-Explain**: Students model-to-explain the forces story (using arrows).
5. **Summarizing Learning**: Recap today's observations, learning, connections

Part 2: Biggest Gap Challenge

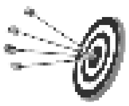
1. **Orient students to an idea:** Use image of gaps*. What do you notice? wonder?*
2. **Engage students in activity for sensemaking**: Challenge students to create the biggest gap. *What configuration of magnets makes the biggest gaps?*
3. **Discuss data patterns:** Collect data as a class and analyze patterns.
4. **Model-to-Explain**: Students model-to-explain the forces story for today's challenge. Use data and info about magnetic poles & gravitational force.

Part 3: Highest Launch Challenge

1. **Pose challenge:** Students notice magnets act like a spring. *How far off the top can this 'magnetic spring' push a magnet? How can we measure height?*
2. **Circulate and compare**: Midway through experimenting, pause the class for a gallery walk to circulate, see others' designs and get ideas from other groups.
3. **Discuss data patterns:** Collect a 'final launch' data as a class and discuss data.
4. **Model-to-Explain**: Students model-to-explain the forces story for today's

challenge. Use info about magnetic poles & gravitational force as well as the data from the investigation to support or justify claims.

Part 1: Describing forces acting on an object



Purpose

1. Launch: Orient to an idea

a) Refer to an observation, idea, or question from L2 related to different strengths of magnets. Tell students that today they will learn more about how weaker and stronger forces affect how objects move. Share the focus questions: *Magnetic force versus gravitational force: Who's the winner? What does it mean for the motion of an object if forces pushing or pulling on it "win" or "lose"?*

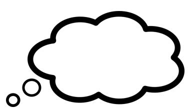
This might sound like:

When you were exploring different shapes of magnets, some of you noticed that some magnets push and pull more strongly than others. Today we'll spend some time thinking about the strength of forces and how forces, like pushes and pulls, can change the motion of an object. A question to work on answering today is: When we compare magnetic and gravity as forces, which wins? loses? What does it mean for forces to win or lose?

Close Read

b) Have students read and think about the quote on the slide from the book *Balanced and Unbalanced Forces* by Jenna Winterberg: *"In a match between gravity and other forces, gravity usually loses. You can see just how weak gravity is by using a magnet to pick up a pile of paper clips. No question, Magnetic force wins!"*

Let's look at this quote from a book titled Balanced and Unbalanced Forces (see slide)*:* "In a match between gravity and other forces, gravity usually loses. You can see just how weak gravity is by using a magnet to pick up a pile of paper clips. No question, Magnetic force wins!" *What do you think it means that forces can win or lose? Like in the paper clip examples in the reading. Think for a few silent seconds* [give 10-15 silent seconds] *Now turn and talk with a partner.*



Think Time

Turn-and-Talk

c) Ask students: *What do you think the author means about how magnetic force or gravitational force can win or lose?* Think-pair-share. Discuss briefly, no resolution is needed right now.

Listening for ideas in turn-and-talk: Highlight ideas that consider stronger, weaker, or equal forces. This will be helpful in the class demonstration.

Make Observations

2. Engage students in an activity for sensemaking: Class Demonstration

a) Tell students they will watch a quick demonstration and to think about this idea of magnetic and gravitational forces winning or losing. Use the same questions to discuss after each test.

Turn-and-Talk

Test 1: Hold 10 sheets of paper against the board with your finger and then let go (so that the papers fall).

Test 2: Hold 10 sheets of paper against the magnetic whiteboard using a donut magnet and another 10 sheets with a horseshoe magnet.

Test 3: Add sheets of paper behind each magnet until the paper and

Questions to discuss on each test:

- *What happened?*
- *Why do you think that happened?*
- *Was there a winning force? How can you tell?*

magnets start to slide or fall down.

Magnet	number of Sheets
donut	18
bar	0
horse shoe	14
rectangle	26

Science Words

b) Introduce the science words scientists use for comparing forces that tell us if it causes an object to move or not. Forces on an object can be balanced, meaning equal, and the object does not move. Or forces on an object are unbalanced, meaning unequal, and the object moves. Add terms to the word wall or to an ongoing list of “helpful science words”.

Mini-lesson

3. Just-in-Time Instruction: Mini-lesson about modeling forces

Use the slides titled “Modeling Forces with Arrows” to show students how to represent forces in models using arrows. Step through examples in presentation mode so the slides animate with each click. The important features are the length, directions, and label (or color code). Briefly discuss in each example if the magnetic or gravitational force wins (unbalanced forces = motion), or if the forces are balanced (no motion).

4. Model-to-Explain: The story of the “hold the paper” demonstration

Model to Explain

Students sketch in their notebooks what they observed in the test today of holding papers to the board.

Have students use what they just learned about balanced and unbalanced forces and try using arrows (length, direction, labels) to show forces.

Back-Pocket Questions

- Observations: *Sketch what we did.*
- Modeling: *How did you show that in your model?*
- Compare: *How can we tell if the forces are unbalanced or not? How can we tell if the papers are moving or not?*

[Timing note: If there is no time today to summarize, engage the following day as a way to reorient students to the idea that knowing if forces are balanced or not helps predict motion.]

5. Summarize Learning

- Activity: What did we do? What did we test?
- Data patterns: What happened? What did we figure out?
- Explanation: What did we learn to help us explain or show our thinking?
- Connection: How can this help us explain our phenomenon?

Activity	Observations & Data Patterns	Explaining our observations and data	Making Connections
Magnetic force vs Gravitational force: Holding papers up	With no magnet, papers fell. Horseshoe magnet held 28 sheets before sliding. Donut magnet held 23 sheets before sliding.	The Earth's gravity pulls down on the papers. Each magnet has a magnetic force that keeps it stuck (attracted) to the board. If papers stay up = forces balanced If papers slide, gravity wins = forces unbalanced We draw forces with arrows: Length = strength / Pointer = direction Remember to label!	The magnetic ring toy always "feels" the gravitational force from the Earth pulling all the magnets down. But the magnetic forces between magnets can attract or repel them depending on where the poles are. We should use arrows when we draw the magnetic ring toy to show the different forces.

Part 2: Biggest Gap Challenge


Photo

1. Orienting students

a) Remind students of the question they are working towards answering: *What does it mean for forces to win or lose when they act on an object?*

b) Show students an image of two vertical magnetic ring toys with different sized gaps near the bottom. Ask: *What do you notice? What do you wonder?* Turn-and-talk.


Turn-and-Talk

2. Engage students in activity for sensemaking

a) Challenge students to work with their group to figure out how to get the biggest gap possible between magnets 1 and 2 (bottom 2 magnets). The magnetic ring toys come with 10 donut magnets so students can use up to 10 magnets in any configuration.


Measurement

b) Decide as a class on a standard way to measure the gaps. Using the centimeter side of a ruler? Put graph paper behind and count squares? Suggest students make quick sketches with measurements as they try different configurations.


Teamwork

c) Send students to gather materials and work as a team to come up with the biggest gap between magnets 1 and 2. Ask back-pocket questions as needed.

Back-Pocket Questions

- Materials: *Do you have what you need to observe gaps between magnets?*
- Observations: *What did you notice about the size of the gaps?*
- Patterns: *When are the gaps small? When are the gaps bigger?*
- Measurement: How will you know when you found the biggest gap?


Analyze Data

3. Collect and analyze data:

a) Have each team show the configuration they figured out that made the highest gap between magnets 1 and 2. Create a class data table (and/or use optional data table).

b) Ask students to look at the data and think about: *What patterns or trends do you notice between magnet position and gap size?*

Model to Explain

4. Model-to-Explain: The forces story behind the biggest gap

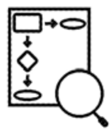
a) Students sketch what they observed about magnet position/ orientation and size of gaps.

b) Have students use what they know about magnetic force, magnetic poles, gravitational force, and balanced/unbalanced forces to explain what conditions cause gaps between magnets and what makes the gaps bigger.

Back-Pocket Questions

- Observations: *Sketch what you did. What did you notice about the gaps?*
- Modeling: *How did you show that in your model?*
- Explain: *What causes gaps between magnets? What makes gaps change size?*

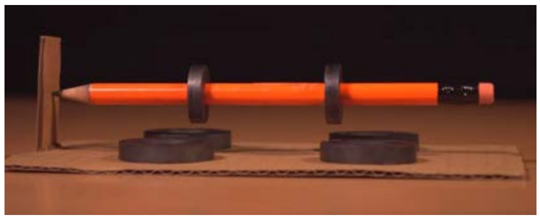
Optional Hands-Down Conversation Opportunity: The floating pencil



Purpose

Use a hands-down conversation structure for about 10-15 minutes about the floating pencil image. The goal for this discussion is to justify our thinking with evidence.

Is this image real or fake? Why do you think the pencil can hover like that?



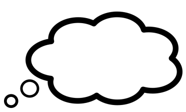
Say something to students like,

"Let's take some time to do some deeper thinking together to build our understanding of forces together. Your challenge for this conversation is to use evidence to decide if this image of a floating pencil is real or fake. What does using evidence sound like? [Jot some ideas on the board.] *You could try including evidence by saying:*
- "It's ____ since we saw that…"
- "I think ___ because we learned…"
- "I heard you say. How do you know?"
- "What evidence do we have that…?"
- "You said ___ and I know that's true because…"

Micro-lesson

1. Micro-lesson: Justifying claims
   a. Say that the focus of this discussion is justifying our ideas or claims with evidence
   b. Provide a list of what they can say to justify their claims.
   c. Have students move into a large circle so everyone can see each other and has space.

Remember, your challenge is to use evidence to support your claims while following the expectations of (1) no hands, (2) one voice at a time, (3) listening to understand, and (4) responding. I'll give you the prompt and some silent think time before we move into our circle.



Think Time

2. After students are in a circle, and can see everyone, ask who would like the first word in the discussion about whether the image of the floating pencil is real or fake

[Teacher role: Provide question/prompt, then step out. Intervene if needed. After about 8 minutes, invite one student to share the last word/contribution to end the discussion. Then do a quick debrief about the discussion experience.]

Discuss

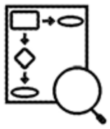
3. Intervene, when needed, to remind students of the expectations or of today's challenge. If students seem stuck, repeat the question and have students turn-and-talk.

Feedback & Follow-up

4. In the last minute, have a student give the last word. Then, check in to get feedback from students. How do they think they did today using evidence? Add any new specific moves to the list to try next time.

Let's check in on how we did today. Show with your thumb-mometer: How did you do personally at trying to use evidence or asking others to use evidence? [Look at thumbs] *Would anyone like to share something you tried with evidence?* [Share a few.] *Are there any moves we want to add to our list? We will have more opportunities to practice arguing from evidence in other science and reading discussions soon*

Part 3: Highest Launch Challenge



Purpose

1. **Pose challenge. Define criteria and constraints.**

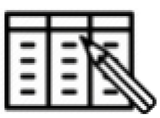
   a) Students have noticed that compressing repelling donut magnets on the pencil/pole acts like a spring -- compressing magnets down and releasing them can even make the top magnet fly off! This part of the lesson gives students an opportunity to practice collecting measurement data and iterating on a design with their team to meet today's challenge. Introduce today's challenge question: *How far off the top of the pole/pencil can we get the 'magnetic spring' to push the top magnet?*

   b) Before we start working on this challenge, ask students, "What are some criteria we need to decide on before we get started?" Or pose each of these questions to decide as a class:

Measurement

   - *How will we measure height?* Students may suggest using the way they measured in Part 2 or have other ideas.

   - *How many magnets can we use?* Decide as a class. Perhaps 10 could be an upper limit as that is how many come in the magnetic ring toy box. If using the ceramic magnets, 10 together are fairly strong so definitely remember the safety warning about pinching.



Discuss data collection

   - *How will you keep track of what designs are working or not?* Quickly share some ideas about how to use science notebook to sketch magnet layouts and heights. *(If desired, provide this optional data table as an option or students can use today to practice figuring out how to organize their own data collection in their notebooks.)*

   - If needed: *What does teamwork look and sound like?* A quick review of teamwork expectations for your classroom, perhaps highlighting sharing materials (not hogging) and being sure to invite people into the group if they are sitting back.

Safety Alert

   c) Teams use the magnetic ring toys (1 per group) if there are enough sets, or use ceramic donut magnets. Remind students about safely:
      - Magnets can pinch so be careful.
      - Wash hands after touching/working with ceramic magnets.
      - If using ceramic magnets, teams should work on a carpeted surface or rug, so if magnets land they are less likely to break.

Teamwork

2. **Getting students started.**

   a) Divide into teams and collect materials (ring toy set or donut magnets + pencil with some measuring device). Circulate and look at how teams are getting started.

   b) Intervene in groups, as needed, to address your noticings about how the team is working together, how they are sharing responsibilities, testing ideas, using their notebooks, etc.

   c) Midway through experimenting, pause the class for a gallery walk to circulate, observe others' designs and get ideas from other groups. Keep

Developed by C. Colley, PhD ccolley@rentonschools.us with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

Gallery Walk

this gallery walk at a perky pace but decide how many launches each group gets to show their design (3 should probably be the upper limit).

d) Return to teams to iterate and improve designs. Tell students when they come together as a class each group will launch and measure in front of the class so bring their best idea for the highest launch.

Collect & Analyze Data

3. *Optional*: Collect and analyze data

This step is optional. Students could move to step 4 using data from their group. If you would like students to have guided practice collecting and comparing data, then include time for this step.

a) Collect 'final launch' data as a class. Have each group do final launch trials of their design in front of the class. Sketch their design. Record the launch heights.

How high did the magnet launch?

Team	Sketch Design	Launch 1	Launch 2	Launch 3

Turn-and-Talk

b) Analyze the data and discuss:
- *What do you notice about our data?*
- *What do the designs with the highest launches have in common?*
- *Are there any launches we should not count? Why or why not?*

Model to Explain

4. Model-to-Explain:

a) Prepare students model-to-explain what conditions make for the highest launch using their learning so far about magnetic poles, magnetic forces, and gravity as a force. Remind students that scientists use arrows to represent forces and their strength, direction, and type. Suggest students try using recent ideas about magnetic poles, attraction, repulsion, and gravitational force to explain their results.

b) Give time for students to sketch models explaining the launch height using ideas they have learned about so far.

c) Have students share their models and get ideas from others by sharing with an elbow partner or doing a stand-up-hand-up-pair-up to allow students to move around the room to share with different partners and compare how they chose to show magnetic and gravitational forces.

Back-Pocket Questions

Getting Started:
- Clarify Task: *What will you explain in your model?*
- Observations: *Start by sketching what you noticed first.*

Pressing & probing:
- Modeling: *You said___. What's one way you could show that with symbols, colors, or arrows on your model?*
- Explain: *What science concepts (magnetic poles, gravitational force) can help explain why some magnets launched higher than others?*

Teacher reflection: Analyzing Student Modeling

Teacher Move:
Attend & Assess

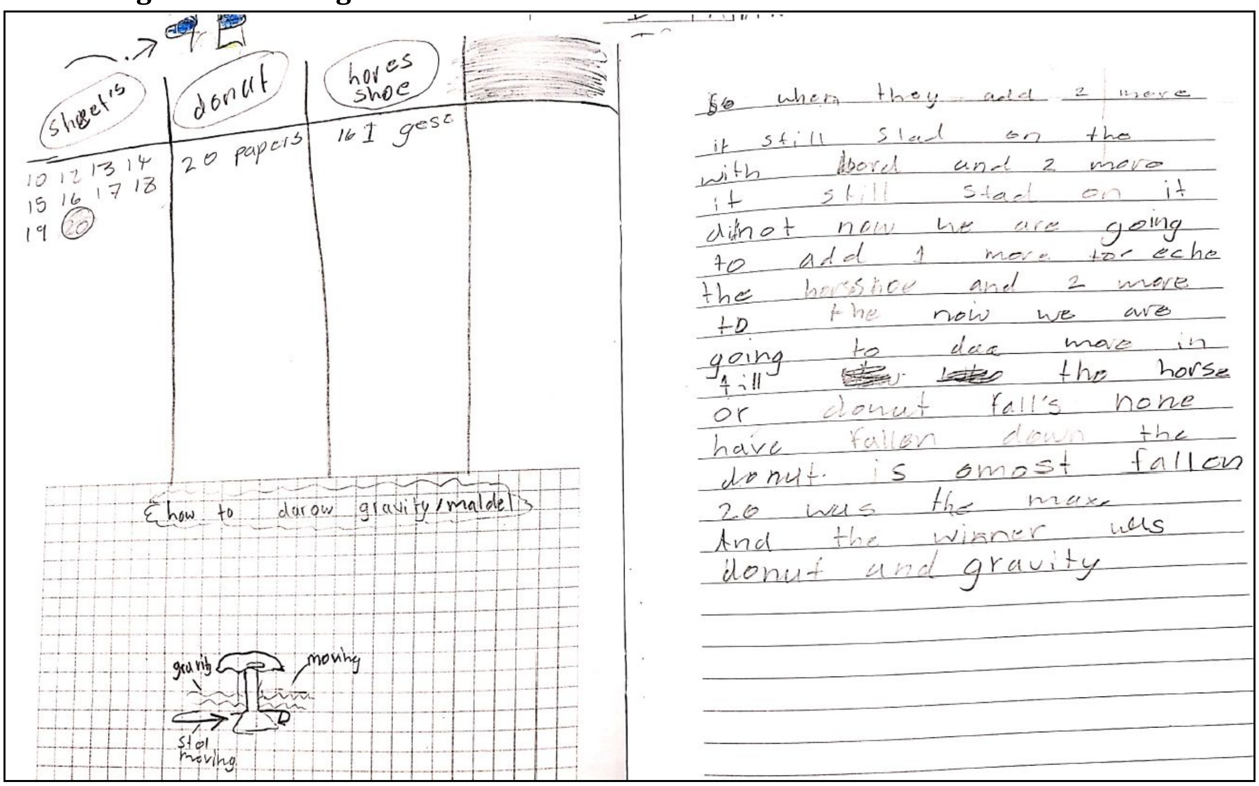
From this lesson, there are two items to look at in students' notebook entries:

1) **Organizing Data**: If students did not use printed data tables, then *how did students organize/record data from their investigations in part 2 and/or part 3?* Students will have other opportunities in Lesson 8 to collect data from their own tests. Note a few student examples of ways to record/organize data that you want to show the class in Lesson 8 as examples to give students some ideas of how to organize data.

2) **Modeling forces and motion:** Using arrows to show strength, direction, and type of force is new for students. Look for how students use arrows and what seems challenging about this for students. For example: *How are students showing motion if arrows are used to show forces?*

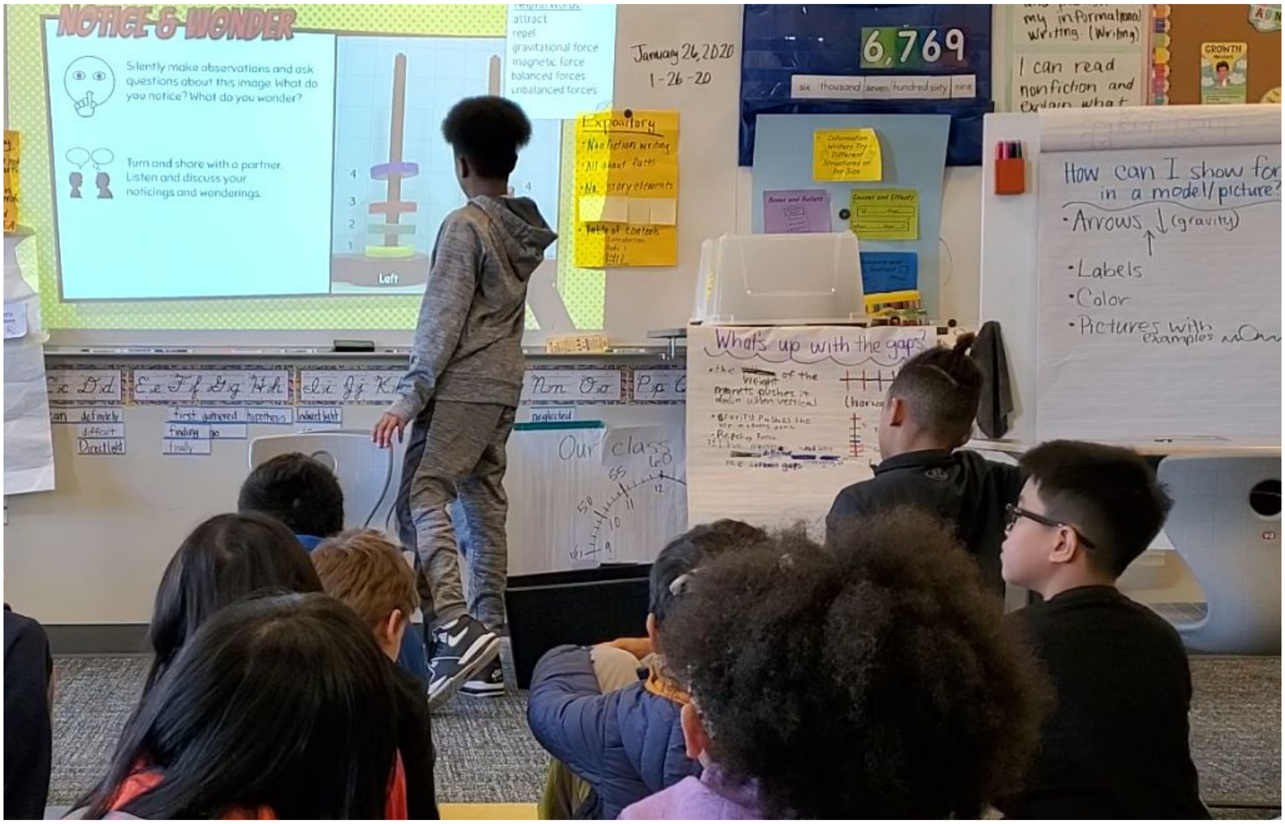
Photos from Lesson 4

Part 1: Magnetic force vs gravitational force



Student notebook example entry: *"So when they add 2 more it still stayed on the white board and 2 more it still stayed on it donut. Now we are going to add 1 more to each the horseshoe and 2 more. Now we are going to make it til the horse or donut falls. None have fallen down the donut is almost fallen. 20 was the most. And the winner was donut and gravity."*

Part 2: Biggest Gap Challenge



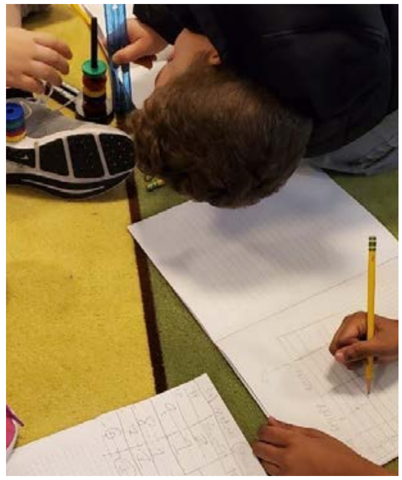
Students noticed the gap on the right between 1 and 2 looked equal to the gap on the left between 3 and 4. Students wondered how, if magnets 2, 3, and 4 weigh the same on both toys, why would they be able to push differently to make a different sized gap between magnets 1 and 2 since gravity pulls down the same. Students used terms like pressure, power, and gravity to explain their thinking. Some students explained that pressure is like the magnetic invisible cushion (repelling) is pressing or applying pressure on other magnets; whereas, others explained that pressure was like a tension between gravity and the magnets repelling creates a pressure.

Students tried different configurations to make the gap between magnet 1 and 2 bigger. With teacher prompting, they measured with rulers or held up graph paper to count squares to support their observations that one gap is bigger than another. Many students quickly abandoned 1 magnet on the bottom, noticing they could get the big gap with 2 magnets on the bottom. This ignored criteria of the challenge; however, it provided a productive context for small group discussion about forces and how that worked, which focused on the science concept understanding (One student idea: the "power" of magnets fighting against gravity and creates the "pressure" that makes the gap).

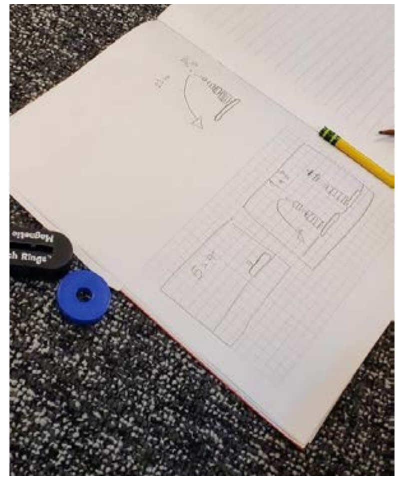
Part 3: Highest Launch Challenge

Here the teacher gave students a choice in how to collect and organize their data, asking “How will *you* record what you figure out?” Midway through, she highlighted to the class some strategies she saw in the room like making a t-chart, columns, or sketching a picture and jotting the height of the launch. During the gallery walk examining each group’s launch and measuring height, this class realized that each group measured the height of the launch from different places (from the floor, the base, or the top of the compressed stack). They had a short, impromptu discussion about what’s “not fair” (kid language) about measuring from the floor compared to measuring from the top of the compressed stack?

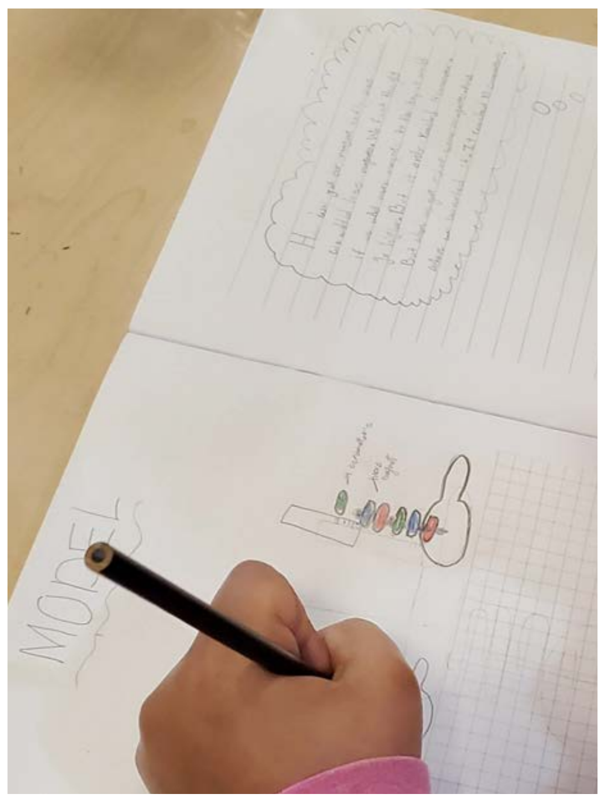
This group prepares to measure the height of the launch from the top of the compressed stack.



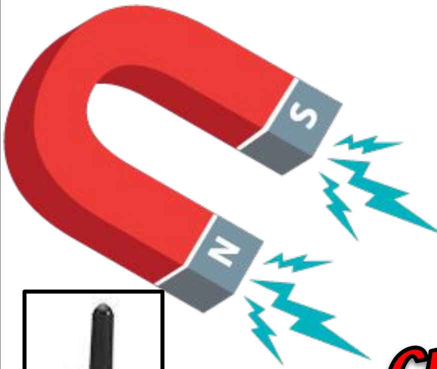
This group measures the height of launch from the floor. They decide to organize their data into a table.



This student decides to collect her data using sketches and numbers



Students write about why the top magnet launches off better with some magnet orientations and not others. What patterns did they notice? Students coordinated thinking about the weight, gravity, the “power” of the different orientations/configurations of magnets and how that affected the height of the launch.



MAGNETIC FORCE VS GRAVITATIONAL FORCE

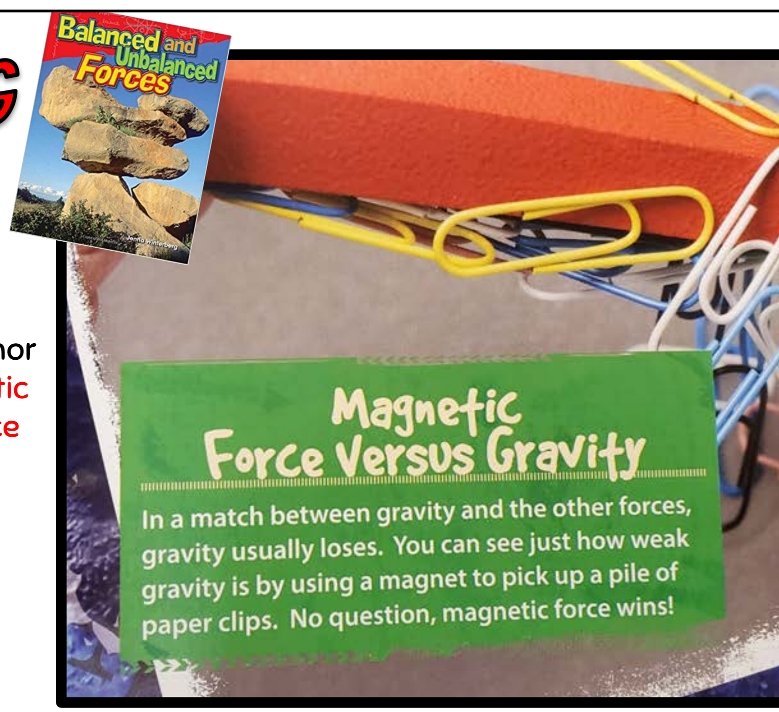
WHICH IS THE WINNER?

Part 1

CLOSE READING

Read the text.

What do you think the author means about how magnetic force or gravitational force can win or lose?



TRY THIS! MAGNETISM VERSUS GRAVITY

You need:
1 donut magnet
1 horseshoe magnet
40 sheets of paper
1 magnetic whiteboard

Try this!

1. Put 10 sheets of paper against the board and let go. What happens? Why?
2. Now, use each magnet to hold 10 sheets of paper each to the whiteboard.
3. <u>Add</u> sheets of paper behind each magnet until one or both magnets slide down the board.

Gravitational force and magnetic force are forces that cause change without directly touching objects.

When does magnetic force win?

When does gravitational force win?

What does it mean to you to say a force wins or loses?

NEW SCIENCE WORDS

Balanced forces

Forces that are equal in strength but opposite in direction are called balanced forces. Balanced forces do not cause a change in motion. When balanced forces act on an object at rest, the object will not move.

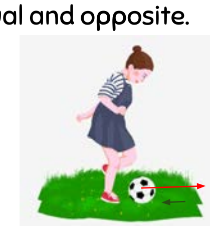
The forces on this soccer ball are balanced.

What about this?

The boy steps on the ball and stands still.
Are the forces on the ball balanced or unbalanced?

Unbalanced forces

Forces that cause a change in the motion of an object are unbalanced forces. Unbalanced forces are not equal and opposite.



The girl kicks the soccer ball to the right.

MODELING FORCES WITH ARROWS

Scientists use arrows to communicate about forces.

- ➢ Length = strength of the force
- ➢ Pointer = direction of force
- ➢ Label = tells the interaction of forces on objects

The lengths of these force arrows are equal which means they are the same strength.

But they are in opposite directions so the table force is pushing up the same amount as a gravitational force is pulling down.

Example 1

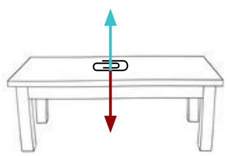


Table force
The table pushes up on the paperclip.

Gravitational Force
The gravitational force of the Earth on paperclip pulls paperclip down towards the Earth's center

balanced forces

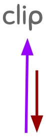
Do you think the gravitational force or table force is "winning"?

MODELING FORCES WITH ARROWS

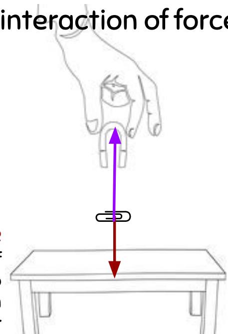
Scientists use arrows to communicate about forces.

- ➢ Length = strength of the force
- ➢ Pointer = direction of force
- ➢ Label = tells the interaction of forces on objects

The length of these force arrows are NOT equal and in opposite directions. Magnetism pulls harder on the paper clip than gravity.



Example 2



Magnetic Force
The magnetic force pulls the paperclip with enough force to cause it to move up..

Gravitational Force
The gravitational force of the Earth on paperclip pulls paperclip down towards the Earth's center

unbalanced forces

Is magnetic force or gravitational force winning in this situation? How do you know?

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

MODELING FORCES WITH ARROWS

Scientists use arrows to communicate about forces.

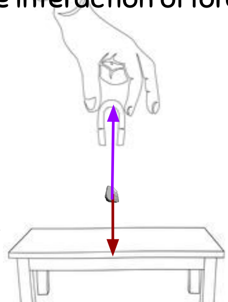
- ➢ Length = strength of the force
- ➢ Pointer = direction of force
- ➢ Label = tells the interaction of forces on objects

Example 3

Tiny piece of a lodestone. Lodestone is a rock that contains iron and is magnetic.

Gravitational Force

The gravitational force of the Earth on lodestone pulls lodestone down towards the Earth's center



unbalanced forces

Magnetic Force

The magnetic force pulls on the lodestone harder than gravitational force pulls the lodestone.

The length of these force arrows are NOT equal which means the tiny piece of lodestone is moving.

The forces are in opposite directions. The Earth's gravitational force pulls the lodestone towards the center of the Earth. The magnetic force pulls the tiny piece of loadstone up, towards the magnet.

Is magnetic force or gravitational force winning in this situation? How do you know?

MODELING FORCES WITH ARROWS

Scientists use arrows to communicate about forces.

- ➢ Length = strength of the force
- ➢ Pointer = direction of force
- ➢ Label = tells the interaction of forces on objects

Example 4

Lodestone is a rock containing iron which makes it magnetic.

balanced forces

Gravitational Force

Earth's gravitational force pulls paperclip down towards the Earth's center

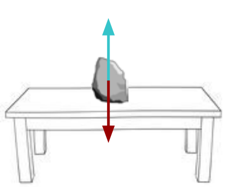


Table Force

The table pushes back on the lodestone.

Why isn't the lodestone moving?

Is table force or gravitational force winning in this situation? How do you know?

Do you like the author's idea the forces can win and lose? Does it help you think?

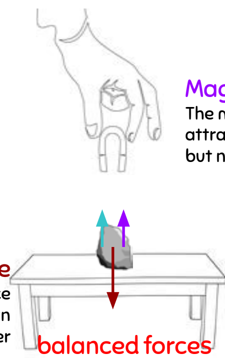
MODELING FORCES WITH ARROWS

The length of these force arrows are equal which means they are the same strength just in opposite directions.

The length of these force arrows are equal which means they are the same strength just in opposite directions.

Example 4

Lodestone is a rock containing iron which makes it magnetic.

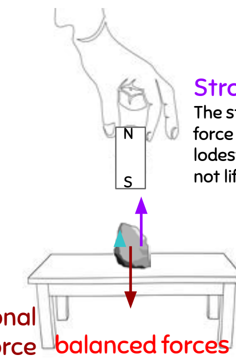


Magnetic force
The magnetic force attracts the lodestone but not enough to lift it.

Table
The table pushes back on the lodestone, holding it.

Gravitational Force
Earth's gravitational force pulls paperclip down towards the Earth's center

balanced forces



Stronger Magnet
The stronger magnetic force attracts the lodestone but still does not lift it.

Table
The table pushes back on the lodestone, holding it.

Gravitational Force

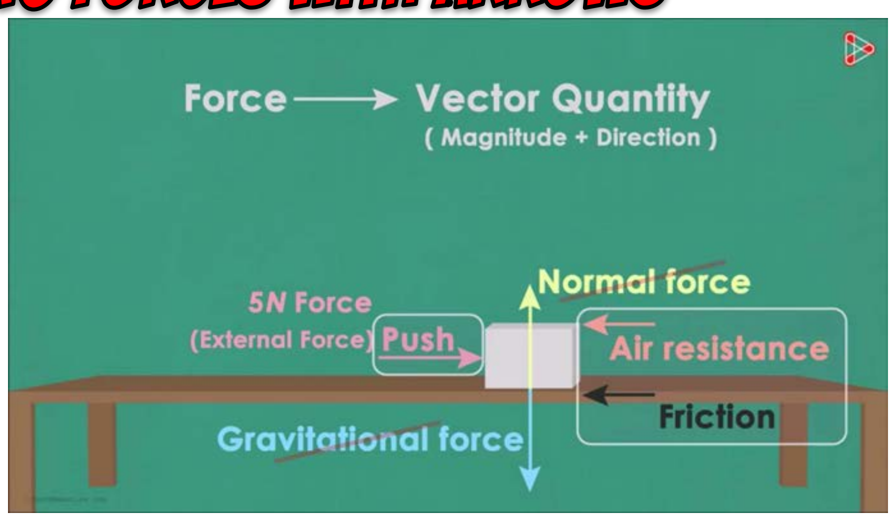
balanced forces

MODELING FORCES WITH ARROWS

Note: This video has some extra words we don't need to know. Don't get bogged down in details. Get the gist!

What's the gist of what the video?

What does the video tell us about drawing forces?



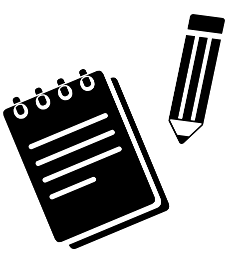
MODELING FORCES WITH ARROWS

Scientists use arrows to communicate about forces.

- ➢ Length = strength of the force
- ➢ Pointer = direction of force
- ➢ Label = tells the interaction of forces on objects

THINK ABOUT OUR EXPERIMENT...

1. How could you use arrows to show forces when the forces were balanced?
2. How could you use arrows to show when the forces were unbalanced?



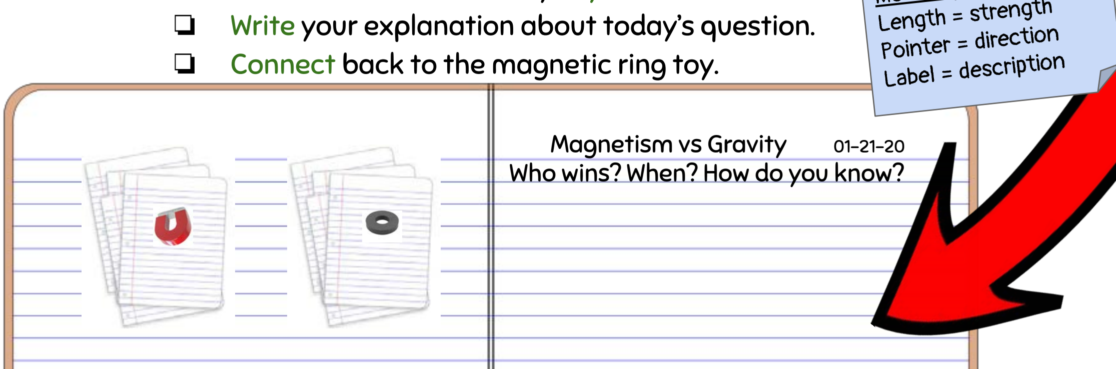
NOTEBOOK

- ❏ Open to a new page.
- ❏ Write title and date.

- ❏ Sketch what we did today. Try force arrows!
- ❏ Write your explanation about today's question.
- ❏ Connect back to the magnetic ring toy.

Helpful Words:
magnet poles
attract pull
repel push
gravitational force
magnetic force
balanced forces
unbalanced forces

Modeling using arrows:
Length = strength
Pointer = direction
Label = description

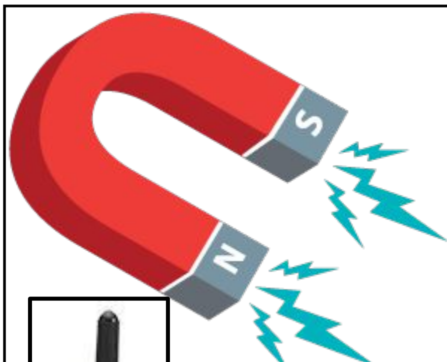


Lesson 4 Slides

SUMMARY TABLE: OBSERVE, EXPLAIN, & CONNECT

- ➢ Activity: What did we do? What did we test?
- ➢ Data patterns: What happened? What did we figure out?
- ➢ Explanation: What did we learn from book/video to help us explain our results?
- ➢ Connection: How can this help us explain our phenomenon?

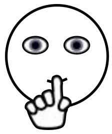
Our Question	Observations & Data Patterns	Explaining our observations and data	Making Connections
Magnetic force vs Gravitational force: Holding papers up	*What did you observe or notice?*	*What did we learn that helps explain our observations?*	*How does this activity help us explain how the magnetic toy works?*



HOW CAN WE CREATE THE BIGGEST GAP BETWEEN MAGNETS?

Part 2

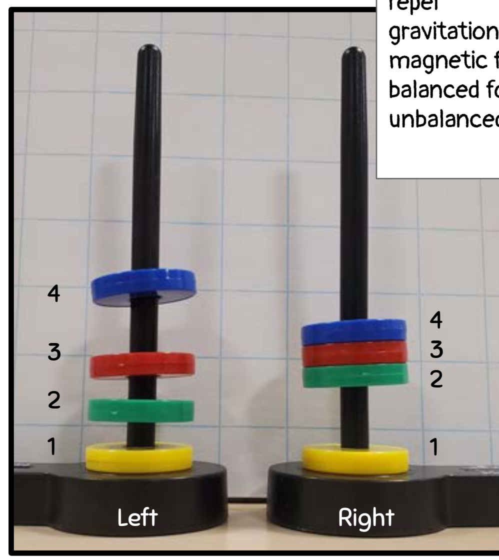
NOTICE & WONDER



Silently make observations and ask questions about this image. What do you notice? What do you wonder?

Turn and share with a partner. Listen and discuss your noticings and wonderings.

Why do you think this gap between magnets 1 and 2 is bigger on the right than the left?



Helpful Words:
attract
repel
gravitational force
magnetic force
balanced forces
unbalanced forces

CHALLENGE: CREATE THE BIGGEST GAP

You need:
1 pencil
4 donut magnets

Safety Note: These magnets can pinch so be careful with your fingers.

Your task:

Stay vertical. Keep a gap between magnets 1 (bottom) and 2 (next to bottom).

How big can you make the gap between magnets 1 and 2?

Notice: What happens with the magnets? What do you notice about the gaps?
Think: What did you figure out about how to make a bigger gap? Why might that happen?
Wonder: What are you wondering now?

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

CLASS DISCUSSION & DEMO TEST

Do you think the gap between magnets 1 and 2 would get bigger if…

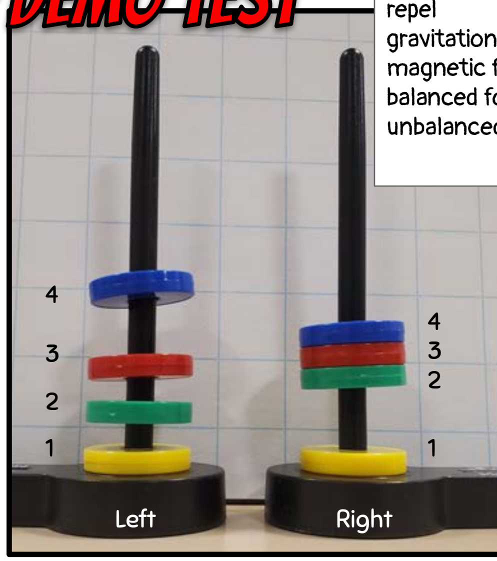
…you add a 5th magnet?
Left side = 5th magnet repels to make a gap
Right side = 5th magnet is attracted, no gap

…you had 3 magnets not 4?

… you _______________?

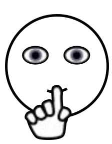
What else do you wonder?

LET'S TRY IT!



Helpful Words:
attract
repel
gravitational force
magnetic force
balanced forces
unbalanced forces

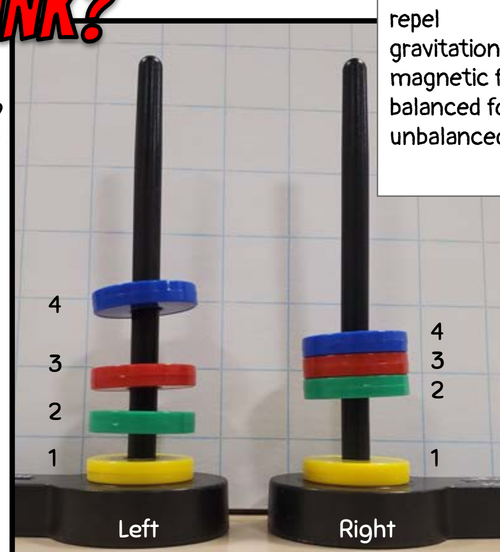
NOW WHAT DO YOU THINK?



What forces are acting on the magnets?
Are the forces balanced or unbalanced?
What do you think? How do you know?

Turn and share with a partner.

Why do you think the gap between magnets 1 and 2 is bigger on the right than on the left?



Helpful Words:
attract
repel
gravitational force
magnetic force
balanced forces
unbalanced forces

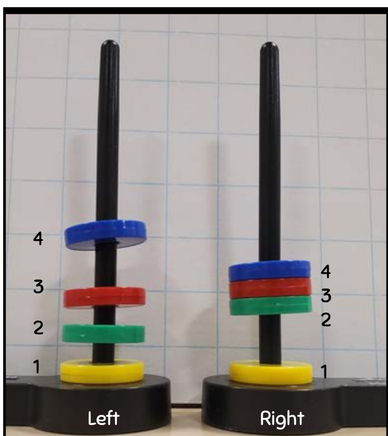
MODELING FORCES WITH ARROWS

Scientists use arrows to communicate about forces.

- Length = strength of the force
- Pointer = direction of force
- Label = tells the interaction of forces on objects

If you're trying to use arrows to show forces but feel stuck in how to show your thinking, what could you do?

- Add a caption to say more.
- Use color to help show something else about the forces.
- ______________________
- ______________________



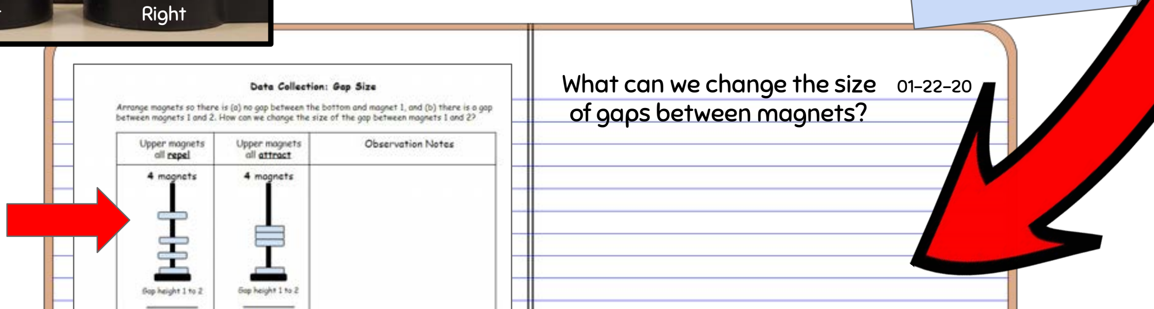
NOTEBOOK

- ❑ Open to a new page.
- ❑ Glue your reading.
- ❑ Write title and date.

Sketch a model to show your ideas.
Write your explanation about today's question.

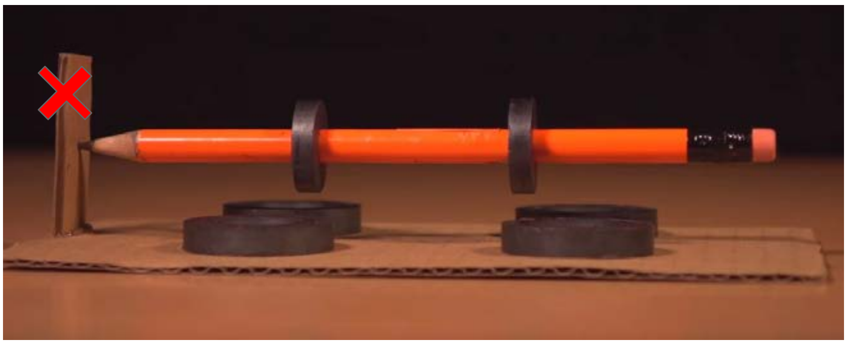
Helpful Words:
magnet poles
attract pull
repel push
gravitational force
magnetic force

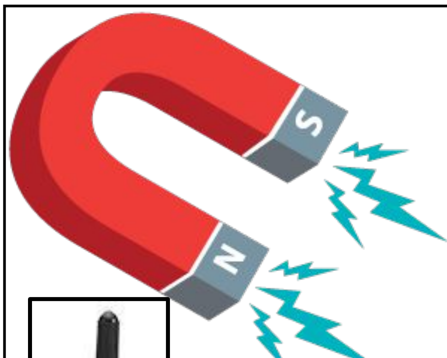
Modeling using arrows:
Length = strength
Pointer = direction
Label = description



EXTENSION: CLASS DISCUSSION

Is this image real or fake?
Why do you think the pencil can hover like that?
What could happen to cause the pencil to fall?
What do you think would happen if we removed the vertical cardboard?





HOW HIGH CAN THE MAGNET GO?

Part 3

CHALLENGE:

<u>Team challenge:</u>
To cause a magnet to launch off the top of the magnetic toy as high as possible. How can you make the magnet go even higher?

Wait...
How will we know how high the magnet goes?

<u>Your job:</u>
Work with your group to make a plan, test it, and revise to improve.

<u>Materials:</u>

- 10 magnetic rings
- 1 pole with base (or your pencil)
- 1 ruler? Meter stick?

If using ceramic donut magnets, work from the carpeted floor. Instead of a hard desk or tile surface.

GALLERY WALK

Repeat these steps at each group. Keep it snappy!

Wait...
What if we need a "do over"?
How many chances should we get at each group?

1. Show us your best launch so far.
2. Tell us what your group thinks is most important to make the magnet go up.

After getting some ideas from around the room, return to your group to continue working on your best design to launch the magnet.

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

CHALLENGE:

Team challenge:
To cause a magnet to launch off the top of the magnetic toy as high as possible. How can you make the magnet go even higher?

Revise and improve your plan.

How high did your magnet fly?

Your job:
Work with your group to make a plan, test it, and revise to improve.

Materials:
- 10 magnetic rings
- 1 pole with base (or your pencil)
- 1 ruler? Meter stick?

If using ceramic donut magnets, work from the carpeted floor. Instead of a hard desk or tile surface.

CLASS DATA

COLLECT DATA

Have each group do official launches in front of the class. Each group does 3 launches. Write down the estimated height of each launch.

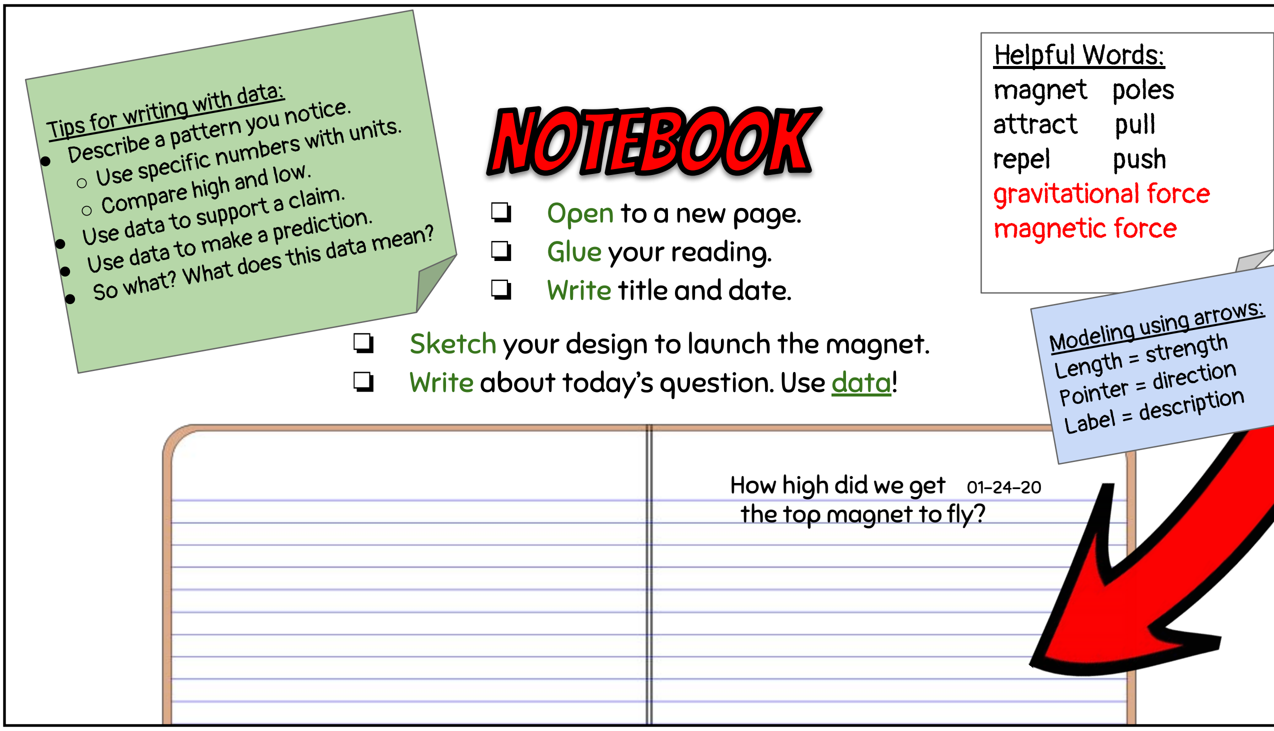
ANALYZE DATA

- What do you notice about the data?
- What do the designs with the highest launches have in common?
- Are there any launches we should not count? Why or why not?

How high did the magnet fly?

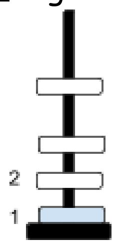
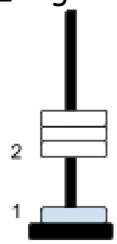
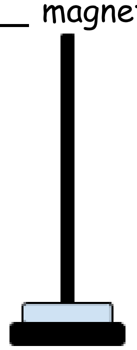
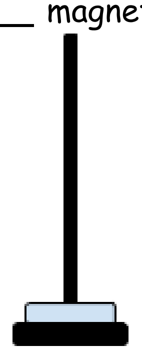
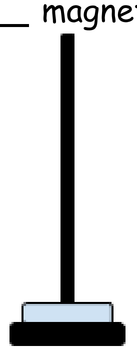
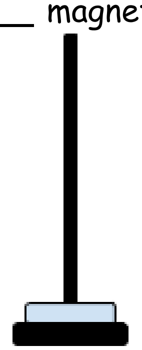
Team	Sketch Design	Launch 1	Launch 2	Launch 3

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools


Tips for writing with data:
Describe a pattern you notice.
Use specific numbers with units.
Compare high and low.
Use data to support a claim.
Use data to make a prediction.
So what? What does this data mean?
NOTEBOOK
Open to a new page.
Glue your reading.
Write title and date.
Sketch your design to launch the magnet.
Write about today's question. Use data!
Helpful Words:
magnet poles
attract pull
repel push
gravitational force
magnetic force
Modeling using arrows:
Length = strength
Pointer = direction
Label = description
How high did we get the top magnet to fly?
01-24-20

Data Collection: Gap Size

Arrange magnets so there is no gap between the bottom and magnet 1, **and** there is always a gap between magnets 1 and 2. How can we change the size of the gap between magnets 1 and 2?

Upper magnets all **repel**	Upper magnets all **attract**	Observation Notes
4 magnets  Gap height 1 to 2 ________	**4** magnets  Gap height 1 to 2 ________	
___ magnets  Gap height 1 to 2 ________	___ magnets  Gap height 1 to 2 ________	
___ magnets  Gap height 1 to 2 ________	___ magnets  Gap height 1 to 2 ________	

Trim paper horizontally and vertically to fit in notebook without folding or sticking out.

Lesson 5 What materials do magnets attract?

Purpose

In this lesson, students test and identify materials that magnets attract or not. This can help students explain the choices of materials in the magnet toy.

- Students conduct a simple test to draw conclusions about what materials are magnetic and which are not.

For more about supporting on-going changes in student thinking, see http://AmbitiousScienceTeaching.org

Learning Target

Focus question
What kinds of materials do magnets attract?

Learning Target
I can test materials to identify objects that are magnetic and use this information to make predictions about solving a problem.

NGSS 3-D
SEP: Develop and use models *Develop a model to describe phenomena* **SEP: Planning and carrying out investigations** *Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation* **DCI: PS2.A: Forces and Motion** *Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.* **CCC: Cause and Effect** *Cause and effect relationships are routinely identified.* ***CCC: Patterns*** *Patterns can be used to make predictions*

Materials

For the class:
- Lesson Slide Guide (GoogleSlides)
- Chart paper and markers, sticky notes

Per student:
- Science notebooks
- *Optional: data table (handout - part 1)*

Per group:
- 1 bag/box of assorted materials
- 1 magnet

For the sculpture activity, per group/student:
- index card
- assorted screws, nuts, washers
- 4 magnets of any shape

Lesson Step Summary

Part 1: Collecting Data, Supporting Claims
1. **Orient students to an idea:** Show a real world problem of sorting recycling. Could magnets help to solve this problem? What do you think?
2. **Engage students in activity for sensemaking**: Collect data from a simple test. What patterns do you see in the data?
3. **Just-in-time instruction:** Learning more about magnetic materials. Using evidence to support claims.
4. **Notebook writing**: Respond to today's question using evidence in writing.
5. **Discuss:** Return to the real-world problem of separating recycling. Would magnets be a good solution? Why or why not? Use evidence from today's investigation, the readings, or videos we have watched.

Part 2: Art Extension - Magnetic Sculptures
1. **Summarize Learning:** Recap observations, learning, connections from Part 1.
2. **Introduce today's task**: Build a small sculpture using a mix of up to 4 donut magnets and assorted magnetic objects. Set expectations for materials.
3. **Creation time:** As students create, notice what challenges students encounter related to balanced and unbalanced forces. Use back-pocket questions.
4. **Gallery walk**: Have the class take a silent gallery walk to admire each creation/sculpture and read the name cards. Take a photo of each.

Part 1: Collecting Data, Supporting Claims

Purpose

Photo

Turn-and-Talk

1. Launch: Orient to an idea

a) Students may have already noticed that magnets attract some objects and not others. Magnets attract and repel each other, but what about other objects that aren't magnets? Introduce the question: *What materials do magnets attract?*

b) Introduce a real-world problem as a context for today's investigation. We need to separate materials in mixed recycling at the city recycling plant (see photo in slides). *Would magnets be a helpful tool in sorting the materials from mixed recycling?* Give time to think. Turn-and-talk. Tell students that they will revisit the question at the end of today so keep thinking as they investigate today's question.

c) Have students set up their notebooks for today's investigation. Come up with a list of objects to test or use the objects and the data sheet provided.

Record data

Back Pocket Questions

Share & Discuss

2. Engage students in an activity for sensemaking

a) Have students work in groups to test each object to see which objects attract to a magnet and record observations in their data table. Circulate as students collect data. Look for:
   i) Discrepancies in test results that should be resolved: *Did two groups get different results for testing the same object?* Have groups compare results and do some retesting together to resolve.
   ii) Patterns: Prompt students to look for patterns in their data. *What patterns do you see? What can you claim about certain materials?*
   iii) Using data to make predictions: *Can we use this data to make predictions about other materials?*
   iv) Reflect on the data: *Did any results surprise you? How come?*

b) Discuss the data as a class. Have students make claims based on their investigation. A *claim* is a statement about an event or phenomenon that we think is true based on our evidence or experience.

LANGUAGE NOTES:
- Vocabulary: If students are using the word repel, clarify language. Does the magnet repel the eraser, meaning actively pushing it away? No, it has no effect.
- Precision: Remind students that scientists use precise, specific language. Start with a claim but revise it: *How could I make this claim more accurate or specific?*

Possible Student Claim →	Follow-up →	Revised Claim
Magnets only attract things that are made of metal. and/or *Metal things stick to magnets.*	How could we revise this claim to make it more accurate?	*Magnets attract objects that contain special metals like iron. Many metals are magnetic, but not all.*
Magnets do not attract plastic, wood, glass, or cloth. and/or *Plastic, wood, glass, and cloth are not magnetic.*		*Magnets do not attract non-metals, like glass, plastic, or cloth. Some metals are not magnetic if they don't have special metals like iron in them.*

Mini-lesson

3. Just-in-Time Instruction: Obtain information from media

Set a purpose for watching/reading these different sources by referring to one or two claims students just shared. Build from one of the claims and watch/listen to see if these other sources support these claims. Have students jot notes from watching the video and listening to excerpts from the book(s) about magnets and what materials are magnetic.

What does the text/video teach or tell us about magnetism?
Does information from these sources support our claims or not?

Writing

4. Notebook Writing

Students answer today's question, "What kinds of things do magnets attract?" and can add, "Why do we need to know this?" Students write and sketch about what they did, what they figured out, what they learned (from video/text) and how it could be helpful to know what materials are magnetic or not.

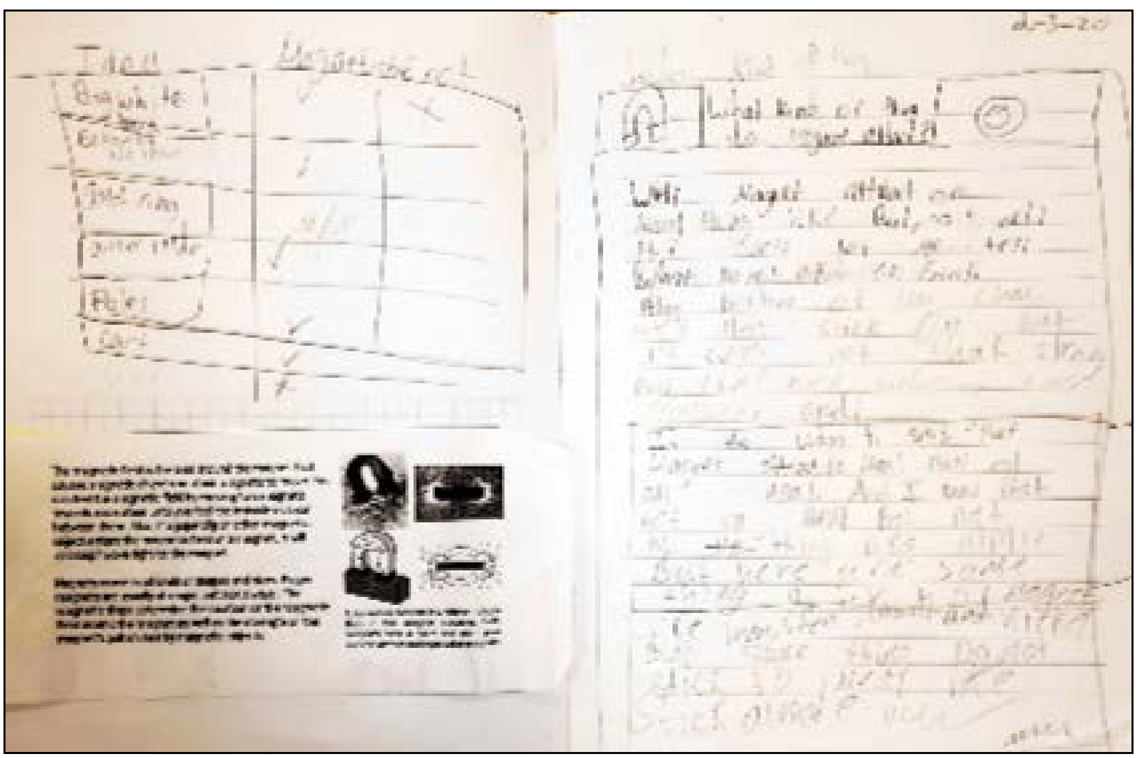
Share & Discuss

5. Class Discussion

Spend a few minutes revisiting the initial real-world problem of separating mixed materials in a recycling plant.

- ➢ *What do you think now? Could magnets solve the problem of separating mixed materials at recycling plant? State your claim (Yes/No… because…).*
- ➢ *How does what we did, read, or watched today support your claim?*
- ➢ *How could you revise or elaborate on your original thinking?*

Photo from Part 1



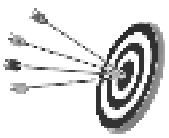
Part 2: Summarize Learning & Magnetic Sculptures

Summarizing Learning

1. Summarize Learning from Part 1.

- Activity: What did we do? What did we test?
- Data patterns: What happened? What did we figure out?
- Explanation: What did we learn to help us explain or show our thinking?
- Connection: How can this help us explain our phenomenon?

Activity	Observations & Data Patterns	Explaining our observations and data	Making Connections
What kinds of things attract to a magnet?	Many metals attracted to a magnet, but not all. None of the plastic, glass, or wood attracted to the magnet.	Materials that contain iron, steel, or other certain kinds of metals are magnetic but plastic, wood, and glass are not magnetic. Iron can be a magnet and is also magnetic.	The magnetic ring toy must have magnets inside the colored plastic on the rings to make the toy safer and not pinch as much. Magnets can work through things so it's like the inside magnet works through the plastic to attract and repel.



Purpose

2. Introduce today's challenge and expectations.

a) Tell students that today they are challenged to us what they know about balanced forces and magnetism to build a free-standing character sculpture using a mixture of magnets and magnetic objects. They can use 4 magnets of any shape and an assortment of objects.

b) Show students the materials available. Ask them to think of some ways we could fairly share or access materials if this is what we have (point to materials table). NOTE: Once students tinker with a few magnets and nuts, bolts, and washers, they will likely want to try different pieces. Students need to easily swap materials to iterate on their design to solve problems that arise.

c) Also have students quickly share expectations for: working with magnets, talk/volume levels while working, being kind, moving around the classroom to get./swap materials, or cleanup materials.

Experiment

3. Creation time!

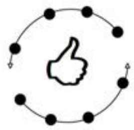
a) As students create their magnetic character sculptures, notice what challenges students encounter related to balanced and unbalanced forces.

b) Give students a 5 minute warning to finalize their sculptures and give their character a descriptive name on an index card.

Back-Pocket Questions

Observations:
- What have you noticed so far as you've been building your sculpture?
- What is easy? What is hard?

Pressing/Probing:
- What do you think caused that?
- What have we learned that could...
  … improve your design?
  … solve that problem?



Gallery Walk

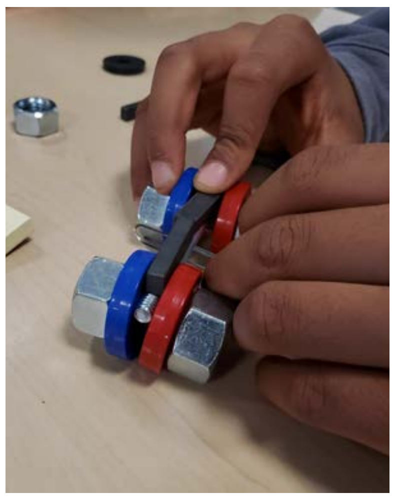
4. Gallery Walk

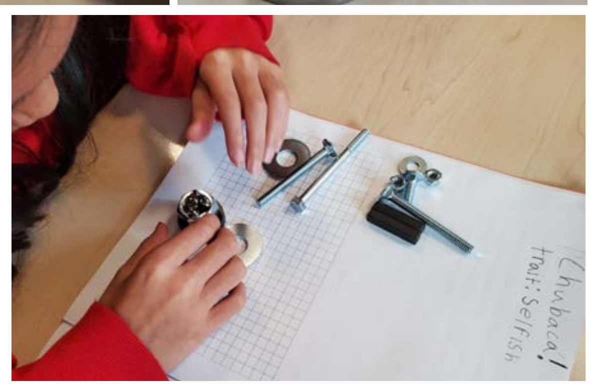
a) Have students set up their sculpture with name-tag and push in their chairs. Students silently, looking only with their eyes, do a gallery walk around the classroom observing each sculpture.

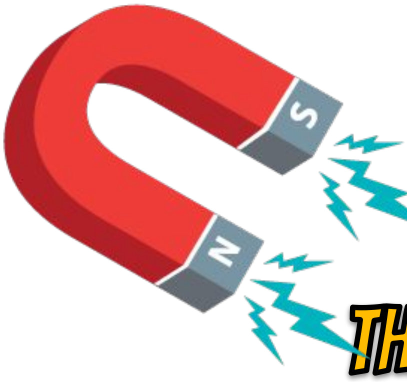
b) Optional: Depending on connections with your current reading/writing units, have a short discussion of character traits. If you said your character is __(adjective)__, how does their body position or face communicate that?

c) Take photos of each sculpture. Options: Post online or print grayscale to cut/glue in their science notebooks.

Photos from Part 2



What Kinds of Things Do Magnets Attract?

Part 1

Real World Problem

The recycling center needs to separate metals from plastic and paper. Should they use a magnet? What do you think would happen?

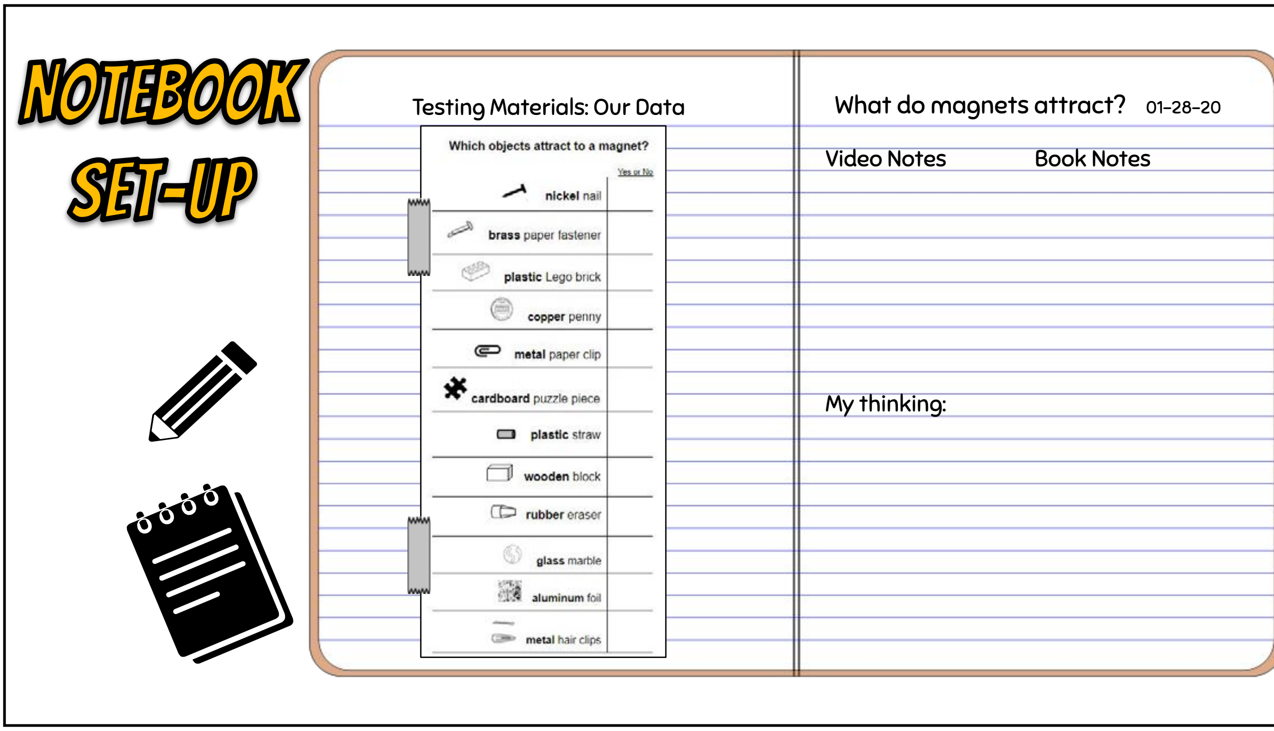
Food and soup cans are often made of steel.

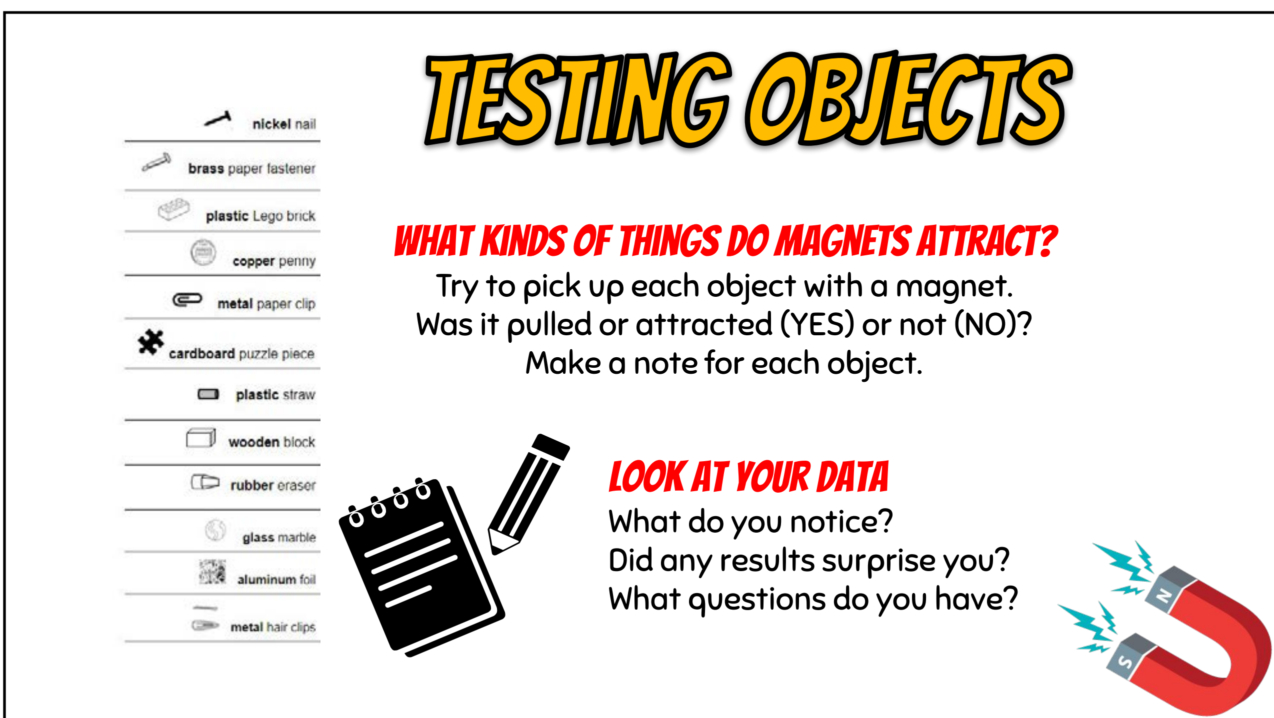
Cereal boxes, magazines, and egg cartons are made of paper.

Sports drinks and water come in plastic bottles.

Soda cans are aluminum

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools


NOTEBOOK SET-UP
Testing Materials: Our Data
Which objects attract to a magnet?
Yes or No
nickel nail
brass paper fastener
plastic Lego brick
copper penny
metal paper clip
cardboard puzzle piece
plastic straw
wooden block
rubber eraser
glass marble
aluminum foil
metal hair clips
What do magnets attract? 01-28-20
Video Notes
Book Notes
My thinking:


TESTING OBJECTS
nickel nail
brass paper fastener
plastic Lego brick
copper penny
metal paper clip
cardboard puzzle piece
plastic straw
wooden block
rubber eraser
glass marble
aluminum foil
metal hair clips
WHAT KINDS OF THINGS DO MAGNETS ATTRACT?
Try to pick up each object with a magnet.
Was it pulled or attracted (YES) or not (NO)?
Make a note for each object.
LOOK AT YOUR DATA
What do you notice?
Did any results surprise you?
What questions do you have?
N
S

MAKING CLAIMS

CLAIM

What do we know?

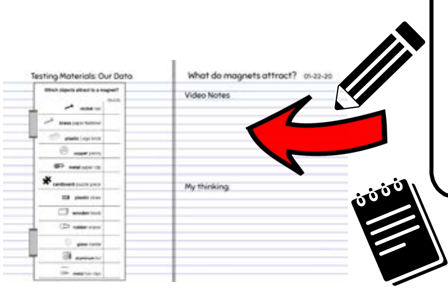
As truthful or accurate a statement as possible

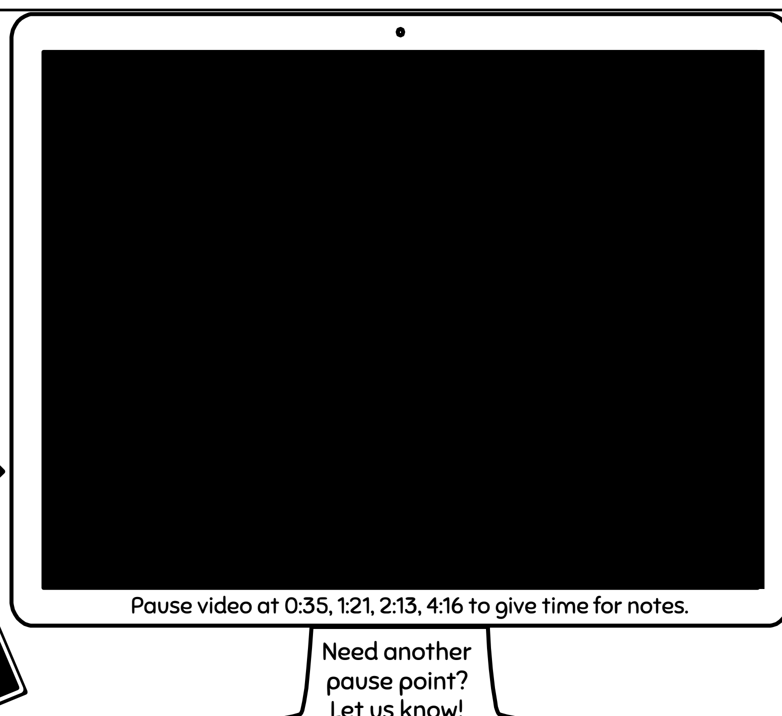
EVIDENCE

How do we know?

Based on the data or information that we have

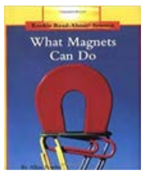
WHAT KINDS OF THINGS DO MAGNETS ATTRACT?



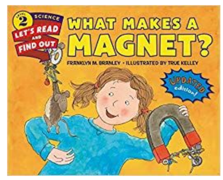


MORE INFORMATION…

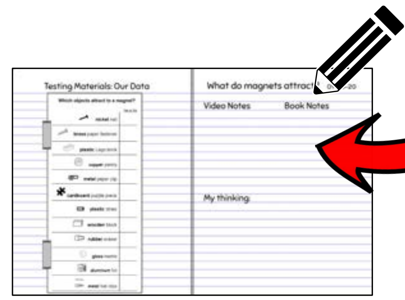
Refer to the pages below for the book(s) you have available.



See pages 3-9



Also, see pages 3-9



Does the information help us answer today's question:

WHAT KINDS OF THINGS DO MAGNETS ATTRACT?

THINK & DISCUSS

WHAT KINDS OF THINGS DO MAGNETS ATTRACT?

EVIDENCE: HOW DO YOU KNOW?

- *We observed that…*
- *Our data showed*
- *The video told us…*
- *The book said….*

EVIDENCE: HOW DO YOU KNOW?

- We observed that...
- Our data showed
- The video told us...
- The book said....

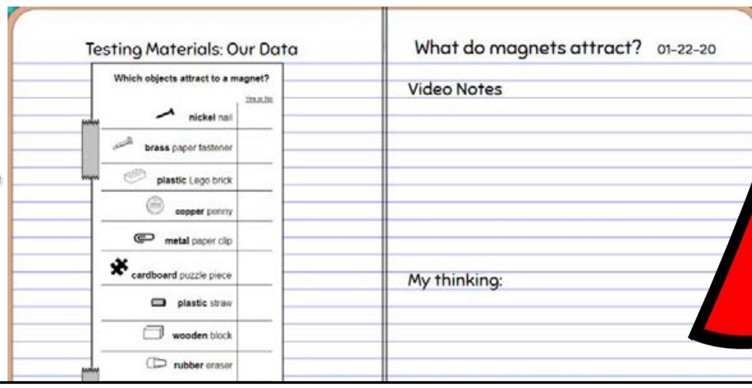
NOTEBOOK TIME

1. Sketch what you did with magnets today.
2. Explain what you figured out. Use evidence.

Helpful Words:

magnet, poles, attract, pull, repel, push, magnetic

WHAT KINDS OF THINGS DO MAGNETS ATTRACT?



REAL WORLD PROBLEM: NOW, WHAT DO YOU THINK?

The recycling center needs to separate metals from plastic and paper. Would a magnet be a useful tool? Why or why not? What do you think would happen?

Food and soup cans are often made of steel.

Cereal boxes, magazines, and egg cartons are made of paper.

Sports drinks and water come in plastic bottles.

Soda cans are aluminum

WHAT KINDS OF THINGS DO MAGNETS ATTRACT?

Part 2

SUMMARY TABLE: OBSERVE, EXPLAIN, & CONNECT

- Activity: What did we do? What did we test?
- Data patterns: What happened? What did we figure out?
- Explanation: What did we learn from book/video to help us explain our results?
- Connection: How can this help us explain our phenomenon?

Our Question	Observations & Data Patterns	Explaining our observations and data	Making Connections
What kinds of things do magnets attract?	*What did you observe or notice?*	*What did we learn that helps explain our observations?*	*How does this activity help us explain how the magnetic toy works?*

ART PROJECT

TEMPORARY MAGNETIC CHARACTERS

Source: BabbleDabbleDo

Materials for each student to borrow:

- 1 metal jar lid or large washer
- Up to 4 magnets (any shape:bar, donut, rectangular, etc)
- Assorted magnetic items (bolts, nuts, washers, paperclips, etc)
- 1 index card + marker (for a name tag)

Directions:

1. Build a free-standing character sculpture. Is it a person? animal? something else?
2. Show personality traits through sculpture. What does an inquisitive pose look like? Scared? Happy? Curious? Move parts to express something about your character.
3. Give your sculpture a name that tells about its character (example: Dinky the curious robot)
4. This is a temporary sculpture. Take a photo of your sculpture with its name card. When you are finished admiring your sculpture, take it apart and return the materials.

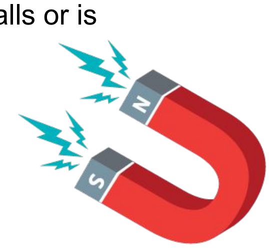
EXTENSION: WORD WISE

WHAT DO YOU NOTICE ABOUT THESE WORDS?

magnet
magnetic
magnetize
demagnetize
remagnetize
magnetization

Try the words out:

Paperclips, nails, and soup cans are magnetic because they contain iron or steel. A piece of magnetic material can be magnetized by rubbing it with one pole of a magnet in one direction. Another way to magnetize a magnetic material is to run electricity through it. If a magnet falls or is heated, it may weaken or demagnetize.



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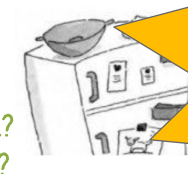
EXTENSION: MUSIC

CHALLENGE!
Work with a partner or group to write a new verse.

MAGNET SONG

Sung to the tune, "Did you ever see a Lassie?"



Chorus
Did you ever see a magnet, a magnet, a magnet?
Did you ever see a magnet pull this way and that?

Verse 1
On iron and steel,
its pull is unreal!
Did you ever see a
magnet pull this
way and that?
Chorus

Verse 2
A magnet has action.
It's called an attraction!
Did you ever see a
magnet pull this
way and that?
Chorus

Verse 3
Their poles are north and south.
Don't put them in your mouth!
Did you ever see a
magnet pull this
way and that?
Chorus

EXTENSION: RHYME

MAGNETS

A poem by an
Unknown Author

I am a mighty magnet.
I can be very strong.
When you use safely,
nothing can go wrong.

I pick up many objects.
But not everything, you see.
I can only pick up objects
that are attracted to me.

So pick me up and try me out
and you will get to see,
What different kinds of things
are pushed and pulled by me.

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Which objects attract to a magnet?

	Yes or No
nickel nail	
brass paper fastener	
plastic Lego brick	
copper penny	
metal paper clip	
cardboard puzzle piece	
plastic straw	
wooden block	
rubber eraser	
glass marble	
aluminum foil	
metal hair clips	

Which objects attract to a magnet?

	Yes or No
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plastic Lego brick	
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cardboard puzzle piece	
plastic straw	
wooden block	
rubber eraser	
glass marble	
aluminum foil	
metal hair clips	

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metal paper clip	
cardboard puzzle piece	
plastic straw	
wooden block	
rubber eraser	
glass marble	
aluminum foil	
metal hair clips	

Lesson 6 Making Magnetic Fields Visible

Purpose

In this lesson, students learn more about that ‘invisible cushion’ or ‘bubble we can feel that they have observed between magnets.

- Students obtain information from media and use simple tools to make invisible properties of magnets visible.

For more about supporting on-going changes in student thinking, see http://AmbitiousScienceTeaching.org

Learning Target

Focus question

What’s going on with that invisible cushion we felt between magnets?

or

How can magnets work without touching?

Learning Target

I can use information from text and video and use simple tests to explain how magnets can move some things without touching them.

NGSS 3-D

SEP:Asking Questions and Defining Problems *Ask questions that can be investigated based on patterns such as cause and effect relationships.*

PS2.B: Types of Interactions Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.

CCC: Cause and Effect *Cause and effect relationships are routinely identified.*
CCC: Patterns *Patterns can be used to make predictions*

Materials

For the class:
- Lesson Slide Guide (GoogleSlides)
- Chart paper and markers, sticky notes

Per student:
- Science notebooks
- Half-sheet student reading (link)

Per table group:
- 4 plastic boxes w/iron filings (link) *and/or* sealed/taped clear bags containing 1 TBSP of iron filings* (link)
- 1 etch-a-sketch (optional)
- 4 small compasses (link)
- 1 pair of horseshoe magnets
- 1 par of donut or circle magnets
- 1 pair of bar or rectangle magnets

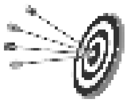
* Never sprinkle iron filings directly on magnets. Make sure bags are taped shut and well sealed for safety.

Lesson Step Summary

1. **Orient students to an idea:** Return to an observation or question students had about feeling an invisible cushion or bubble between magnets and/or the distance at which magnets work to move magnetic objects. Introduce today’s question or purpose related to that observation or question.
2. **Just-in-time instruction:** Give information about magnetic fields to students using a reading: What are they? Where are they? What do they do?
3. **Engage students in activity for sensemaking**: Can we find magnetic fields of different magnets? Make observations using the materials available to make these invisible magnetic fields visible. What do you notice? How can we make observations about this force field that we can’t see?
4. **Notebook writing**: Respond to today’s question and have students elaborate, adding what matters to them and their science thinking.
5. **Summarize Learning:** Recap observations, summarize learning, and make connections back to magnetic ring toy. Create a summary chart public record.

Developed by C. Colley, PhD ccolley@rentonschools.us with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

Lesson Plan



Purpose

Turn-and-Talk

1. Launch: Orient to an idea

a) Return to an observation or question students had about feeling the invisible cushion or bubble between magnets and/or the distance at which magnets work to move magnetic objects. Introduce today's question or purpose related to that observation or question:

What's going on with that invisible cushion we felt between magnets? or
How can magnets work without touching objects?

b) Have students think about today's question. Turn and discuss with a partner to help focus students on the idea that magnets have invisible forces that act at a distance (without touching magnetic objects).

Read for information

Science Word

2. Just-in-Time Instruction: Obtain information from text

a) Set a purpose for reading this short text about magnetic fields. Something like: *This short text gives us something to think about as we make observations with magnets in just a few minutes."*

b) Have students read the [text]. There are 3 copies to a page so they should fit nicely in notebooks so students can refer to this text as a source of information. These questions can focus students as they read:

What does the text teach or tell us about magnetism?
Does information help address or answer today's question?

c) Have students define the term *magnetic field* based on information from the text. You could do a turn-and-talk or have students jot a note on a sticky note or in their notebooks about this new science term. The purpose here is to spend a moment processing this new term.

Make Observations

Back Pocket Questions

3. Finding the magnetic field

a) Show students the materials they have available today: iron filings in a case (or bag), different shapes of magnets, paperclips, rulers, graph paper. Let students explore these tools and make observations of how each magnet interacts with the paperclips and iron filings. (NOTE: Never pour iron filings directly on magnets. They will be nearly impossible to remove. Place iron filings inside a securely sealed plastic bag before moving the magnet near the outside of the bag.)

b) Circulate as students explore and observe how the iron filings and paper clips behave near each magnet. As table groups share materials, and make observations, students talk with each other about what they notice.

- ➔ *Does the magnet have to touch the iron filings to make them move?*
- ➔ *Does the magnet shape or direction/angle you hold the magnet affect the motion of the iron filings?*
- ➔ *What connections can you make between the reading and your observations?*

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Share & Discuss

c) Discuss briefly as a class. *Were students able to see the magnetic fields using the iron filings or the paper clips? What do students know now about magnetic fields?* Have students make claims based on their investigation.

A *claim* is a statement about an event or phenomenon that we think is true based on our evidence or experience.

Writing

4. Notebook Writing

Students answer today's question using what they read and observed about magnetic fields: "*How can magnets move magnetic objects without touching them?"* Students write and sketch about what they did, what they figured out, what they learned (from text) and how it could be helpful to know about magnetic fields. They can also jot any questions/wonderings.

Summarizing Learning

5. Summarize Learning

Create a summary public record of today's learning for future reference:

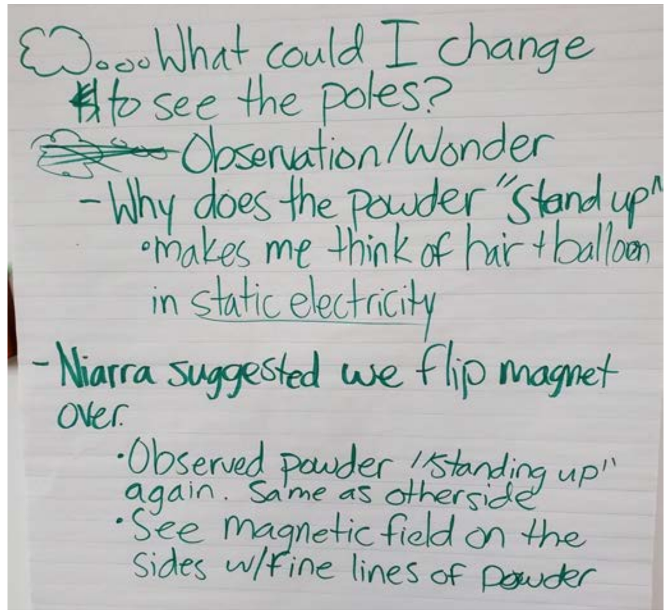
- Activity: What did we do? What did we test?
- Data patterns: What happened? What did we figure out?
- Explanation: What did we learn to help us explain our new ideas?
- Connection: How can this help us explain our phenomenon?

Activity	Observations & Data Patterns	Explaining our observations and data	Making Connections
How can magnets move objects without touching them?	The poles of the magnet moved iron filings more than the middle or side of the magnet.	The invisible cushion we feel between magnets is helping us "see" the magnetic fields. All magnets have a magnetic field that goes between the north and south poles. Magnetic field = zone where magnet works	Each donut magnet in the ring toy has a magnetic field. If another magnet gets close to the first magnet it will either attract or repel depending on which poles are facing AND if the magnets are close enough to be in each others' magnetic fields.

Photos from Lesson 6

This student noticed that he could hold the rectangle magnet an inch above the plastic case and still attract some iron filings, just not as many as if he puts the magnet touching the plastic case

★ **Key idea**: *Importance of magnetic force acting over a distance without touching. The farther away, the weaker the magnetic force.*



This teacher paused the class mid-observation to capture what they observed/wondered and gathered suggestions from students of what to explore next. When students resumed exploration, several students tested Niarra's idea of flipping magnets over to see if the iron powder moves the same way as the first side of the magnet.

These two students noticed they could use a magnet under her desktop to move the iron filings and still see a pattern. The magnet worked through the table. Students changed magnets and noticed that the shape and "perkiness" (how tall the iron 'stood up') of the iron filings changed (showing that different magnets have different magnetic field shapes and strengths) but that all magnets, except for the weakest bar magnets we had, would work through the desktop.

★ **Key idea:** *Magnetic force cannot be blocked or stopped. Magnetism can work through all kinds of materials.*

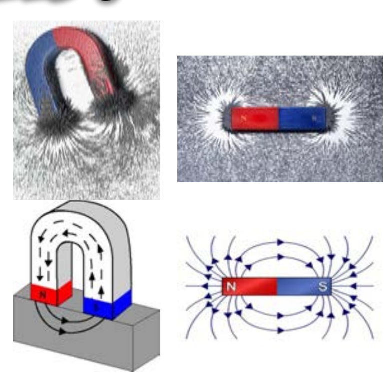
★ **Key idea:** *Different magnet shapes have different shapes of magnetic fields. All magnets have a magnetic field, or invisible zone near and around the magnet within which the magnet can attract magnetic objects.*

HOW CAN MAGNETS MOVE OBJECTS WITHOUT TOUCHING THEM?

WHAT IS A MAGNETIC FIELD?

The magnetic field is the area around the magnet that causes magnetic objects or other magnets to move. You can feel the magnetic field by moving two magnets towards each other until you feel the invisible cushion between them. Also, if a paperclip or other magnetic object enters the magnetic field of a magnet, it will *zzzziiiiip!* move right to the magnet.

Magnets come in all kinds of shapes and sizes. Bigger magnets are usually stronger, but not always! The magnet's shape determines the location of the magnetic field around the magnet as well as the strength of the magnet's pull on nearby magnetic objects.



A horseshoe magnet is a different shape than a bar magnet. However, both magnets have a north and south pole and can attract and repel other magnets.

WHAT DO YOU WONDER NOW?

Sources: Jefferson Lab and KJ Magnetics

MAKE OBSERVATIONS

Work with a partner or group and use the tools to figure out these questions:

How can we find a magnetic field for a magnet if we can't see it?

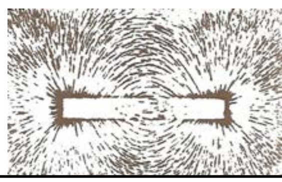
Are magnetic fields the same size and shape for every magnet?

Ruler

Graph Paper

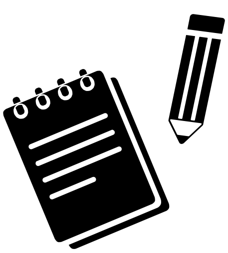
compass

Iron filings



Magnets

Paperclips

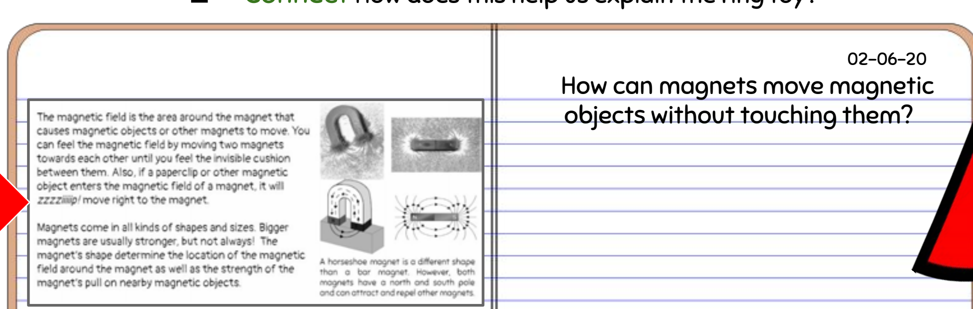


NOTEBOOK

- ❑ Open to a new page.
- ❑ Write title and date.
- ❑ Glue in the reading.
- ❑ Sketch what you did today.
- ❑ Write your response about today's question.
- ❑ Connect How does this help us explain the ring toy?

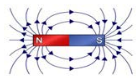
Helpful Words:

magnet poles
attract pull
repel push
gravitational force
magnetic force
balanced forces
unbalanced forces
magnetic field



magnetic field

the invisible area around the magnet that causes magnetic objects or other magnets to move without touching them



SHARE & LISTEN

Share and listen to the ideas and questions from one other pair or group.

Then, come together as a whole class to summarize what we did and figured out.

SUMMARY TABLE: OBSERVE, EXPLAIN, & CONNECT

- Activity: What did we do? What did we test?
- Data patterns: What happened? What did we figure out?
- Explanation: What did we learn from book/video to help us explain our results?
- Connection: How can this help us explain our phenomenon?

Our Question	Observations & Data Patterns	Explaining our observations and data	Making Connections
How can magnets move objects without touching them?	*What did you observe or notice?*	*What did we learn that helps explain our observations?*	*How does this activity help us explain how the magnetic toy works?*

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

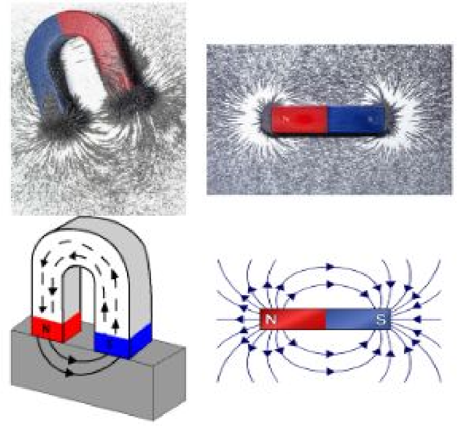
Extension: Word Wise

What about force?

1. "She forced me to do it," accused the brother, pointing at his sister, standing over the broken vase.
2. The hurricane was a force of nature!
3. "Lifting that dumbbell was an act of brute force," commented the announcer during the weightlifting competition.
4. The Air Force, Army, Coast Guard, Marine Corps, Navy, Reserves and National Guard are branches of the armed forces in the United States.
5. The attractive force can move magnetic objects towards the magnet.

The magnetic field is the area around the magnet that causes magnetic objects or other magnets to move. You can feel the magnetic field by moving two magnets towards each other until you feel the invisible cushion between them. Also, if a paperclip or other magnetic object enters the magnetic field of a magnet, it will *zzzziiiiip!* move right to the magnet.

Magnets come in all kinds of shapes and sizes. Bigger magnets are usually stronger, but not always! The magnet's shape determine the location of the magnetic field around the magnet as well as the strength of the magnet's pull on nearby magnetic objects.



A horseshoe magnet is a different shape than a bar magnet. However, both magnets have a north and south pole and can attract and repel other magnets.

The magnetic field is the area around the magnet that causes magnetic objects or other magnets to move. You can feel the magnetic field by moving two magnets towards each other until you feel the invisible cushion between them. Also, if a paperclip or other magnetic object enters the magnetic field of a magnet, it will *zzzziiiiip!* move right to the magnet.

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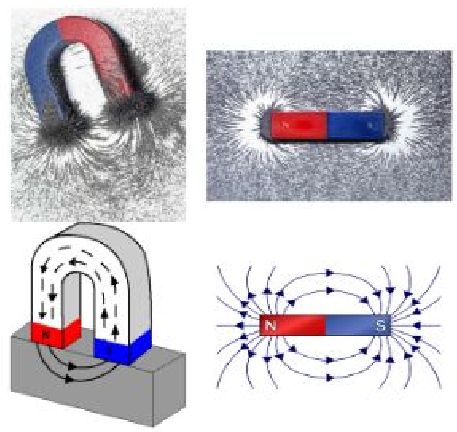

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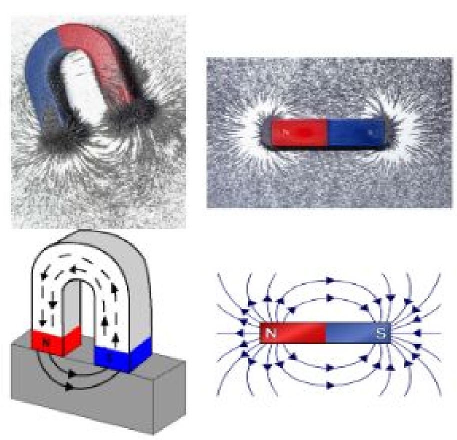


A horseshoe magnet is a different shape than a bar magnet. However, both magnets have a north and south pole and can attract and repel other magnets.

Lesson 7 Updating & Revising Explanations

Purpose

In this lesson, students synthesize what they have experienced and learned so far to update and revise their initial explanations.

- Students apply new learning to revise (add, change, remove) their initial explanations and models using evidence.

For more about pressing for evidence-based explanations, see http://AmbitiousScienceTeaching.org

Learning Target

Focus question

How does this magnetic ring toy work?

Learning Target

I can use evidence from our investigations to explain how the magnetic ring toy works.

NGSS 3-D

SEP: Constructing Explanations and Designing Solutions *Use evidence (e.g., observations, patterns) to support an explanation.*

DCI: PS2.A: Forces & Motion *Each force acts on an object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.*

PS2.B: Types of Interactions *Magnetic forces between a pair of objects do not require that the objects contact. The size of the forces depends on the properties of the objects and their distances apart, for forces bet. two magnets, on their orientation relative to each other.*

CCC: Cause and Effect *Cause and effect relationships are routinely identified.* ***CCC: Patterns*** *Patterns can be used to make predictions*

Materials

For the class:
- Lesson Slide Guide (GoogleSlides)
- Summary charts from prior lessons
- Magnetic ring toy (for reference)

Per student:
- Science notebook
- Blank paper or blank scaffold (options)
- Initial model from Lesson 1
- Sticky notes

Lesson Step Summary

Part 1: Updating Models

1. **Launch: Orient students to recent learning.** Look over summary charts and notebooks. What have we done so far to learn about forces? Turn-and-talk. Generate a "gotta have" checklist of ideas everyone needs to address.
2. **Explore: Update Models, Draft Explanations:** Tell students expectations for revising/updating models and remind students of their resources (notebooks, summary charts, gotta have checklist). Send students off to work.
3. **Summarize: Self-check.** Students check their work so far against the checklist. What have they addressed so far? What's the next step? Leave themselves a sticky note of what to work on tomorrow.

Part 2: Providing & Incorporating Peer Feedback

1. **Launch: Continue working on explanations.** Have students use their note-to-self sticky note from Part 1 to continue work on their model and written paragraph(s) to explain the magnetic ring toy.
2. **Explore: Peer feedback using "gotta have" checklist.** Give students your expectations for feedback. Have students do a silent gallery walk and leave sticky notes for other students with some feedback.
3. **Summarize: Incorporate/address feedback.** Students read and address peer feedback by adding to their model and explanation. Finally, have students identify one place their thinking has changed and what experience helped shape their current thinking.

Preparation

Teacher Decision

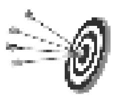
There is no precise "right way" to go about supporting students in revising and updating models. Students need only the opportunity to identify where they have changed their thinking and what experiences helped them change or elaborate on their original ideas. Here are three options for support:

(1) Students could start on a blank paper or blank template. Then, when completed, students compare their current model to the original model to identify places their thinking has changed and/or been elaborated.

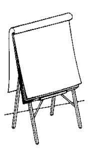
(2) Students use a different color pen to mark up their original model with revisions so we/they can easily compare their original with their revised understanding. Emphasize that to revise an idea, do not scribble it out, just place one line through it and write your new thinking above or next to it.

(3) Students use sticky notes to show additions, elaborations, changes on their original model. (See pg 8-9 of this document for more details).

Part 1

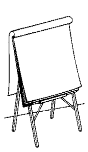


Purpose



Summary Charts

Turn-and-Talk



"Gotta have" checklist

1) Introduce purpose and orient students to recent learning experiences.

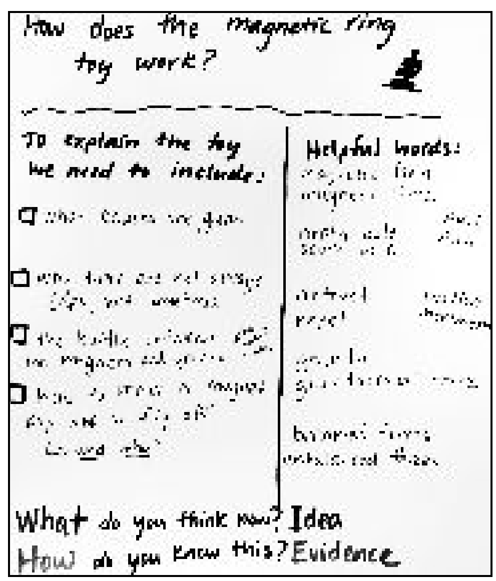
a) Open with a statement of purpose. Something like: *Today, we will look back on what we have learned so far and all the evidence we have* (point to summary charts)*. We will go back and update our original ideas to see what we have evidence for and also to our questions to see if we can answer some of them now.*

b) Remind students of the main question: *How does this magnetic ring toy work?* Then, students recall and review what they have done so far by taking a *silent* minute to look over the summary charts from prior lessons and flip through their notebooks. *What did we do? What did we learn?*

c) Ask students: *What do you remember doing or learning so far? Think for a few seconds to get ready to share one thing with a partner.* Turn and share. This helps students quickly reorient to recent learning and review resources they can use (notebooks, summary charts).

d) Generate a "gotta have" checklist as a class to ensure students remember to include important ideas. As students work on their models and explanations today and tomorrow, redirect them back to this checklist as needed.

For more teacher information about "Gotta Have" checklists, see pages 10-11 of this document and/or watch this video.



"Gotta Have" Checklist, at right: Created with student input and projected under document camera for easy reference. Teacher emphasized adding in evidence for ideas.

Update ideas

Model to Explain

2) Explore: Update Models, Draft Explanations

Let students know the expectations for the task-- whether they are starting a new model, using colored pens, or sticky notes to update their initial models *(see decision point above in "Preparation")*.

Students use the "gotta have" checklist, summary charts, and their notebooks to help them develop and update their models and explanations.

Circulate as students work. As needed, confer with students to help them make progress on the task.

If a student…

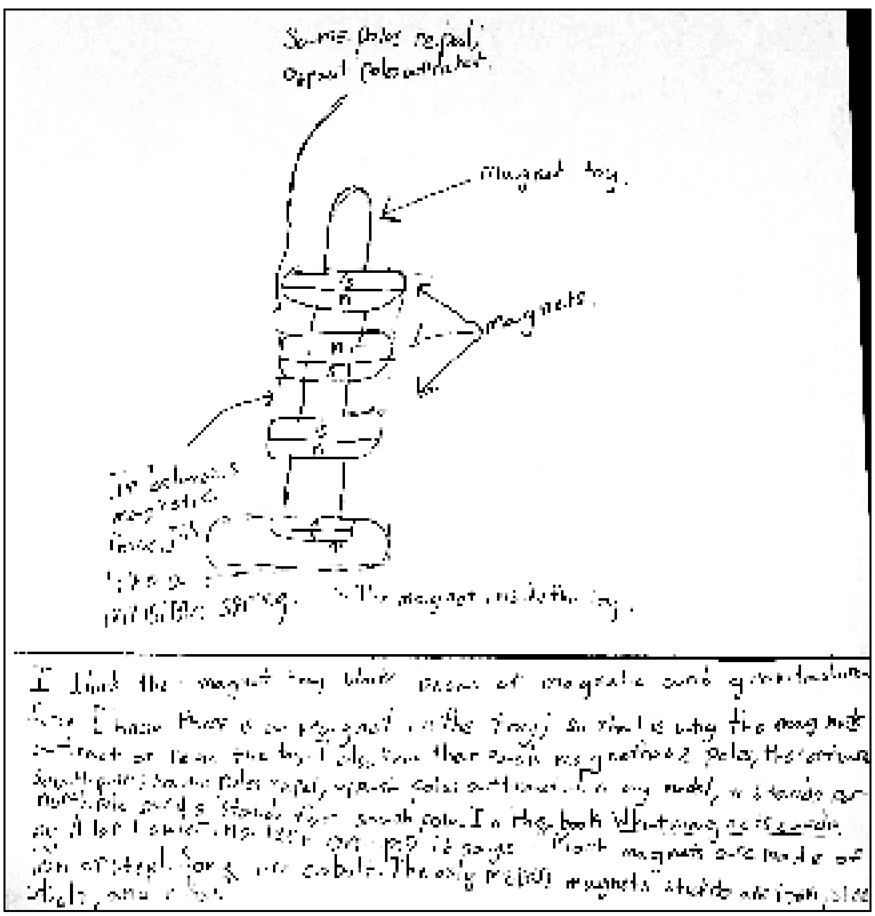
… *seems stuck getting started*:
Ask student to choose an idea from the checklist to start with and to tell you a little bit about it (oral rehearsal) and then ask: *How could you show that in pictures and words on your model?*

… talks to you about their idea but isn't putting it on paper.
Ask the student if drawing or writing that idea in words makes more sense to them. Suggest they start there. If the student often does not write a lot, sticky notes can help as they don't have to fill a page just enough to fill a sticky note for *that* idea. Suggest starting by writing one sticky note for each idea on the checklist to help get their ideas flowing.

Closing

3) Closing: Self-Check

Have students check what they have addressed so far on the "gotta have" checklist. *If needed, read each item and have students point to it as you go down the list to help them identify places to work on next.* Have students jot a sticky note to themselves to remind them of their next steps tomorrow.



Student Explanation Example from Part 1:

Model labels:
- Same poles repel, opposite poles attract.
- In between is magnetic force.
- It's like an invisible spring. The magnet inside the toy.

Written portion:
I think the magnet toy works because of magnetic and gravitational force. I know there is a magnet in the toy so that is why the magnets attract or repel the toy I also know that each magnet has 2 poles, the north and south pole; same poles repel, opposite poles attract. In my model, n stands for north pole and s stands for south pole. In the book What magnets can do by Allan Fowler in a text on p. 7 it says "Most magnets are made of iron or steel. Some are cobalt. The only metals magnets stick to are iron, steel, cobalt, and nickel." *[Unfinished, student worked on the next day]*

Part 2

Model to Explain

1. Launch: Resume work on explanations

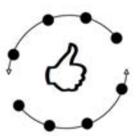
a) Tell students that today they will have more time to complete their models and explanations and get some feedback from partners to make sure they are showing everything they know in their explanation of the magnetic ring toy.

b) Have students return to the sticky note students left themselves at the end of part 1. Give students a few focused minutes (5-7 mins) to work on adding ideas and evidence. Direct students to use their resources: notebooks, summary charts, books, and "gotta have" checklist.

2. Explore: Provide peer feedback

Mini-lesson

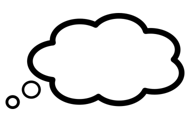
a) Set expectations for the peer feedback gallery walk. Tell students that they will have a few minutes to silently circulate around the room, read what other students have written so far, and leave a sticky note that recognizes a specific idea and suggests a next step. *If students have not done peer feedback before, insert a mini-lesson here to teach about how to give helpful feedback and discuss examples. Use the examples in the slides or select other criteria you prefer instead.*



Gallery Walk

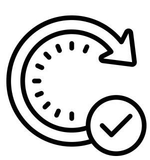
b) Have students silently circulate to leave at least two (preferably three) helpful feedback sticky notes on other students' work. Remind students to look beyond items like handwriting and spelling and give feedback about science ideas or evidence. By the end of the gallery walk, each student should have at least 2 sticky notes.

3. Summarize: Address/Incorporate peer feedback



Think Time

a) Have students return to their desks and read feedback. Check in to see if students know what they will do next. If students know, continue working on the model and explanation. If students aren't sure what to do, then:
   i) If 1-3 students are unsure, do some 1-on-1 conferencing.
   ii) If 4-7 students are unsure, pull a small group to talk through feedback as a group while the rest of the class works on their own at their desks.
   iii) If 8 or more students are unsure, workshop examples as a whole class (e.g., "*Martin's note says, 'You have labels on your model but you should add more about how these parts work together and why they are important.' What might Martin do next?* Take ideas from the class. Repeat with another sticky/student.)



Update ideas

b) Allow students some time to finish updating their models and explanations using the "gotta have" checklist and peer feedback.

4. Closing: Self-reflection

Reflect

Ask students to compare their original models to their current thinking. *What is one idea that you changed your mind about or learned more about? What experiences helped you change or grow you thinking?* Have students turn and share with a partner.

Teacher Reflection: Analyzing Student Work

❏ **Includes and/or describes important science ideas.** These could be shown in the student's drawn model and/or written explanation.

Important Idea	What this might look/sound like...
❏ Identify forces acting on an object which can result in changing or maintaining motion. This includes whether forces' strengths and directions are balanced or unbalanced. ❏ Distinguish between forces that work by touching objects to move them (contact forces) and forces that work over a distance (non-contact forces such as gravitational force and magnetic force) ❏ Use patterns in observed motion to make predictions (if/then) about future motion ❏ Magnets exert forces on each other. The orientation of magnets can cause the forces between magnets to be attractive or repulsive. The strength of the force depends on the material and shape, not size.	*"If we put the ring magnets so the same poles attract, the magnets all stick together in a stack and there is no invisible spring. The magnets won't move.That invisible spring is a magnetic push that we need it to launch the top magnet. So if we put the ring magnets with opposite poles facing each other, then there are gaps between each magnet. I can use my hand to push down the stack and make the magnets touch. When I let go the magnetic force between magnets repels them and launches the top magnet up. Our group got the top magnet to go 23 cm from the floor! We tried making different size gaps and figured out that it's a battle between magnetic power and gravity. If we had stronger ring magnets, I think we could get the magnet to hit the ceiling. But they would have to be stronger, not heavier, or else gravity would win and it wouldn't go as high."*

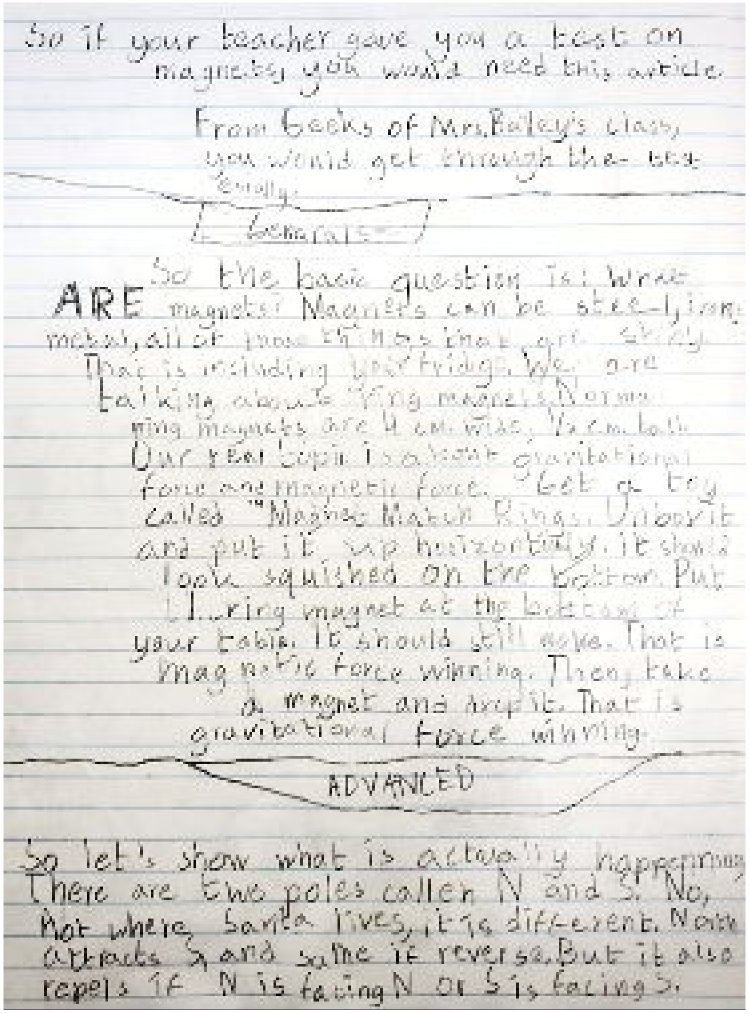
❏ **Evidence supports or refutes a claim.** Note how/if students attempted to provide evidence. Add other categories as they arise in student work (the chart is not exhaustive).

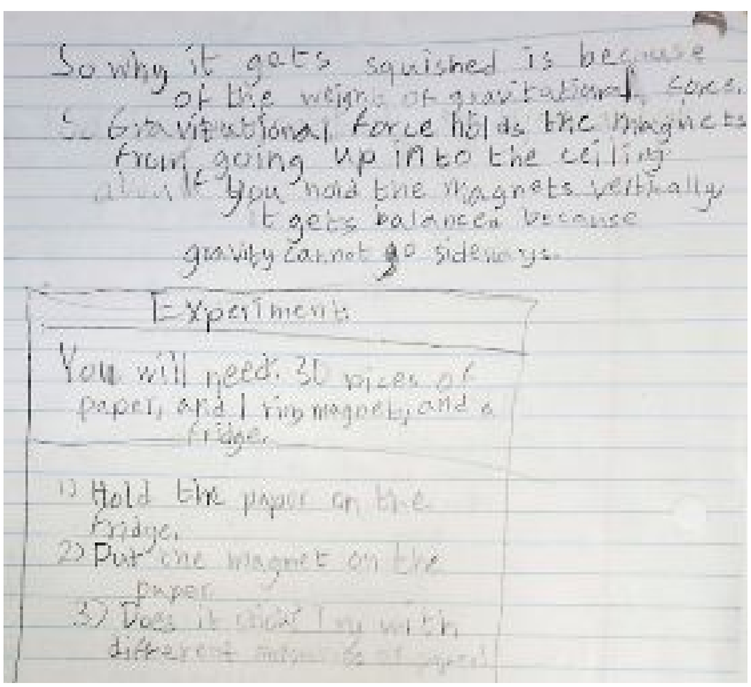
Generic *Evidence attempt is generic, references source, lacks detail*	**Detailed retelling** *Evidence provides detail about the source, but lacks explicit connection to a claim*	**Connects to a claim** *Evidence is relevant to the claim.*	**Supports or refutes a claim** *Evidence is relevant and sufficient to support or refute the claim.*
"Magnets have a force. I know this because we did things in class that proved it."	"In this unit, we learned about magnets. We did so many experiments to learn about magnets. Martin and I put magnets on our desk and chair and hands and the magnets still stuck together. Then we had donut magnets on a pole and saw how high we could get them to go. We also chased one magnet around with another."	"Magnets have an invisible force. I know this because I pushed one magnet near paperclips and the magnet pulled the paper clips to it without even having to touch them!"	"Magnets have an invisible force. I pushed one magnet near paperclips and observed the magnet pulled the paper clips to it without even having to touch them! I could also see the force field using iron filings.The magnetic force made the iron make a shape to show the force field around each magnet."
"Magnets have forces.The reading and video taught me about magnets so that's how I know."	"Magnets are cool. The book Let's Make a Magnet by Franklyn Branley said, 'There is a reason why only some things stick to a magnet.They have to be made of the right stuff. The material they are made of has to be magnet sticky or ferromagnetic.'"	"Not everything is attracted to magnets, just paper clips and some other metals are.The book Let's Make a Magnet by Franklyn Branley said that only materials made of the right stuff is magnetic."	"Not every material is magnetic. The book Let's Make a Magnet by Franklyn Branley said that only materials made of the right stuff are magnetic. Also, in class, we tested different objects and the metal sink faucet did not attract the magnet but metal paper clips and the metal chair legs did so they must be made of the right stuff."

Remember, learning to use evidence can be improved over the grade 3-5 band. Use what you notice in student work as a formative assessment point. Identify what students are already doing well, attempting, and/or not yet attempting to support in future lessons (when appropriate) or units to help students develop their proficiency in this practice of evidence-based explanation.

Photos from Lesson 7

Student explanation example 1





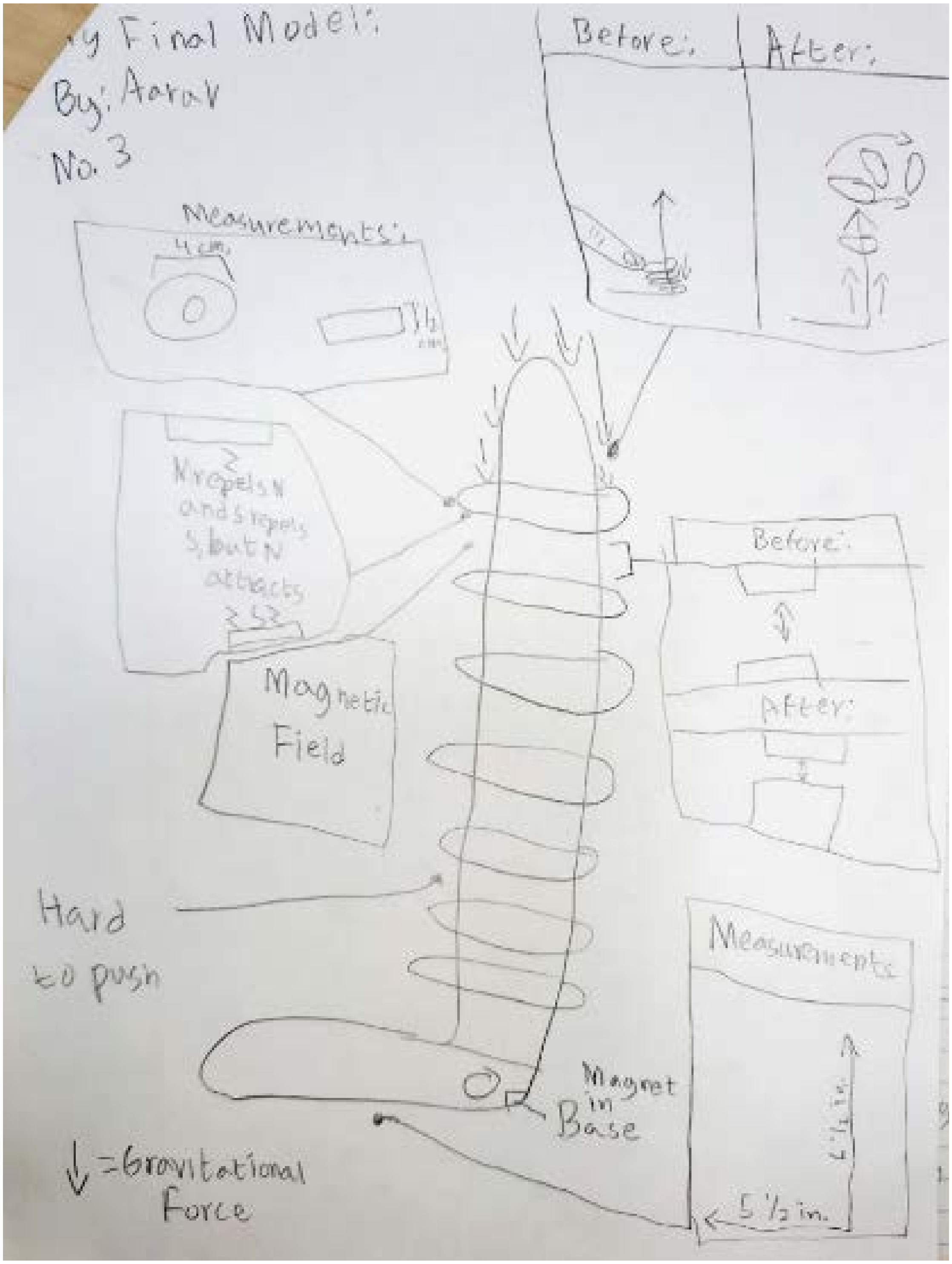
The student wrote:

"So if your teacher gave you a test on magnets, you would need this article. From weeks of Mrs. Bailey's class, you would get through the test easily.
Generals
So the basic question is: What ARE magnets? Magnets can be steel, iron, metal, all of those things that are shiny. That is including your fridge. We are talking about ring magnets. Normal ring magnets are 4 cm wide, ½ cm tall. Our real topic is about gravitational force and magnetic force. Get a toy called "Magnet Match Rings" Unbox it and put it up horizontally [vertically]. It should look squished on the bottom. Put the ring magnet at the bottom of your table. It should still move. That is the magnetic force winning. Then, take a magnet and drop it. That is gravitational force winning.
Advanced
So let's show what is actually happening. There are two poles called N and S. No, not where Santa lives, it is different. North attracts S and same if reverse. But it also repels if N is facing N or S is facing S.

So why it gets squished is because of the weight of gravitational force. Gravitational force holds the magnets from going up into the ceiling. If you hold the magnets vertically [*horizontally*] it gets balanced because gravity cannot go sideways.

Experiment: You will need 30 pieces of paper, 1 ring magnet, and a fridge.

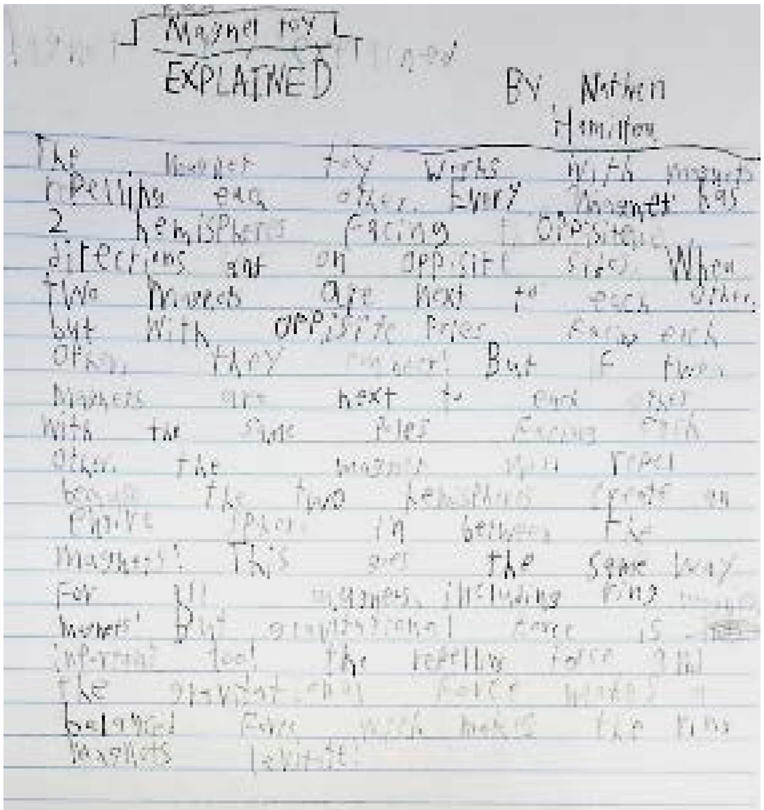
1. Hold the paper on the fridge.
2. Put a magnet on the paper.
3. Does it stick? Try it with different amounts of paper!"

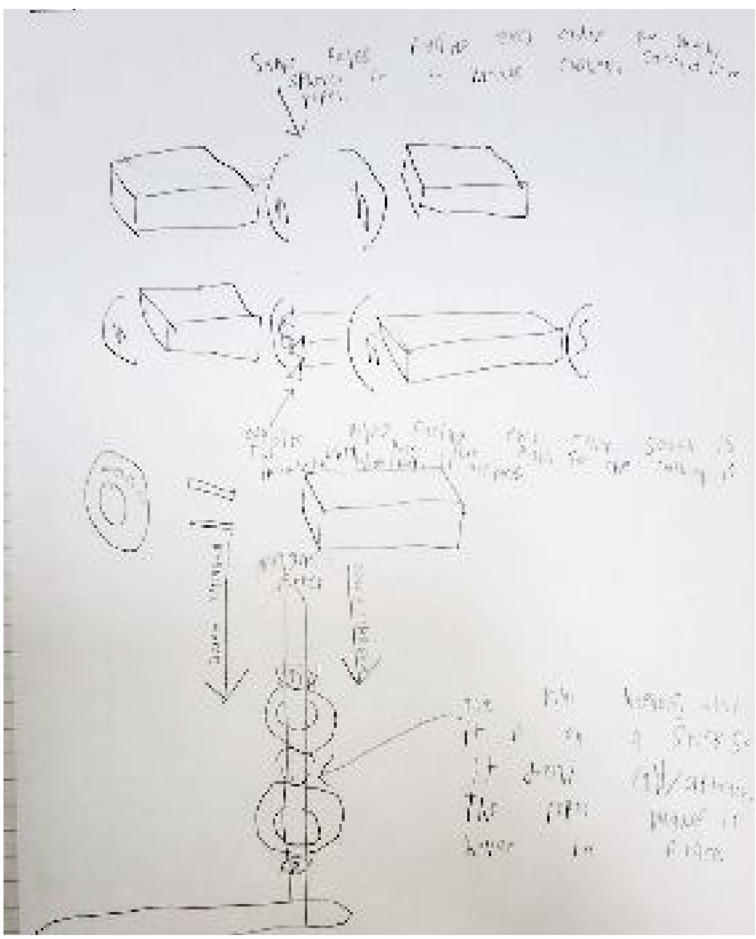


Accompanying model from the example explanation 1 provided on the prior page.

This student (Example 1) demonstrates an understanding of the different forces acting on the magnets (gravitational and magnetic) by including how gravity pulls vertically on the magnets and the magnetic force has to fight gravity to push apart and stay up but the gaps can get smaller. The student uses some evidence in the form of describing what happened with the magnetic ring toy as evidence for the ideas of the forces interacting. The model includes many features with multiple before/after situations, measurements, and captions that are important to this students' explanation.

Student explanation example 2





"Magnet Toy EXPLAINED

The magnet toy works with magnets repelling each other. Every magnet has 2 hemispheres facing opposite directions and opposite sides. When two magnets are next to each other but with opposite poles facing each other, they connect! But if two magnets are next to each other with the same poles facing each other the magnet will repel because the two hemispheres create an entire sphere in between the magnets! [*Is this like a magnetic field?*] This goes the same way for all magnets including ring magnets! But gravitational force is important, too! The repelling force and the gravitational force makes a balanced force which makes the ring magnets levitate."

Accompanying model from the example explanation 2. Descriptive label/captions:

- "Same poles facing each other to make a sphere so it makes a cushion causing it to repel."
- "Opposite poles facing each other. South is the only pole that pulls, so the cushion is incomplete, therefore it attracts."
- "The ring magnets, but it is on a stick so it doesn't fall/attract. The repel makes it hover in place."

This student (Example 2) demonstrates an understanding of how the orientation of magnets changes the magnets motion (together or apart). The student touches on the notion of the different forces acting on the magnets (gravitational and magnetic) and that these forces are balanced (levitate, hover). The student makes an attempt at providing evidence in the form of prompting the reader to try a test with two magnets to experience the poles attracting/repelling. The model includes many ways of showing the attraction and repulsion between magnets, which was a significant idea in this students' explanation.

NOW, WHAT DO WE THINK...

HOW DOES THIS MAGNETIC RING TOY WORK?

Part 1

WHAT HAVE DONE? WHAT HAVE WE LEARNED?

Look over the summary charts and your notebook.

What have we done so far to learn about forces?

What is one important idea we have learned about so far?
What did we do to learn about it?

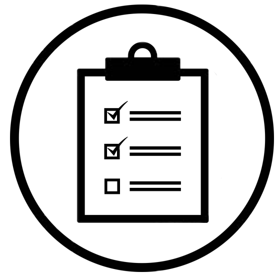
Turn and share with a partner.

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

"GOTTA HAVE" CHECKLIST

What are the important ideas we have got to include to explain how the magnetic ring toy works?

What are some words that might help us?



UPDATE YOUR MODEL & SHOW WHAT YOU KNOW ABOUT FORCES BY EXPLAINING THE TOY

How will you show FORCES and MOTION in your model?

Modeling forces using arrows:
Length = strength
Pointer = direction
Label = description

If arrows show forces, how can you show movement or motion?

Write paragraphs to explain your thinking!

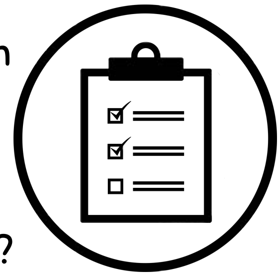
_______ happens when____.
_______ causes_____.
_______ only moves if_____.

I learned this when we...
I know this because...
My evidence for this idea is...

SELF CHECK

Check your explanation so far with the "gotta have" checklist.

- What have you done?
- Could you elaborate more?
- What do you need to add next?



Leave yourself a sticky note of what to work on next.

NOW, WHAT DO WE THINK...

HOW DOES THIS MAGNETIC RING TOY WORK?

Part 2

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CONTINUE WORKING ON YOUR EXPLANATION

Next, I need to... ______________

And then ________________.

Use your sticky note and continue working on your model and explanation of the magnetic ring toy.




GIVING HELPFUL FEEDBACK

Helpful feedback is...

- specific = I know <u>what</u> to do.
- actionable = I can actually do that <u>next</u> or <u>now</u>.

IS THIS FEEDBACK HELPFUL OR NOT?

You drew the magnetic fields in the model.

Do you think magnetic fields are always the same?

Why are magnetic fields important to explaining the toy?

Specific = About magnetic fields in my model

Actionable = I can add more about when magnetic fields are the same or different and why they are important to how the toy works.

GIVING HELPFUL FEEDBACK

Helpful feedback is...

- specific = I know what to do.
- actionable = I can actually do that next or now.

IS THIS FEEDBACK HELPFUL OR NOT?

You have lots of details and labels in your model and you don't have a lot of writing yet. You should add more to your writing.

Specific = Not specific. Very general.

Actionable = I can add more to my writing next but without specifics, this feedback doesn't help me know WHAT to add next.

HELPFUL OR NOT?

Helpful feedback is...

- specific = I know what to do.
- actionable = I can actually do that next or now.

IS THIS FEEDBACK HELPFUL OR NOT?

You should check your work with the gotta have checklist.

ACTIONABLE, BUT NOT SPECIFIC

You wrote a lot but you need neater handwriting.

NOT SPECIFIC TO IDEAS, NOT ACTIONABLE

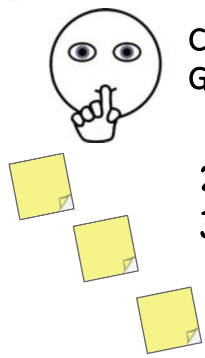
You have 3+ facts about magnets. I agree with what you said.

NOT SPECIFIC NOT ACTIONABLE

Do the arrows on your model show forces like gravity or movement (up/down)? You should make that clear.

SPECIFIC AND ACTIONABLE

GALLERY WALK FEEDBACK



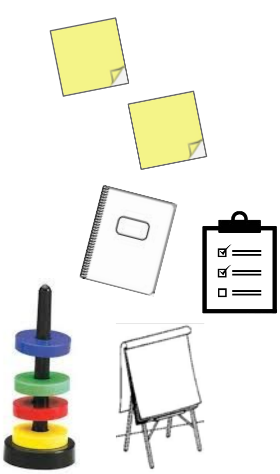
Clear off your desk top except for your model and explanation.
Get a pencil + 3 sticky notes.

1. Choose another desk. Silently read.
2. Leave specific and actionable feedback sticky.
3. Walk around and repeat three times.

Make sure each person has at least 2 notes!

I like how you _________. It would be clearer if you _________.
Add more about ________ because I'm not sure what you mean by______
I disagree with________. What is your evidence that_________?
I agree that____________. Add evidence to tell how you know that_____.

ADDRESS FEEDBACK & FINISH EXPLANATION



How will you show FORCES and MOTION in your model?

Modeling forces using arrows:
Length = strength
Pointer = direction
Label = description

If arrows show forces, how can you show movement or motion?

Write paragraphs to explain your thinking!

_______ happens when____.
_______ causes_____.
_______ only moves if_____.

I learned this when we...
I know this because...
My evidence for this idea is...

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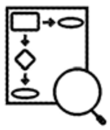
COMPARE: THEN VS NOW

What is one way your thinking changed? What experience helped change your thinking?

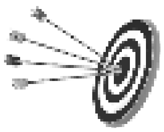
Lesson 8 Collect & Display Data: The Strongest Magnet



Purpose

This three-part lesson walks students through the process of designing and improving a simple test. Each group is tasked with answering the same question, *"Which magnet is the strongest?"* but can do so with different procedures. Groups compare procedures and data. Then, they learn how to create graphs of their data for easy communication.

- Students plan and conduct an investigation collaboratively to produce data that serves as evidence.



Learning Target

Focus question

How do we know which magnet is strongest?

Learning Target

I can work with a group to test the strength of different magnets and collect data.

**You do not need to post a target statement. Instead, pose a question on the board.*

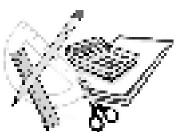
NGSS 3-D

SEP: Plan & carry out investigations
Make observations and measurements to produce data to serve as basis for evidence for an explanation of a phenomenon

DCI: PS2B Types of Interactions Electric and magnetic forces do not require objects to be in contact. The size of the forces depend on the properties, distance apart, and orientation.

CCC *Patterns* *Patterns can help make predictions*

CCSS math connection: Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs.

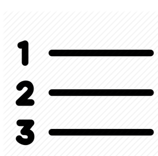


Materials

For the class:
- Lesson Slide Guide (GoogleSlides)
- Chart paper and markers
- *Optional: Practice w/graphs (Slides)*

Per student:
- 1 5"x8" index card
- ruler or straight edge
- Science notebooks
- *Optional: colored pencils/crayons*

On a materials table for groups to use:
- 8 rulers
- string + scissors
- clear tape
- graph paper
- 8 boxes of 100 metal paper clips
- 100 metal, magnetic washers
- various magnets: horseshoe, bar, rectangular, donut (1 set per group)



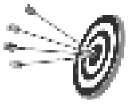
Lesson Step Summary

Part 1: Simple tests for strength
1. **Launch: Orient students to an idea.** Revisit the simple test from L4 and interpret graphs. What does this data tell us? How else can we test for strength?
2. **Explore: Make a simple plan and try it out.** Students work in teams to make and enact a plan to collect evidence of the strength of a magnetic force.
3. **Summarize: Coordinate results of simple tests.** Visit each group to collect class data about which magnet is strongest/weakest. Consider improvements.

Part 2: Improve the test, Compare results
1. **Launch: Orient students to an idea.** How can we improve our tests?
2. **Explore: Improve the plan and try it.** Teams improve their tests. Collect data.
3. **Summarize: Coordinate data & write with evidence.** Visit each group to see improved tests and collect class data. Students write evidence-based claims.

Part 3: Graphing data
1. **Launch: Orient students to an idea.** Showing data two ways, introduce graphs.
2. **Explore: Try out pictograph and bar graphs.** Students graph shared data first and then graph data from their own test.
3. **Summarize: Coordinate ideas about visual displays of data.** Look at student-made graphs. Are there advantages/disadvantages to pictographs & bar graphs?

Part 1: Simple tests for strength



Purpose

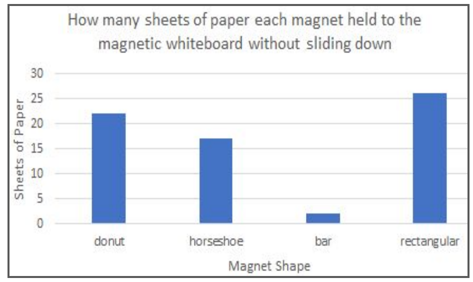
1. Orient students to an idea: *Testable Questions*

a) Tell students that in the next few days they will work together to figure out different ways to test how strong magnets are: *Which magnet is the strongest? How can we tell?*

Analyze data

b) Remind students of the simple test they conducted in Lesson 4, where they used each magnet to hold sheets of paper to a magnetic board. Show students the bar graph (slide 2). Turn-and-talk about what they notice and what they infer from the graph. (Part 3 unpacks graphing.)

Turn and talk



- *What does this graph show?*
- *What can we infer about the strength of each magnet from the data shown?*
- *How many more paperclips did the rectangular magnet pick up that the bar?*
- *How many paperclips were needed for this experiment?*

Share & Discuss

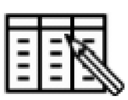
c) Tell students that for this test we inferred strength by how many sheets of paper each magnet held. Brainstorm and share with a partner and/or as a class: *What are some other ways we could show how strong a magnet is if we can use these materials?* (see slide 3).

d) Tell students they will work on groups to design their own test that shows the strength of the magnets. Use the materials available but the data they collect has to be numbers, like counting or measuring.

Teamwork

2.) Collaboratively plan and enact a simple test for a magnet's strength

Students work in teams to develop and enact a simple test to show how strong each magnet is. Each group needs the same set of magnets and use any materials from the material table. Groups jot data and sketch their set-up in their notebooks as they work.



Record Data

i) Each member sketches a plan to test strength. Then, share and discuss as a team to agree on a plan.Teacher circulates and checks to see that students are collecting data with numbers (e.g., measurement/counting).
ii) Once the team agrees on a plan, send a student to get materials.
iii) Conduct your test and see if the data shows which magnet is strongest.

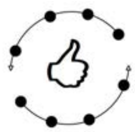
Teacher Move:
Circulate & Notice

Notice: What are students doing in their investigations?

Circulate and notice how students conduct tests. Do you notice successes or challenges in the areas below? No need to intervene right now. Just observe and make note of any examples.This will be used in Part 2.

- **Is the test valid?** Does the test address the question? In this case, are students measuring/counting something that indicates the strength of the magnet?
- **Is the test fair?** Scientists only change one thing (variable) at a time. Are students changing more than just the magnet each trial? Why?
- **Is the test reliable?** Are students trying the test multiple times or not? If so, do they get the same or similar data in each trial?

3.) Coordinate results of simple tests


Gallery Walk

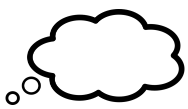
a) Give teams a 5-minute warning to finish testing and prepare a quick 1-minute share-out about their test and results of strongest/weakest.

b) Take the class to visit each team and have each team show their test and their results. This should have a perky pace spending no more than 2 minutes per group. Keep tally marks on the class data table to show the strongest and weakest magnets tested.


Analyze data

c) After completing the gallery walk, gather as a class and look at the class trends on strongest/weakest magnets.

What do we notice? Did each group have the same results?
If so, how could that happen if we had different tests?
If not, how could different tests give us different results?


Think Time

d) Next, look at the paperclip test (slide 6) and tell the class that this scientist, if she did the test again, would tie a string around the magnet instead of holding it with her fingers because maybe each magnet could attract more paper clips if her fingers were not in the way. Tell students they will work on their test to make it better tomorrow. Ask:

What would you change next to improve your test?

4.) Quick Write in Notebooks

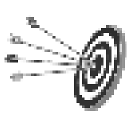

Quick Write

Give students time and space to process what they did and figured out today.

What did you do today? What did you notice?
What were your results?
What would you do differently if you did the test again?

Part 2: Refine the test & compare results

1.) Orient students to an idea: *Qualities of Scientific Investigations*


Purpose


Mini-Lesson


Science Words

a. Tell students that today they will improve their test. To do that, it is helpful to know a few qualities of scientific investigations:

*Scientific tests need to be **valid**, which means the test answers the question. Put another way, the test should match the question. If I had students vote for their favorite magnet shape, would that help us answer our question of magnet strength? No! So, that would not be a valid test for our question about strength.*

*Scientific tests need to be **fair**. This means scientists only change one thing, or one variable, at a time. In our paper test, we changed the magnet and nothing else. We did adjust the number of sheets of paper in response to the magnets' strength, which gave us our data. But we did NOT change the type of paper in the middle of the test—like using cardstock for the rectangle magnet and then construction paper for the donut magnet. That wouldn't be fair and we couldn't compare our results.*

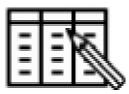
*Scientific tests need to be **reliable**. This means that we get similar results or outcomes each time we do the test. If we did the paper test 3 times, we should get similar results.*


Share & Discuss

b. Examples: Ask students to think about their test from Part 1. Think of an example for each characteristic and briefly share out and/or share examples you observed and noted during Part 1 to illustrate:
   i. **Valid**: __________ *was a valid test for strength because it...*
      Possible response: *Picking up paper clips with each magnet was a valid test for strength because we knew the strongest magnet held the most paper clips so it helped answer our question.*
   ii. **Fair**: __________ *was a fair test for strength because…*
      Possible response: *Our test was a fair test for strength because we only changed 1 thing each time and that was the magnet.*
   iii. **Reliable**: Finally, have students share example(s) or leave them with this as a criteria for today to try your test at least 3 times to see if you get similar results.


Teamwork

2.) Explore: Improve the plan and try it. ***Is your test valid? fair? reliable?***


Record Data

Have students return to the groups they worked with in Part 1 to make improvements to their test and make sure it is valid, fair, and reliable for answering our testable question: *Which magnet is the strongest?*

Tell students to collect data for 3 trials to check if their test is reliable.


Analyze data

3.) Summarize: Coordinate results of simple tests

a) Collect data about strongest/weakest magnet on the class data table.
   (Optional: Gallery walk presentations with 2 minutes per group. Each group shares results and describes how their test is valid, fair, and reliable.)

b) Analyze and discuss the class data table.


Share & Discuss

Does each group have the same results?
  If so, how could that happen if we had different tests?
  If not, how could different tests give us different results?

Were our tests valid, fair, and reliable? How do we know?


Quick Write

4.) Quick Write in Notebooks

a) Before sending students off to write, remind them about claims and evidence. A *claim* is what we know to be accurate or true. Evidence is supporting information that shows how we know what we know.

b) Give students time to process what they did and learned today.
   What did you do today? What did you notice? What were your results?
   Was your test valid? fair? reliable?
   Write an evidence-based claim about magnet strength.

Part 3: Displaying data in graphs

Purpose

Turn and talk

Mini-Lesson

Math connection

1. **Orient students to an idea: *Represent data in graphs***
   a. Tell students that they will be working with the data they collected yesterday about the strength of each magnet *(Each group should have data with numbers, measurements, counts)*.
   b. Show students the paper clip photos for each magnet on slide 16. Ask students to use the images to share an evidence-based claim with a partner. Quickly remind students that a claim is something we think we know to be true and evidence is how we know.
   c. Use slide 17 to introduce *(or review, if students have seen them before in math)* pictographs and bar graphs.
   d. Use slides 18-19 for students to practice graphing the paperclip data. This can be done with quick sketching on whiteboards or paper. Then have them compare with a partner.
      - *Does your graph look the same?*
      - Pictograph: *What number did you choose for the key? Why?*
      - Bar graph: *What did you count by on your vertical axis (number line)? Why?*

Display data

2. **Explore: Represent your data in a graph**
   a. Tell students to choose either a pictograph or bar graph to represent their data from their test. Every student in the class will make a graph on a 5x8 index card.
   b. As students finish making their graphs, have them swap with another student and write an evidence-based claim on a sticky note using the data represented in the graph. *(e.g. The graph shows the rectangle magnet picked up 101 paper clips which is more paper clips than any other magnet. So that's why I think the rectangle magnet is the strongest.)*

Share & Discuss

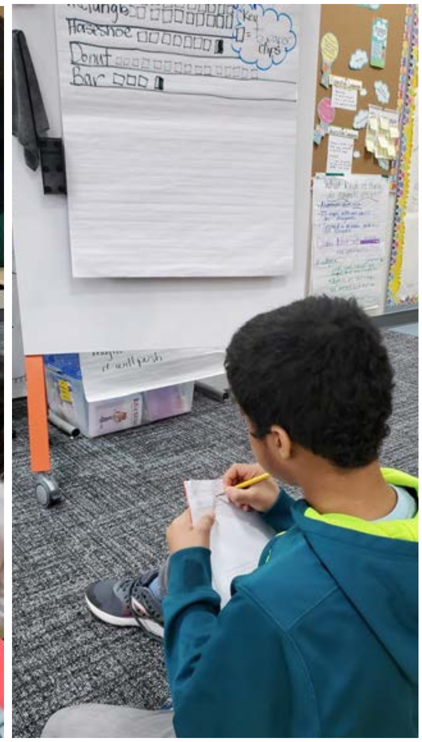
3. **Summarize: Coordinate ideas about visual displays of data.**
   a. Post index card graphs from students on the board. Look at student-made graphs. What do we notice?
   b. Discuss:
      - *Which graph is easier to make?*
      - *Which graph is easier to read?*
      - *Which graph do you prefer, pictograph or bar graph? Why?*

Lesson Closing

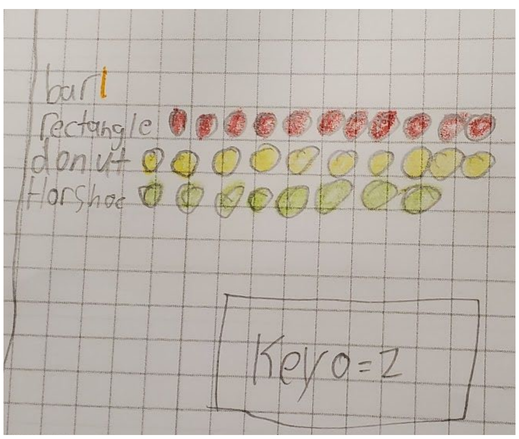
Preview the next lesson telling students they will start planning their own investigations about magnets. Collect index cards if you would like to look at them or have students tape them into their notebooks next to the data they collected yesterday.

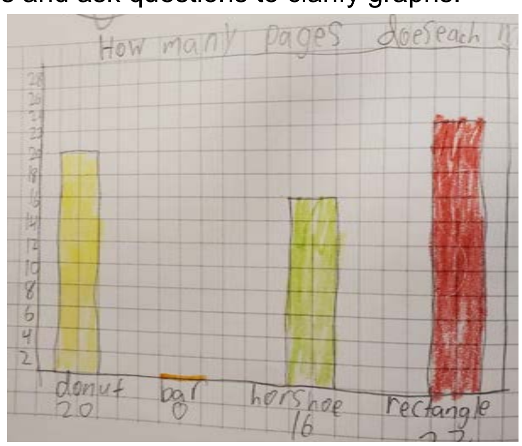
Optional: For more practice with graphs, use the examples on these slides.

Photos from Lesson 8

Students worked as a class to create a bar graph and pictograph for the example data: paperclips held by each magnet as a measure for strength. Then, students graphed their own data from their strength test in bar graphs and then pictographs. Students examine each others' graphs and ask questions to clarify graphs.





WHICH MAGNET IS STRONGEST?

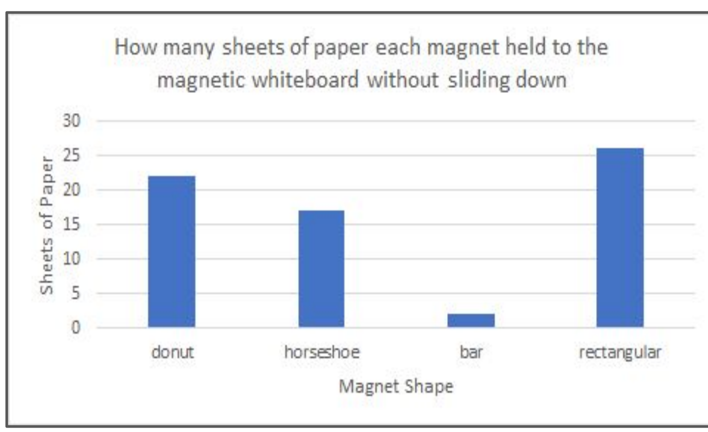
Part 1

1

TEST REVISIT

Ms. Bickford's class tested how many sheets of paper each magnet held to the whiteboard without sliding down.

Here's what they found.



donut horseshoe bar rectangular

WHICH MAGNET HOLDS THE MOST SHEETS OF PAPER? DOES THAT MEAN IT IS THE STRONGEST MAGNET?

2

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

SCIENTIFIC INVESTIGATIONS

Scientific investigations help us answer testable questions.

We can answer other questions with research.

Some questions can be answered with both tests and research!

Our question:
WHICH MAGNET IS STRONGEST?

HOW ELSE CAN YOU TEST A MAGNET'S STRENGTH?


string


tape

ruler



washers

donut

horseshoe

bar

rectangular

magnets


graph paper

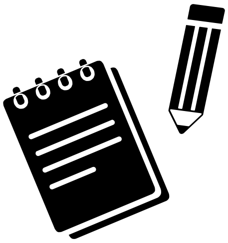

paperclips

Work in a group. Come up with a way to test how strong a magnet is using the materials available. Use numbers (count or measure).

How will you know what magnet is stronger than another?

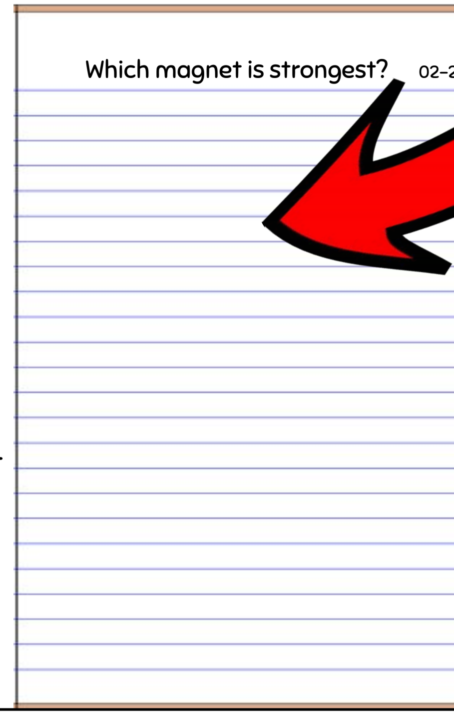
Test each magnet.

- Which magnet is the strongest?
- Which magnet is the weakest?
- What's your evidence? How do you know? Use your data!



NOTEBOOK TIME

1. Open to a new page.
2. Write the title and date.
3. Quickly sketch your test and record your results, if you haven't already..



GALLERY WALK

ANALYZE & COMPARE RESULTS

After you visit each group, quickly mark which magnets each group found to be the strongest and the weakest.

What do you notice and wonder about the class data?

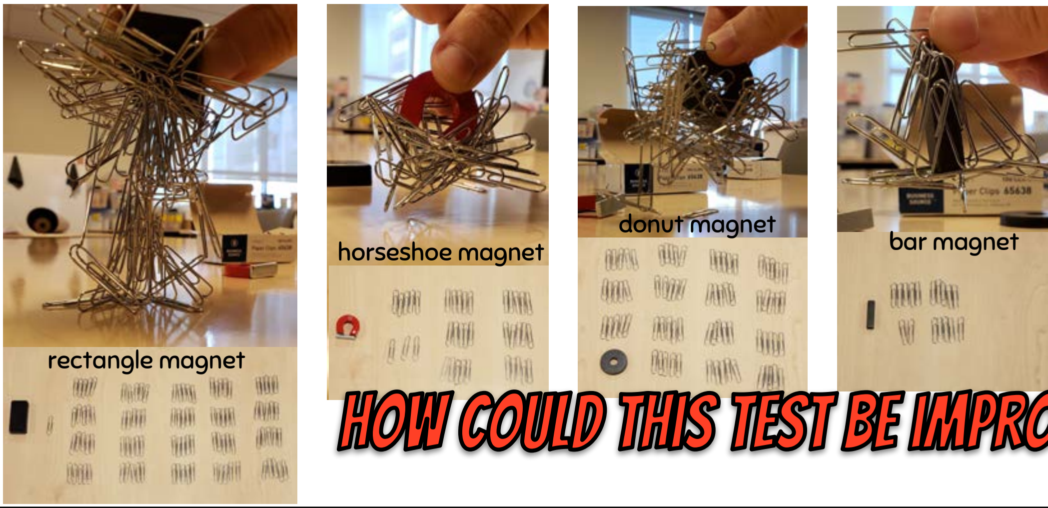
Are there are differences in results, what might explain that difference?

How strong are magnets?

	strongest	weakest
donut		
horseshoe		
bar		
rectangle		

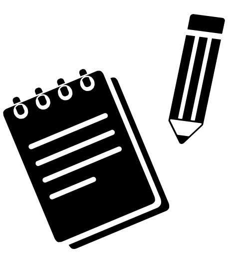
TESTING MAGNET STRENGTH

Dr. Colley decided that strength means how many paper clips each magnet can pick up. So the magnet that picks up the most paper clips is the strongest compared to other magnets tested.



HOW COULD THIS TEST BE IMPROVED?

7



NOTEBOOK TIME

Which magnet is strongest? 02-24-20

On the bottom half, add:

- What else did you notice?
- What did you figure out?
- What are you thinking now?

Helpful Words:

magnet	poles
attract	pull
repel	push
strength	strong

TRY IT AGAIN! WHICH MAGNET IS STRONGEST?

Part 2

SCIENTIFIC INVESTIGATIONS

WHICH MAGNET IS STRONGEST?

Is the test valid?
The test answers the question

Is the test fair?
Only change one thing (variable) at a time.

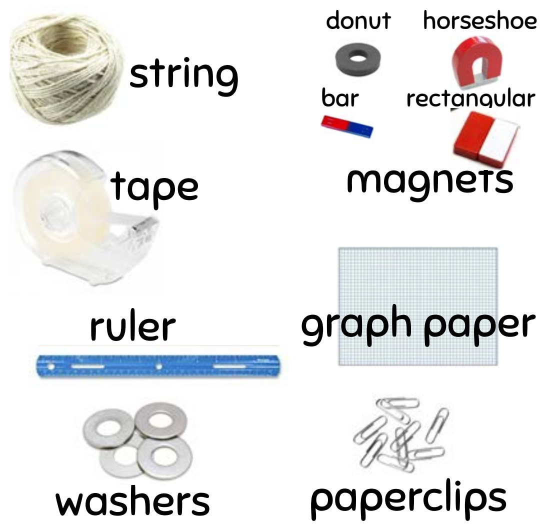
Is the test reliable?
Try it 3 times. Do you get the same or similar data in each trial?

Valid: Does your investigation test for strength? Does it help us figure out which magnet is STRONGEST?

Fair: If you change the magnet, nothing else changes!

Reliable: Do you get similar results on each trial? Did you try it 3 times?

LET'S TRY THIS AGAIN...



Now that you have experience with these materials, you have time to improve or change your test for magnetic strength.

Work in a group. Figure out how you want to test a magnet's strength today.

Test each magnet.

- Which magnet is the strongest?
- Which magnet is the weakest?
- What's your evidence?

11

ANALYZE & COMPARE RESULTS

On the data table, quickly mark which magnets your group found to be the strongest and the weakest.

What do you notice and wonder about the class data?

Any different results between yesterday and today? What might have caused the similarity (or difference)?

How strong are magnets?

	strongest	weakest
donut		
horseshoe		
bar		
rectangle		

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

EVIDENCE-BASED CLAIMS

CLAIM: WHAT YOU KNOW

The _________ magnet is the strongest.

EVIDENCE: HOW YOU KNOW

The ________ magnet [lifted/moved/pushed + numbers] compared to… which is how I know the ________ magnet is the strongest.

SCIENTIFIC TESTS

Valid	test answers question
Fair	one change at at time
Reliable	repeatable results

NOTEBOOK TIME

1. Open to a new page.
2. Write the title and date.
3. Describe your test and what you improved.
4. Write about today's tests. Include a claim with evidence.

CLAIM What you know

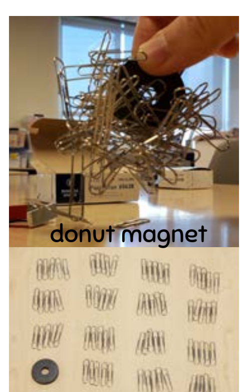
EVIDENCE How you know

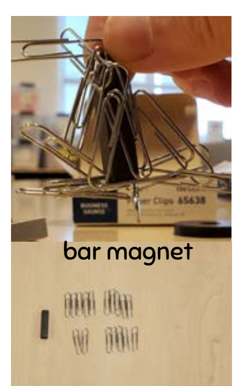
GRAPHING RESULTS: WHICH MAGNET IS STRONGEST?

Part 3

ANALYZE DATA

Dr. Colley decided that strength means how many paper clips each magnet can pick up. So the magnet that picks up the most paper clips is the strongest compared to other magnets tested.

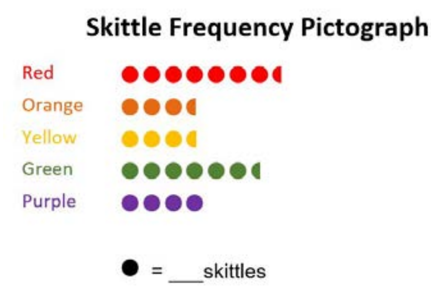




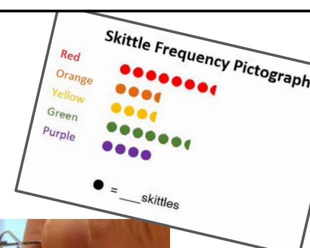
WHICH MAGNET IS STRONGEST?

How can you show data in a graph?

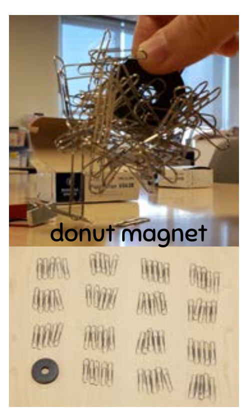
EXAMPLE We count how many Skittles we have of each color we have.
Here is the same data, two ways:



Show this data in a pictograph...

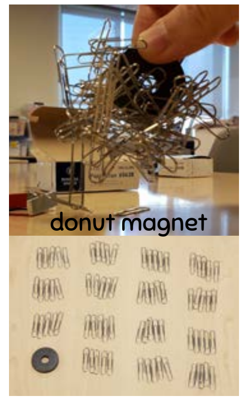


Remember pictographs use a picture to represent a quantity. What quantity will you show with each picture? Why? Sketch out your pictograph.



SHOW THIS DATA IN A BAR GRAPH...

Remember bar graphs have a scale. The scale is a vertical number line (axis) that often skip counts. What will you skip count by? Sketch out your bar graph.



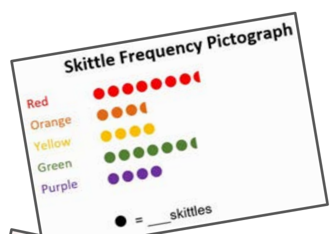
19

NOW, GRAPH YOUR DATA!

Choose how to represent <u>your</u> data from yesterday's test.

1. Will you make a bar graph or a pictograph?

2. Sketch your graph on an index card. Remember labels and a title!



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COMPARE GRAPHS & DISCUSS

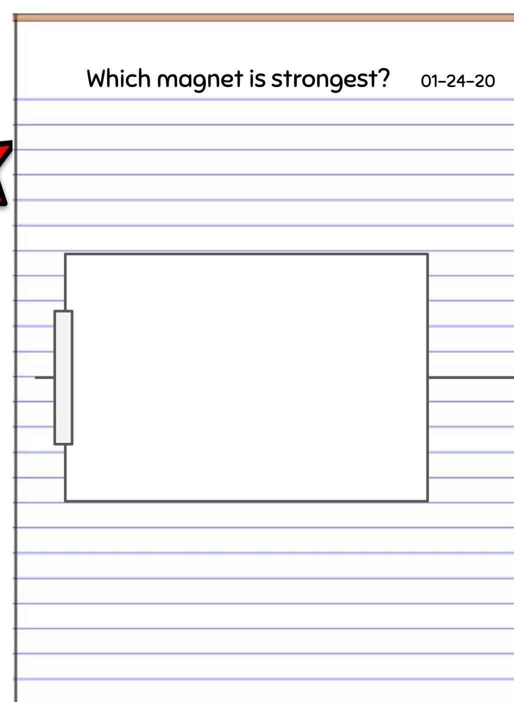
DISPLAY INDEX CARD GRAPHS ON THE BOARD

1. Look across all the pictographs and bar graphs. What do you notice?

2. Scientists choose how they display data in graphs . As a scientist, which graph do you prefer? Pictograph or bar graph? Why?

NOTEBOOK TIME

Tape your index card in your science notebook so that you can lift it to read your writing underneath it.



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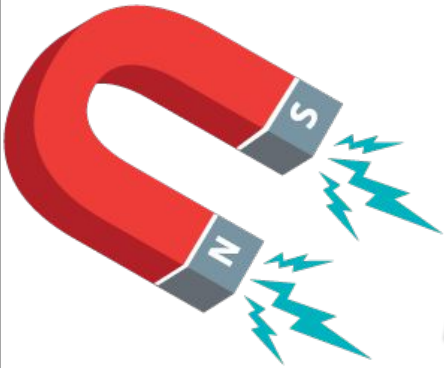


PICTOGRAPH PRACTICE

Task 1: Magnetism Experiments

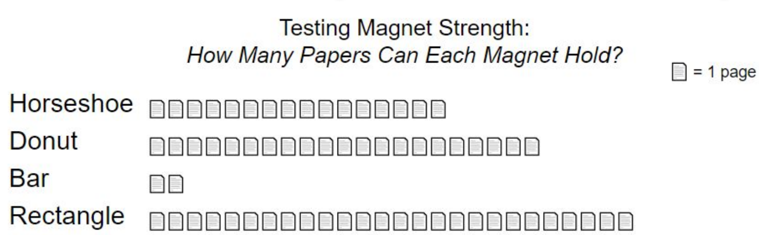
WHAT DO THESE PICTOGRAPHS SHOW?

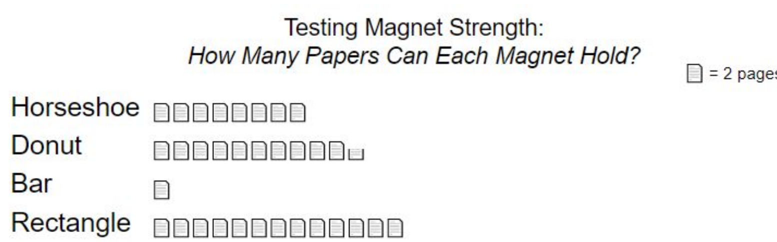
These pictographs show the same data.

What do you notice?

Which pictograph do you like better?

Why?





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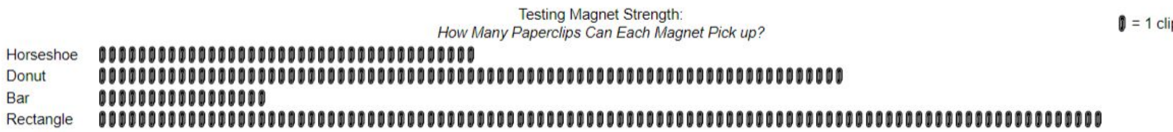
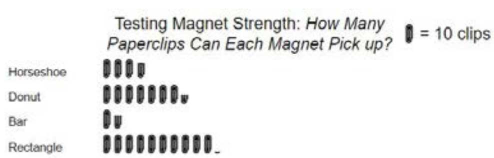
WHAT DO THESE PICTOGRAPHS SHOW?





This is the data table from the experiment.
Which pictograph do you like best? Why?
Which is easiest for you to read?

Magnet Shape	Number of Paperclips
Horseshoe	38
Donut	75
Bar	17
Rectangle	101

TRY THIS!

This data shows how close the magnet had to get to a paperclip to cause the magnetic paperclip to move to the magnet.

Magnet Shape	Distance pulled (cm)
Horseshoe	4
Donut	7
Bar	1
Rectangle	8

How can we show this data in a pictograph?

CREATE A PICTOGRAPH

Title?

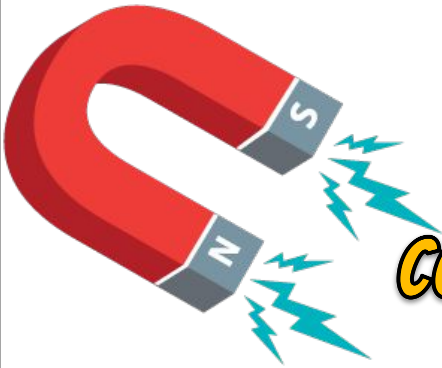
Key?

Horseshoe

Donut

Bar

Rectangle



COMMUNICATING DATA WITH PICTOGRAPHS

Task 2: Solving Problems Using Magnets

TRY THIS! CREATE A PICTOGRAPH

Problem: There are staples on the carpet when teachers change work on the bulletin boards.
Solution: Use a magnet to pick up staples. However, we need a strong magnet so we aren't having to stop clean up to pull off and throw away staples very often. Which magnet should we use?

This data shows how many staples each magnet could pick up and hold without any falling off.

Magnet Shape	Number of Staples
Horseshoe	160
Donut	210
Bar	20
Rectangle	260

How can we show this data in a pictograph?

Title?

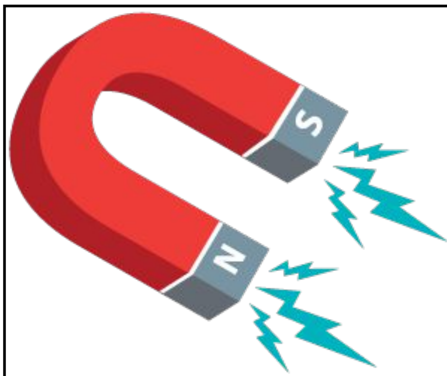
Key?

TRY THIS! FILL IN THE MISSING PIECES

Problem: We decided to pick up staples off the hallway floor using magnets but don't want to be crawling around on the floor.
Solution: We need a magnet that can pick up staples without having to get too close to them and can attract the staple at a distance. Which magnet should we use?

Magnet Shape	Distance pulled (inches)
Horseshoe	6
Donut	9
Bar	1
Rectangle	

What's missing from the pictograph?
What's missing from the data table?



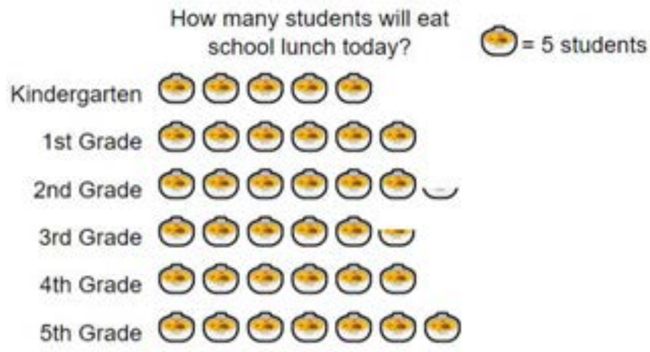
DISPLAYING DATA WITH PICTOGRAPHS

Task 3: Solving Problems Using Magnets

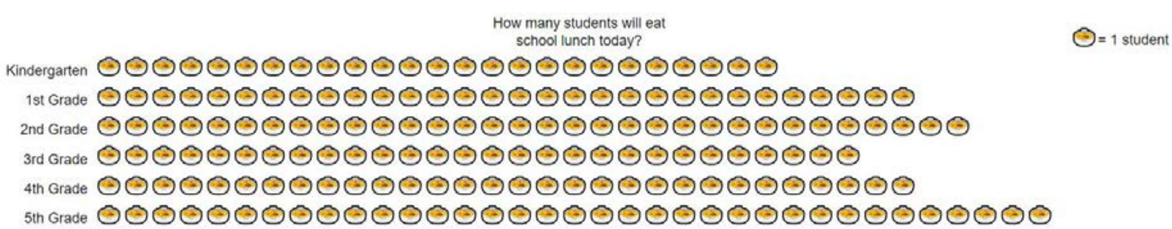
TRY THIS! ANALYZE A PICTOGRAPH

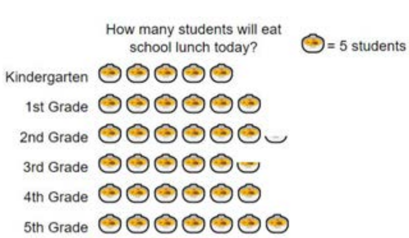
Problem: Ms. Loida in the cafeteria is not getting accurate lunch counts. Without an accurate count, she has to make food during lunch which makes the lines longer and slower.

Solution: Each student has a magnet and moves it under “home lunch” or “school lunch” to take an accurate school lunch count. Then, the classes in a grade level combine their data to display it on a pictograph outside the cafeteria.



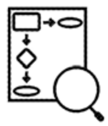
TRY THIS! CRITIQUE A PICTOGRAPH





This is the data from the grade level lunch counts.
Which graph do you prefer? Why?
Which graph is easier to read and understand?
Which graph is easier if you had to make it? Why?

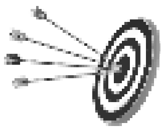
Lesson 9 Conducting Simple Tests with Magnets



Purpose

This lesson walks students through the process of designing and conducting their own simple test with their group and publishing their results.

- Students plan and conduct an investigation collaboratively to produce data that serves as evidence to answer their questions.



Learning Target

Focus question

What else do we wonder or what to know about magnets? What can we do to answer our questions?

Learning Target

I can work with a group to design an experiment to answer our question.

**You do not need to post a target statement. Instead, pose a question on the board.*

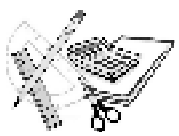
NGSS 3-D

SEP: Plan & carry out investigations Make measurements to produce data to serve as basis for evidence for an explanation

DCI: PS2B Types of Interactions Electric and magnetic forces do not require objects to be in contact. The size of the forces depend on the properties, distance apart, and orientation.

CCC Patterns *Patterns can help make predictions*

CCSS math connection: Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories.



Materials

For the class:

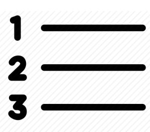
- Lesson Slide Guide (GoogleSlides)
- Chart paper and markers

Per student:

- graph paper
- Science notebooks
- *Optional: colored pencils/crayons*

On a materials table for groups to use:

- 8 rulers
- string + scissors
- clear tape
- graph paper
- 8 boxes of 100 metal paper clips
- 100 metal, magnetic washers
- various magnets, different shapes



Lesson Step Summary

Part 1: Choose a testable question and make a plan

1. **Launch: Orient students to an idea.** Types of questions (testable and research)
2. **Explore: Sort Questions.** Small groups sort sticky note questions to decide which are testable, researchable, or both. Then, discuss the sort as a class.
3. **Summarize: Cluster themes, select, and draft.** Group testable questions by theme. Students choose one of interest and draft a plan idea (individually) in NBs.

Part 2: Plan a valid, fair, and reliable test. Preliminary data collection

1. **Launch: Orient students to an idea.** Tests must be valid, fair, and reliable.
2. **Explore: Create a plan and try it.** Teams develop their valid, fair, reliable tests.
3. **Summarize: Evaluate current plans and discuss as a class.** In what way is your test valid? fair? reliable? What might you improve in your test design?

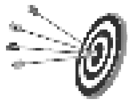
Part 3: Collect data and graph it.

1. **Launch: Orient students to an idea.** Tests must be valid, fair, and reliable. What might we notice as we collect data to show our test isn't valid? fair? reliable?
2. **Explore: Collect and graph data.** Groups improve and finalize their plans and then collect data. Prompt them to make a pictograph and bar graph of their data.
3. **Summarize: Coordinate ideas about visual displays of data.** Look at student-made graphs. Does the graph help answer our testable questions?

Part 4: Publish your results

1. **Launch: Orient student to an idea.** Scientists write with structure.
2. **Explore: Draft an organized report.** Students draft to publish their results.
3. **Summarize: Self-assess your draft.** Have students share what they have tried as a science writer today. (Allow additional time to complete the draft. If desired, add days for peer feedback and/or revisions to polish a final draft.)

Part 1: Choose a testable question & draft a plan


Purpose

1. Orient students to an idea: *Types of Questions, Testable vs Research*

a) Tell students that they will work collaboratively to answer questions about magnets. Have students take a few moments at their desks to jot questions about magnets and magnetism -- Each question gets its own sticky note. Leave sticky notes and come to the carpet.


Mini-Lesson

b) Tell students that they will have the next few days to create their own investigations so they need some testable questions to answer. Remind students about the difference between testable questions and researchable questions using the examples on the slides: *Scientific investigations help us answer **testable** questions. We can answer other questions with **research**. Some questions can be answered with both tests and research! There are some questions that are **testable**, however, we might not have the right equipment, time or money to do the test. Therefore, we have to use **research** to learn from the work other scientists have done.*


Science Words

c) Use a combination of think time, turn-and-talk, and sharing out to talk through if the example questions provided on the slide:
   i) *"Do magnets work underwater?"* This question is testable given the materials we have available (TESTABLE). However, students could argue that we could research to see if anyone else has done this experiment to see if our results match (so, 'both,' is aso a reasonable categorization).
   ii) *"Are all metals magnetic?"* This question is testable given materials we have available (TESTABLE); however, since we don't have every metal in the world in our classroom, we would benefit to do some research to obtain information to add to our data. (BOTH).
   iii) *"What's the strongest magnet in the world?"* Since we only have a limited sample of magnets in the classroom, this question would be best answered by doing some research (RESEARCHABLE).


Share & Discuss


Teamwork

2. Explore: *Sort Questions*

a) Have students return to their table groups to read each sticky note question and decide what kind of question it is. Sort the sticky notes into 3 groups: testable, researchable, or both. (Students may need a fourth pile for "not sure yet.")


Share & Discuss

b) When completed, bring the sticky notes to the front and put them on the board under the headings: *testable*, *both*, *researchable*, and *not sure*. Look over the sort and quickly discuss any "not sure" questions as a class.


Quick Write

3. **Summarize: Select a testable question and draft a plan.**

Quickly group or cluster the testable questions sticky notes by topic or theme. Have students choose one of interest and draft a plan idea (individually) in their notebooks. This will let them bring something to their groups tomorrow in Part 2. *(NOTE: Jot down what each student is interested in to make groups for Part 2, grouped by interest.)*

Part 2: Plan a valid, fair, and reliable test.

Purpose

1) Launch: Orient students to an idea. Tests are valid, fair, reliable.

a) Tell students that today they will begin testing to see if they can answer their questions from part 1. To do this, students need to make sure their tests are valid, fair, and reliable. Quickly, remind students that experiments should be valid, fair, and reliable.

*i) **Valid**: The test answers the testable question.*
*ii) **Fair**: We can only change one thing at a time in a fair test.*
*iii) **Reliable**: The data from each trial is similar so we can trust it.*

Science Words

b) Work through the example on the slide as a class before sending the groups to design their tests. Use a combination of turn-and-talks and whole class discussion to reason about if this test is valid, fair, and then reliable just using the description and data table.

Mini-Lesson

EXAMPLE McKayla, Alisha, and Thomas are testing magnetic strength of four different magnet shapes using paper clips and washers.

washers paperclips

Examine their data table.

Magnet Shape	Trial 1	Trial 2
Horseshoe	44 paper clips	42 paper clips
Bar	17 paper clips	15 paper clips
Donut	37 washers	35 washers
Rectangle	35 washers	70 washers

Is the test valid?
The test answers the question

Is the test fair?
Only change one thing (variable) at a time.

Is the test reliable?
Try it 3 times. Do you get the same or similar data in each trial?

What feedback do you have for this group to improve their test?

Turn-and-Talk

Share & Discuss

Possible student responses: Note that students might see how validity, fairness, and reliability are connected or related.

- *The test is **valid** because it does test strength BUT it is **not valid** because we can't really answer the question because they used paper clips and washers so we can't tell for sure which magnet is strongest.*
- *The test is **not fair** because they changed the magnet type and the items they picked up.They should choose paperclips or washers, not both.*
- *The test is **not reliable** because they did not get similar data for the rectangle magnet, 35 and 70 are pretty different numbers. They should do another trial to have three numbers to compare to see if data is similar.*

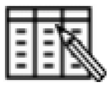
Teamwork

2) Explore: Create a plan with your group and try it.

a) Students work in groups based on interest in a testable question from Part 1. They bring their notebooks where they jotted ideas at the end of part 1 to use in discussion with a group to make a plan for their test. Once a team feels like they have a reasonably solid plan, ask students to raise their hands for a teacher check-in before getting materials. *(Note: Students may not know if their plan will work until they try it, but they should agree on a first draft before getting materials to try it.)*

Experiment

b) Groups make adjustments to their tests as they make attempts to collect data. As they work, circulate and ask groups how they know if their data will be…
   i. ...valid? How will this data answer your question?
   ii. ...fair? How do you know the data is fair?
   iii. …reliable? How will you know if your data is reliable?



Record Data

c) Groups can record preliminary data; however, some groups may still be revising their test procedure. Tell students that they can take some data today but they will have time to do their official test and collect their "real" final data tomorrow.

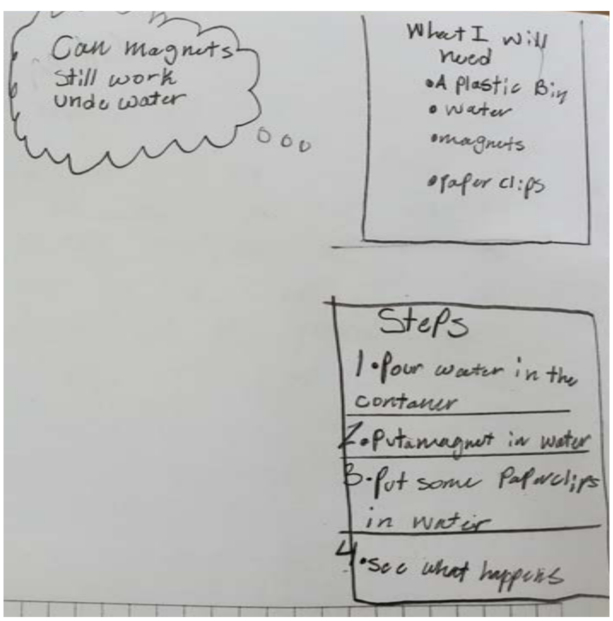
Share & Discuss

3. Summarize: Evaluate current tests for validity, fairness, and reliability.

Have groups share out to the class how they think their test is valid, fair, and/or reliable. They can also share stuck points where they fixed something to improve their test to make it valid, fair, or reliable. This could be done in a Hands-Down Discussion circle (student-led) where students summarize their test and justify how it is valid, fair, or reliable.

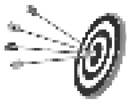
Students should leave today with a solid idea of any changes they still need to make to their test because tomorrow they will collect their "official" data.

Example from Part 2



This group was interested in seeing if magnets attracted underwater ("Can magnets still work underwater?") Their original plan was using a plastic bag but after discussing it together decided an empty container would be better because a bag of water might spill and make a mess. At one point in their design process, the group didn't have a way to measure or count any data but had a plan to make a "yes/no" data chart and test all the magnets in the materials box. Then they decided to attract paper clips and they could count those. The teacher suggested they do the same test on 'dry land' to compare so they really could see if water affected how magnets worked.

Part 3: Collect Data and Create Graphs

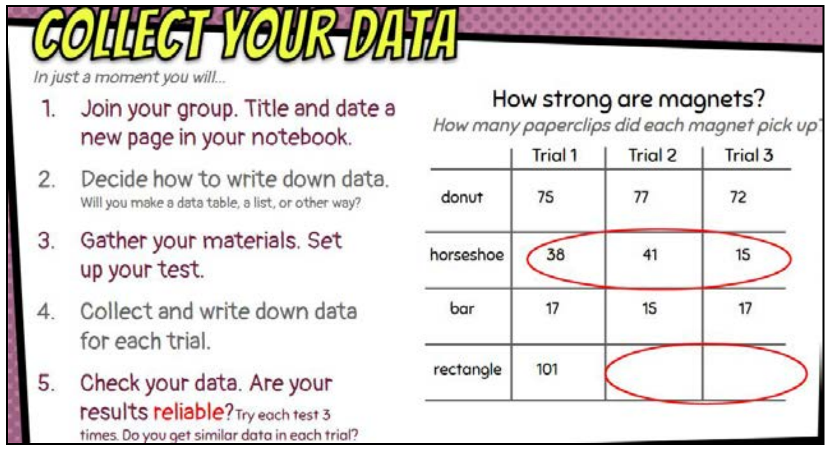


Purpose

1.) Launch: Orient students to an idea. Tests are valid, fair, and reliable.

Tell students that today they will perform their tests and collect their “official” data. Remind students that scientific tests must be valid, fair, and reliable. In particular, as they collect data today, what might be evidence that their test is **reliable** or not? Use the example in the slides to talk about reliability briefly.

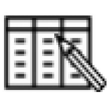
Mini-Lesson



We know data is **not reliable** if…

- We don’t have at least 3 data points for each test. Multiple numbers for one test makes it possible to compare and determine if the numbers are similar or not. *In the example, there is missing data from the rectangle magnet. With only one result of 101, we can’t be sure if this is a reliable result.*
- If we do have 3 data points for a test, the numbers should be close or similar. If not, then the data is not reliable. If the numbers are really far apart, that signals that something in the test might need to be revised. *In the example, the horseshoe magnet picked up 38, 41, and then 15 paper clips. What happened during these tests that might explain the difference? The scientists can redo the test to see if results are closer to 40.*

Experiment



Record Data

Display Data

2.) Explore: Groups perform tests, collect data, and graph results.

a) Groups make adjustments to their tests and collect their official data. As groups work, circulate and see how groups and students are deciding to record data. Ask students about the data they have recorded so far. How do they know their test is valid, fair, and reliable?

b) Once groups collect data, they create a pictograph or bar graph of their data to show their results. Depending on the needs of the class, students could work on this:
- Individually with some support from their team/group. Encourage students to help each other and offer help if someone looks stuck.
- Most of the class works individually, and the teacher pulls a small group of students who are having trouble getting started to work with them in a more guided practice way.
- Create graphs as a whole-class guided lesson. Students might be comfortable making bar graphs on their own, but may need a mini-lesson for creating pictographs (or vice versa, for whichever graph seems tricker for students to create).

Share & Discuss

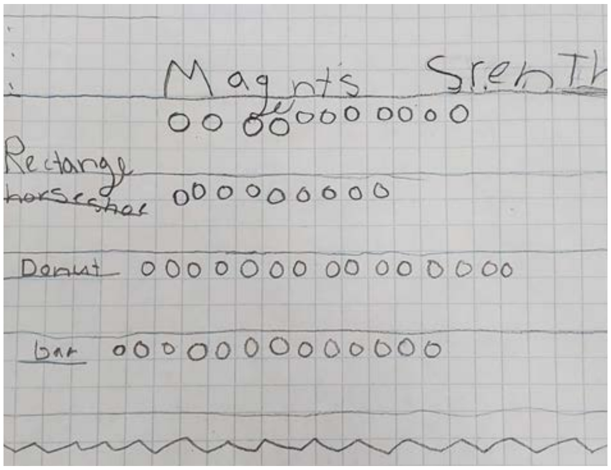
Math Connection

3. Summarize: Coordinate ideas about visual displays of data.

Write each testable question on the board and have at least 1 student from each group post their graph on the board under their testable question. Discuss test results to reflect on how each group did on having a valid, fair, and reliable test (valid and reliable might be the most obvious from a graph).

As time permits or as an extension into a math lesson, zoom in on one graph under the document camera and ask questions (or have students ask questions) about it. Ask questions that require one- and two-step "how many more" and "how many less" problem-solving using information presented in bar graphs or pictographs.

Examples from Part 3



Students created bar graphs and pictographs of their data then got feedback from their peers. In the pictograph above, group members suggested this scientist add a key to tell the reader what each circle represents. On other graphs, common feedback included things like labels for the graph to tell the reader what the numbers mean and a graph title. Other comments were about accuracy of graphing (e.g. the data table said 17 but the bar only went to 15).

Step 4: Publishing Scientific Work

Teacher Decision Point

The slides for this lesson and the plan below are geared towards a robust writing task of a scientific paper, around 3-4 pages plus graphs students made in Part 3. This will likely take 2-3 days, depending on if you include time for peer feedback. It is a nice way to review essay writing using evidence. Alternatively, students could write a conclusion paragraph (1 day) with an intentional focus on identifying claims and evidence (use slide 30 to show claims and evidence examples).

Purpose

Mini-Lesson

1. Launch: Orient students to a new idea. Scientists write with structure

a.) Tell students they will decide how their evidence answers their testable question and will have time to publish what they figured out from their investigation.

b.) *Clarify purposes for writing*: Remind students that there are different kinds of science writing. Some writing is for processing new ideas and just for our own thinking. Other writing is formal and shared with others.

c.) *Examine the organization of a mentor text:* Use the slides to show the anatomy of a formally published scientific paper from the Journal of Applied Physics. Students might make connections to how they have structured and organized writing with different headings themselves.

It might sound like this:

You've collected and displayed data to answer your testable question, so today you'll have time to communicate what you figured out with others. Scientists do this by publishing.

There are many reasons why scientists write. Scientists jot notes everyday about their ideas or their data in notebooks to help them think. This writing is not shared with others and is similar to what you do as scientists during our quick write at the end of our science lessons.

Another type of writing scientists do is a formal, structured essay which they publish so other scientists learn from their work. This writing is organized into sections. Each section has a purpose to help the reader understand something about their investigation (see slides to quickly review sections and purpose)

Your job today as scientists is to try this structure and write about the investigation you did with your group.

Science Writing

2. Explore: Draft an organized report.

Send students off to get started drafting their manuscripts.

Teacher Move: Circulate & Notice

- **Is a student stuck getting started? Provide a suggestion.** Suggest that students choose which section to draft first and then can put the sections in order. It might be easier to get started with the procedure because it is retelling what they did in their test, move to results, then other sections.
- **Notice and confer where needed.** Do some conferring with students to keep them focused on moving their writing forward. Jot notes on areas of need and also examples of how students are achieving the purpose of a section (e.g. an introduction where the author is really careful to not include *everything*).

Think Time

3. Summary: Self-assess your draft.

Have students read what they have written so far:

- *What did you try today? What part makes you feel proud?*
- *What's one way you helped your reader understand your investigation?*
- *What is one next step for you in your writing?*

Extension: Analyze student writing & provide feedback

Teacher Decision Point

At the end of writing time today, look over student writing (in-progress) and notice what students are doing in the introduction, results, and conclusion. Consider which section might be a good focus for a mini-lesson tomorrow as students continue work and begin to reread/revise.

- **Introduction**: *Are students writing EVERYTHING they know or NOTHING because they aren't sure what to include?* Note how students tackle the introduction. This could be a mini-lesson tomorrow before students resume drafting and begin revising. Students either write *everything* they know about magnets or they do not write *anything* because they are not sure what should be included/excluded for the reader. Students can use their testable question to help filter information. For example, if their testable question was about a magnet's strength, sort what you know about magnets and see what ideas help explain strength. Knowing that that earth is a big magnet is likely not closely related to a small magnet's strength so that fact would not need to be included.
- **Results**: *How are students writing about their data?* Often students have no problem writing about what they did (procedure) but can be overly specific in their results, listing every single data point. Something students could try instead is a summary of the data which includes the high point, low point, and a description of a pattern or trend in the data. Results can also include statements about the tests reliability or fairness so that the reader can trust the data.
- **Conclusion**: *Are students writing a lot of claims without evidence in the conclusion?* Students may be quite proficient at sharing their ideas and their current thinking to answer their question but are not yet including specific evidence to support their claims. This could be another option for a mini-lesson tomorrow to target students to focus on how they are including evidence in their conclusion.

Extend & Follow-up

Begin tomorrow's science time with a mini-lesson on one of the sections above (see slide for example revision as a mentor text). If you can't decide on a section to target, start with the conclusion because students wrote claims with evidence earlier in the unit and this can continue that learning now.

Mini-Lesson

Additional extensions could include peer feedback about a specific section (the section targeted in the mini-lesson, for example, the claim-evidence writing in the conclusion). Can you find your partner's claims? What are they? What evidence does your partner provide for these claims? What might they add or change to convince the reader their claims are true or accurate?

Examples from Part 4

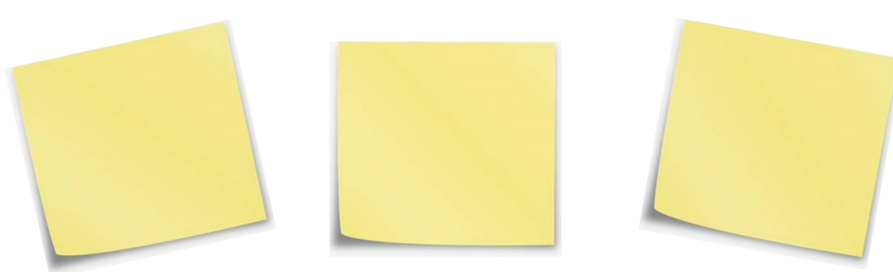
WHAT ELSE DO YOU WONDER ABOUT MAGNETS?

Part 1

MORE QUESTIONS!

What else do you wonder about magnets?

Write each question on a NEW sticky note.



donut horseshoe bar rectangular

SCIENTIFIC INVESTIGATIONS

Scientific investigations help us answer testable questions.

We can answer other questions with research.

Some questions can be answered with both tests and research!

Note:

Think about "testable" given our time, money, and materials that we have available to us.

Some questions are testable but because of our time, money, or material constraints, we can't do the test. Then, we can find answers from reading about other people's experiments (researchable).

TESTABLE, RESEARCHABLE, OR BOTH?

Is the question testable, researchable, or both? Discuss and justify your claim.

Do magnets still work underwater?

Are all metals magnetic?

What's the strongest magnet in the world?

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

SORTING OUR QUESTIONS

Testable
I can plan and design a test to collect data to help me answer my question.

BOTH

Researchable
I can read books, watch videos, or find articles to help me answer my question.

Not sure?
Place your stickies here →

5

IDENTIFYING Q'S

Testable
I can plan and design a test to collect data to help me answer my question.

What are our clusters or themes of questions?

Write a testable question for each cluster of sticky notes.

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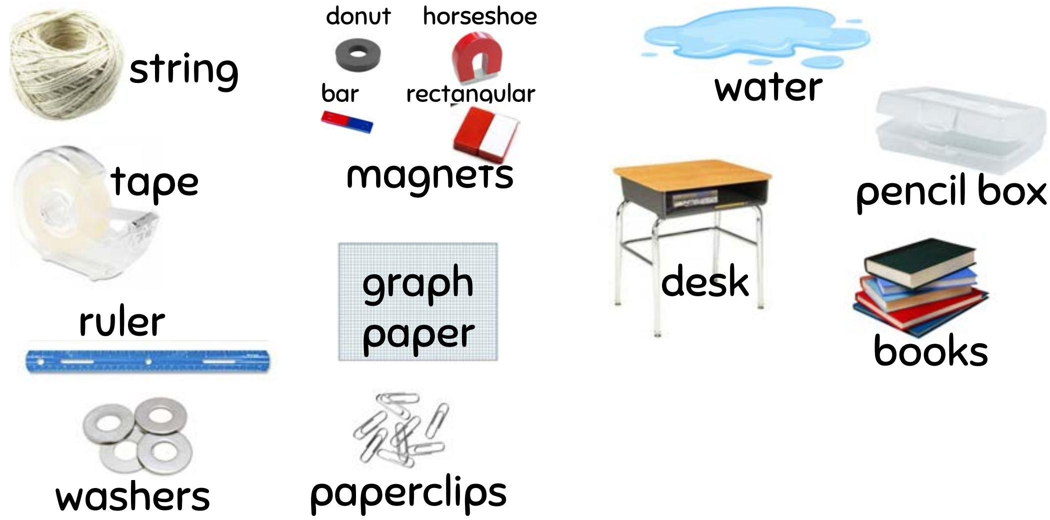
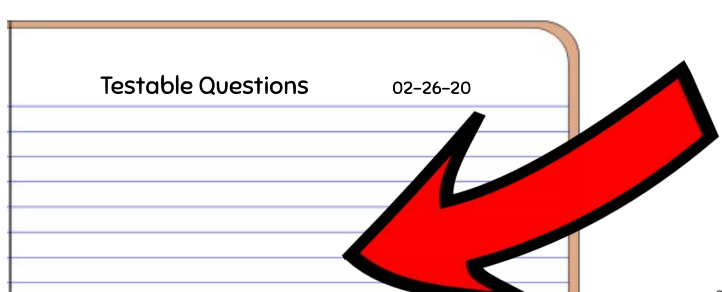
Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

MATERIALS: WHAT ELSE MIGHT YOU NEED?

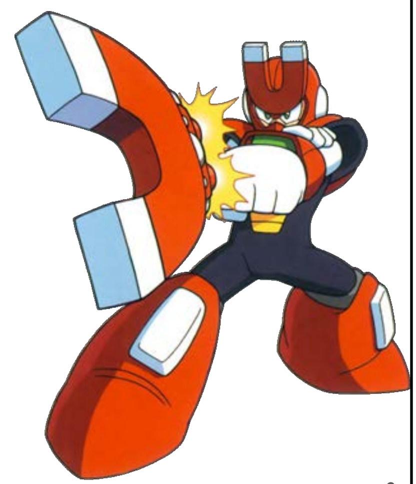


NOTEBOOK TIME

1. Choose a testable question that interests you.
2. Title and date a new page in your notebook. Write your testable question.
3. Sketch and draft a plan for how you might do an experiment to answer that question.



HOW WILL YOU ANSWER YOUR TESTABLE QUESTION?



Part 2

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SCIENTIFIC INVESTIGATIONS

Is the test valid?
The test answers the question

Valid: Does your investigation help you answer your question?

Is the test fair?
Only change one thing (variable) at a time.

Fair: If you change the magnet, nothing else changes! Or keep the magnet the same, but change 1 other thing!

Is the test reliable?
Try it 3 times. Do you get the same or similar data in each trial?

Reliable: Do you get similar results on each trial? Did you try it 3 times?

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SCIENTIFIC INVESTIGATIONS

EXAMPLE McKayla, Alisha, and Thomas are testing magnetic strength of four different magnet shapes using paper clips and washers.


washers


paperclips

Examine their data table.

Magnet Shape	Trial 1	Trial 2
Horseshoe	44 paper clips	42 paper clips
Bar	17 paper clips	15 paper clips
Donut	37 washers	35 washers
Rectangle	35 washers	70 washers

Is the test valid?
The test answers the question

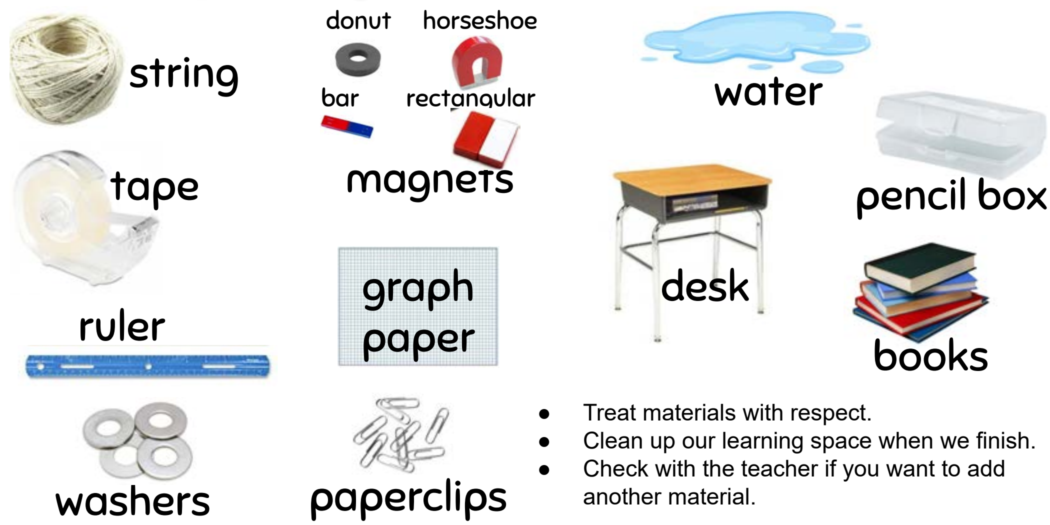
Is the test fair?
Only change one thing (variable) at a time.

Is the test reliable?
Try it 3 times. Do you get the same or similar data in each trial?

What feedback do you have for this group to improve their test?

SCIENTIST TEAMS

REMEMBER OUR MATERIALS



- Treat materials with respect.
- Clean up our learning space when we finish.
- Check with the teacher if you want to add another material.

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MAKE A PLAN WITH YOUR TEAM

1. Share your ideas from yesterday. Make a plan as a team to collect data to help you answer your question. *Data for this test needs to be numbers like measuring or counting something.*

2. Make sure your plan for your test is:
   - Is the test valid? The test answers the question
   - Is the test fair? Only change one thing (variable) at a time.
   - Is the test reliable? Try it 3 times. Do you get similar data in each trial?

3. When you have a solid draft, raise your hands so the teacher can approve or give feedback before gathering materials.

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Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

TRY YOUR PLAN. MAKE IMPROVEMENTS!

MATERIALS

- Treat materials with respect.
- Check with the teacher if you want to add another material.
- Clean up our learning space when we finish.

TEST OUT YOUR PLAN

- Does your test work as planned? What adjustments or improvements will you make?
- Is your data valid, fair, reliable? How do you know?

TODAY Make sure your test is valid, fair, and reliable.
TOMORROW You will collect your official data.

NOTEBOOK TIME

If you haven't already...

1. Date a new page in your notebook and write your testable question.
2. Quickly sketch and jot the basic steps to your test in a list or flowchart ("how-to") so that you remember what to do.
3. Write about how you know your test is valid, fair, and reliable.

Is the test valid?
The test answers the question

Is the test fair?
Only change one thing (variable) at a time.

Is the test reliable?
Try it 3 times. Do you get similar data in each trial?

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

COLLECT DATA & GRAPH IT!

Part 3

17

COLLECT YOUR DATA

In just a moment you will...

1. Join your group. Title and date a new page in your notebook.
2. Decide how to write down data.
   Will you make a data table, a list, or other way?
3. Gather your materials. Set up your test.
4. Collect and write down data for each trial.
5. Check your data. Are your results reliable? Try each test 3 times. Do you get similar data in each trial?

How strong are magnets?

How many paperclips did each magnet pick up?

	Trial 1	Trial 2	Trial 3
donut	75	77	72
horseshoe	38	41	15
bar	17	15	17
rectangle	101		

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GO!

1. Join your group. Title and date a new page in your notebook.
2. Decide how to write down data. Will you make a data table, a list, or other way?
3. Gather your materials. Set up your test.
4. Collect and write down data for each trial.
5. Check your data. Are your results reliable? Try each test 3 times. Do you get similar data in each trial?

How strong are magnets?

How many paperclips did each magnet pick up?

	Trial 1	Trial 2	Trial 3
donut	75	77	72
horseshoe	38	41	15
bar	17	15	17
rectangle	101		

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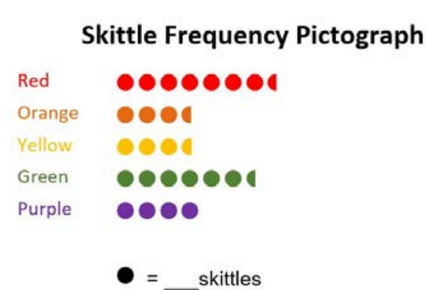
GRAPHING DATA

EXAMPLE We count how many Skittles we have of each color we have.
Here is the same data, two ways:



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Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

NOW, GRAPH YOUR DATA!

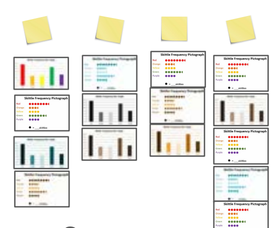
Choose how to represent your data from today's test.

1. Will you make a bar graph or a pictograph?

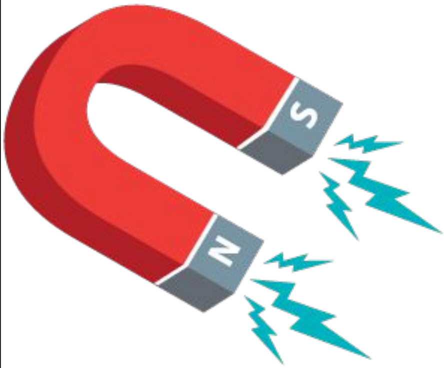
2. Sketch your graph on an index card. Remember labels and a title!

CLOSING: ANALYZE RESULTS

DISPLAY GRAPHS UNDER EACH QUESTION



1. What was challenging about making the graphs?
2. Look across the graphs by question. What do you notice?
3. How does this data help answer the question?



PUBLISHING YOUR SCIENTIFIC RESULTS

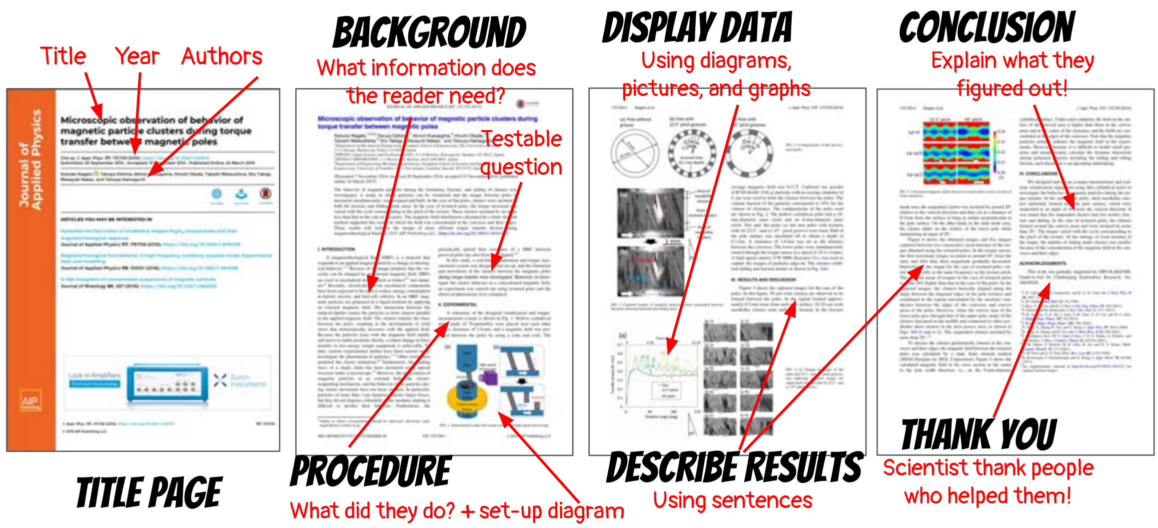
Part 4

SCIENTISTS PUBLISH THEIR WORK

SO WE CAN LEARN NEW THINGS!

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

SCIENTISTS WRITE WITH STRUCTURE



SCIENTISTS WRITE WITH STRUCTURE

TITLE PAGE

Title, Authors, Year

INTRODUCTION

What background information does the reader need to understand your experiment? Also, include the question you are investigating here, too!

PROCEDURE

What did you do in your test?
Write sentences to describe "how-to."
Sketch a diagram to show the test.

DATA AND RESULTS

Include a data table and/or graph of your data.
Describe what happened in sentences.

CONCLUSION

Summarize what you figured out.
CLAIM + EVIDENCE statement

ACKNOWLEDGEMENTS

Thank people who helped you with learning new information, doing the experiment, or helping with improving your science writing.

EXTENSION

WORKSHOPPING PARTS OF A SCIENTIFIC PAPER

INTRODUCTION: BACKGROUND INFORMATION

What background information does the reader need to understand your experiment?
Select information related to your question, not EVERYTHING you know.

What parts help us understand strength?

Which magnet is strongest?

Introduction
Magnets are so interesting. Magnets have north and south poles that help them attract or repel each other. Magnets come in different shapes and sizes but they all have some special metals in them like iron, steel, cobalt. Magnets have a magnetic field around them which is like a zone or distance around them where they can pull paperclips to them. Did you know magnets attract iron powder? We did it in class and it was awesome. Another thing I know about magnets is that the Earth is a big magnet which is why compasses work to point north. And then we learned about how magnets can break by heating them or dropping them. I know this because I read about it. I wanted to know what the biggest magnet in the world was but my group asked which magnet is strongest.

REVISED INTRODUCTION

Which magnet is strongest?

Introduction
Magnets are interesting because sometimes they push each other apart (repel) and sometimes they pull together (attract). This happens because magnets have north and south poles. If opposite poles of two magnets are near each other, the magnets will attract or pull together with a lot of force. When a magnet attracts another magnet, we can feel if it's stronger or weaker by how many magnetic objects it attracts. We used this information to plan a test to figure out which magnet has the strongest pull. Our question was, "Which magnet is strongest?"

RESULTS: WHAT DOES YOUR DATA SAY?

Describe what happened. Share your data (numbers) and graphs. Tell the reader what the data is.

ORIGINAL

Which magnet is strongest?

What parts help us answer the question?

Results

We tested each magnet: rectangle, bar, horseshoe, and donut shapes. It was really hard to keep the paperclips to stop sticking to all the magnets during the test. Paperclips made of plastic wouldn't work. The rectangle had the most.

Magnet	Paperclips
Horseshoe	38, 40, 41
Rectangle	101, 97, 99
Bar	15, 17, 16
Donut	75, 75, 76

REVISED

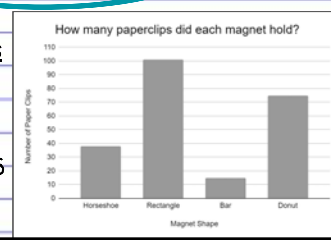
Uses specific data (numbers). Tells high and low data points.

Tells why we can trust the data.

Results

We tested four shapes of magnets: rectangle, bar, horseshoe, and donut. We did our test 3 times to make sure our data was reliable. The rectangle magnet picked up the most paper clips (101 clips). The bar magnet picked up the least (15 clips).

Magnet	Paper clips
Horseshoe	38, 40, 41
Rectangle	101, 97, 99
Bar	15, 17, 16
Donut	75, 75, 76



CONCLUSION

Explain your claims using evidence. Then summarize or recap what you found.

CLAIM + EVIDENCE

ORIGINAL

Which magnet is strongest?

What is the answer to our question? What's the supporting evidence?

Conclusion

The strongest magnet is the rectangle because it had the most paper clips. We tested it so that's how we know. I think rectangle is the strongest because it probably has some special material that has extra magnetic force to make it stronger. I don't think it's the shape or size that causes strength because my cousin has these tiny circle magnets that are super strong. So the size or shape might not cause strength, it is probably the material the magnets are made of that makes one magnet stronger than another magnet. Magnets are in different shapes and sizes and strengths.

REVISED

Which magnet is strongest?

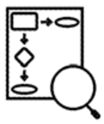
Claim *What we think or know*

Evidence *How we know*

Conclusion

Our experiment found the rectangle magnet was the strongest because it held the most clips. The rectangle is also the biggest so maybe bigger means stronger, but I read, "Bigger magnets are stronger, but not always." So I think what the magnet is made of makes the magnet stronger. My cousin has two tiny magnets that are super strong and they are made from a different metal. So maybe the material caused the rectangle to be stronger. In conclusion, we found the rectangle is the strongest magnet. However, this might not be true if we test more magnets.

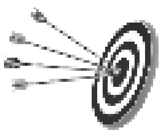
Lesson 10 Solving Simple Problems with Magnets



Purpose

In this lesson, students discuss possible solutions for a few simple problems before brainstorming their own list and developing a solution that addresses criteria and constraints.

- Students use their knowledge of magnetic properties to develop and communicate a solution to a simple problem.

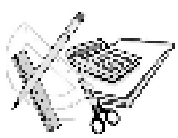


Learning Target

Focus question
How can we use our knowledge of magnetism to solve simple problems?

Learning Target
I can use what I know about magnetism to solve a simple problem and communicate my solution to others.

NGSS 3-D
SEP: Asking Questions and Defining Problems *Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.*
SEP: Constructing Explanations and Designing Solutions *Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.*
PS2.B: Types of Interactions Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depends on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.
CCC: Cause and Effect *Cause and effect relationships are routinely identified.*

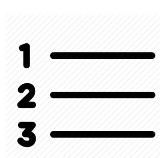


Materials

For the class:
- Lesson Slide Guide ([GoogleSlides])
- Chart paper and markers, sticky notes

Per student:
- Science notebooks

Optional: If students are doing the extension to build and test their solution Materials table:
- *various magnets*
- *other common school supplies (paper clips, rulers, rubber bands, string, etc) that might be used in their design.*



Lesson Step Summary

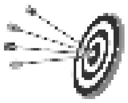
1. **Launch: Orient students to an idea:** *Design criteria and constraints.*
   Today students will use what they know about magnetism to propose solutions to simple problems. Introduce new vocabulary. Use examples provided to step through 3 simple problems, discussing possible solutions and how solutions address criteria and constraints.

2. **Engage: Exploring Solutions:** *Individual planning*
   Brainstorm a list of simple problems as a class. Students pick one they would like to solve and individually develop a plan to solve the problem using what they know about magnets and magnetism.

3. **Summarize: Partner Feedback** *Listen and respond*
   Students pair up and share their designs. Listening students consider how to respond: recap, clarifying questions, offering a suggestion, making comparisons, etc.

Optional Extension: Build, test, and refine designs for the simple solutions
Students prototype (build, test) and refine their designs for these simple problems. They could work in partners/teams particularly if the problem they solved is not feasible to actually build given some constraints like time, cost, materials, location, etc. Once completed, students could present solutions to the class or do an A/B gallery walk (A's stay, B's wander; then switch) to show their solutions to their peers.

Lesson Plan



Purpose

1. Launch: Orient to an idea *Design criteria and constraints*

a) Tell students that today they will get to use what they have learned about magnets to propose solutions to simple problems.

b) Introduce two new science words by telling students that engineers solve problems and they have to work within constraints to address the design criteria to have a successful solution.

Criteria are the rules a good design must follow to be successful.
Constraints are the boundaries or limitations (time, cost, materials).

Science Words

c) Using turn-and-talks and share-outs discuss the 3 simple problems provided in the slides. Provide opportunities to talk about how the possible solutions address the criteria and work within the constraints.

Turn-and-Talk

Possible responses/discussion of sample problems might include:

#1: The lanyard that holds teachers' badges could be replaced with a magnet and piece of iron or steel. One piece of magnetic metal goes inside the badge sleeve with the badge and a flat magnet can be placed on the inside of the shirt to hold the badge onto the shirt.This works because we know magnetic force pulls through different materials. It should be a stronger magnet, not like our weak bar magnets. The magnet needs to be flat or else it might feel uncomfortable to wear.

- *Criteria*: Probably won't damage clothes as long as it's not delicate fabric. It is easy to wear as long as the magnets are not too big or heavy. Badges should stay on the shirt because magnetism can work through things like fabric.
- *Constraints*: A small magnets and piece of magnetic metal are inexpensive so it's under $2. The solution uses magnets. It would be quick to make.

Share & Discuss

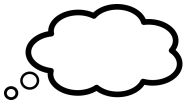
#2: The door that won't shut could be held shut with two magnets. Glue one on the door and one inside the door so that they touch when the door is shut. Make sure to glue them so that opposite poles are facing each other because then the magnets will attract or pull together which will keep the door shut.

- *Criteria*: This solution would keep the door shut as long as the magnets are installed with opposite poles facing each other. If the magnets are small, the strength between the magnet should be easy to pull against with one finger but strong enough to hold the door shut.
- *Constraints*: The solution uses magnets. The cost of two small magnets should definitely be less than $5, especially if the magnets are from the Dollar Store.

#3. One solution to keeping the bag up requires four magnets. Place a magnet on the outside of the trashcan near the top and place the other magnet on the inside of the can, near the top, so that the magnets attract, holding that side of the bag up. Repeat on the other side of the can.This works because magnetic force can pull through different materials like the plastic can and plastic bag.

- *Criteria*: This solution should hold the bag up and is easy to change -- just pull off the magnets before removing the bag.
- *Constraints*: This solution is quick to install, just snap 2 magnets together on each side of the can. It might waste magnets if a magnet falls in the trash. It costs $4 or less because I know the Dollar Store sells magnets.

2. Explore: Brainstorm problems. Pick one. Design a solution



Think Time

a) As a class, generate a list of simple problems that students encounter in their classroom, school, or at home that they think could be solved with their knowledge of magnetism.

If students are having a hard time thinking of problems, here are a few to get started. Add more to this list:

- Pencil box won't stay closed. *(Some pencil boxes are hard to open and close so they could get a new latch. Magnets could also help pencil boxes stay closed)*
- Projector remote or the TV remote is hard to find. *(We never know if the remote is on the teacher's desk, the document camera table, on the whiteboard ledge or sometimes falls on the floor! At home, the TV remote is never in the same place and sometimes it gets lost in the sofa.)*
- We can't hang work in the hallway easily. *(We don't have full bulletin boards in the hallway. How could magnets help us easily display work in the hallway?)*

Quick Write

b) Tell students to pick a problem they would like to solve. Share the criteria and constraints for their designed solution. Give students time to draw and write in their notebooks about the problem and their proposed solution. Remind students to justify how their design meets the criteria and constraints.

Back Pocket Questions

Circulate as students work on designing their solution. Help students get started with their ideas by sketching or writing.

(If you plan to do the optional extension where students build and test their solutions, make note of students who selected the same problem. This will help make groups.)

Back Pocket Questions

- ➔ *Which problem did you choose?*
- ➔ *How can magnets or what you know about magnetism help solve this problem?*
- ➔ *How does your design meet our criteria? our constraints?*

Share & Discuss

3. Summarize: Partner Feedback *Listen and respond to compare solutions*

Students pair up and share their designs. Listening students consider how to respond: recap, clarifying question, offering a suggestion, making comparison etc. These sentence starters can support partner talk:

Student sharing	Student listening and responding
I chose the problem…	I heard you say your solution will…
My solution is…	What's your next step?
The next thing I plan to do is...	I think your solution meets the criteria because it…
	Your solution is similar to mine when...

NEXT DAY ***Optional Extension: Build, test, and refine designs for the simple solutions***

Students prototype (build, test) and refine their designs for these simple problems. They could work in partners/teams particularly if the problem they solved is not feasible to actually build given some constraints like time, cost, materials, location, etc. Once completed, students could present solutions to the class or do an A/B gallery walk (A's stay, B's wander; then switch) to show their solutions to their peers.

USING MAGNETIC FORCES TO SOLVE SIMPLE PROBLEMS

Part 1

CRITERIA & CONSTRAINTS

Solutions to problems must address all the design criteria to be successful.

CRITERIA

What you must do
Requirements
Rules

Solutions must fall within any constraints. Time, cost, and materials are common constraints.

CONSTRAINT

What you cannot do
Limitations
Boundaries

SIMPLE PROBLEM 1

Teachers must wear badges. Many teachers wear their badges on a lanyard around their necks. But the badge hangs and gets in the way when teachers bend over or carry boxes. Teachers need a better way to wear their badges. How could teachers use magnets to solve this problem?

CRITERIA	CONSTRAINTS
Design is successful if it meets all criteria: ❏ Badge must be visible. ❏ Solution cannot damage clothing or badge. ❏ Solution must be more convenient than a lanyard. ❏ Must use magnetism	Limitation or restrictions that constrain our designs ❏ **Cost**: Solution must cost less than $2. ❏ **Time**: Solution must be quick to make. ❏ **Materials**: Solution must use a magnet.

3

SIMPLE PROBLEM 2

A cabinet door in the principal's office won't stay closed. There is nothing in the way pushing it open, but the door keeps swinging open. How could the principal use magnets to solve this problem?

CRITERIA	CONSTRAINTS
Design is successful if it meets all criteria: ❏ Solution must keep the door shut. ❏ Solution must allow door to be opened easily with one finger. ❏ Solution can't be too big. ❏ Must use magnetism	Limitation or restrictions that constrain our designs ❏ **Cost**: Solution must cost less than $5. ❏ **Materials**: Solution must use a magnet.

4

SIMPLE PROBLEM 3

The garbage bag keeps sliding down inside the plastic garbage can. When people throw away trash, it lands on top of the bag instead of inside the bag. The bag won't stay up inside the can. How could we use magnets to fix this problem?

CRITERIA	CONSTRAINTS
Design is successful if it meets all criteria:	Limitation or restrictions that constrain our designs
❏ Must keep the bag open ❏ Must allow the bag to be changed daily (durable) ❏ Must use magnetism	❏ **Cost**: Solution can't be too expensive. ❏ **Materials**: Solution must use magnetism. ❏ **Materials**: Solution can't waste magnets. ❏ **Time**: Must be quick to install.

WHAT PROBLEMS WE CAN SOLVE WITH MAGNETS?

Think about the classroom, school, or home.
What are some simple problems?
Could they be solved with magnets?

Brainstorm and list simple problems. Choose one you want to solve using magnetism.

NOTEBOOK TIME!

Write and sketch in your notebook.

- What is the problem? Describe it.
- How will you solve it? Sketch and write.
- Do you think your solution meets the criteria and constraints?

CRITERIA

Design is successful if it meets all criteria:

❏ Solution must solve the problem.
❏ Solution must be easy to use.
❏ Must use magnetism.

CONSTRAINTS

Limitation or restrictions:

❏ **Cost**: Solution is inexpensive.
❏ **Materials**: Can't waste magnets.
❏ **Materials**: Must use magnetism
❏ **Time**: Must be quick to use or install.

PARTNER SHARE

CRITERIA

Design is successful if it meets all criteria:

- ❑ Solution must solve the problem.
- ❑ Solution must be easy to use.
- ❑ Must use magnetism.

CONSTRAINTS

Limitation or restrictions:

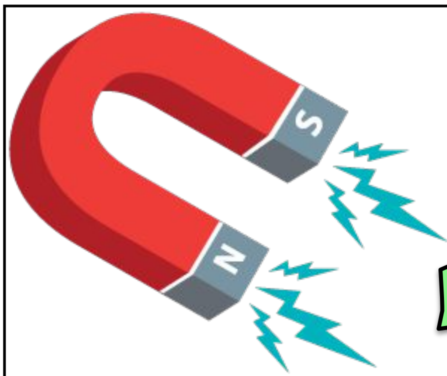
- ❑ **Cost**: Solution is inexpensive.
- ❑ **Materials**: Can't waste magnets.
- ❑ **Materials**: Must use magnetism
- ❑ **Time**: Must be quick to use or install.

SHARE

The problem I chose is...
My solution idea is...

RESPOND

I heard you say your solution is...
Your solution meets the criteria by...
Your solution is similar to mine in that...



TRY OUT YOUR SOLUTION!

Built it! Test it! Improve it!

Does your solution solve the problem?
What improvements do you need to make?
Show your solution to a partner.

OPTIONAL/EXTENSION

	Extensions: More about Magnetism *These extension ideas do not have accompanying lesson plans. Resources are linked below.*	
	Purpose	Questions/Prompts in this Lesson
A	Forces at work: Mysterious Motion 1 day	**Hands-down conversation** Watch the video clip and/or do the demo shown in the video showing motion between a balloon and empty aluminum can. Have students make observations, and then discuss: **Systems**: How is the motion of the can-balloon system similar/different than the motion of a paperclip-magnet system? **Cause-and-effect:** Could the force between the aluminum can and latex balloon be a magnetic force? Why or why not? How do you know? What else would you need to know? Defend your position with evidence from prior activities.
B	The Earth is a Big Magnet 1+ day	**Reading: The Earth is a Big Magnet** What is the main idea of this reading? What does the Earth's magnetic field do for us? What do you think would happen if the Earth was not a magnet? **Video: How Compases Work** Compare the information from the reading and the video: What information is repeated? What is new information? **Hands-on: Make a compass** Follow the video guide to make-your-own compass; Use the thimble to protect fingers while magnetizing the needle. **Video: Magnetizing materials** Examine a model presented in the video of how materials become magnetized. How does this apply to our compasses?
C	Manipulating magnets: Using magnets to store data 1 day	**Video: How Magnets Store Data** What did the video say about how magnets store data? What are some uses for magnets shared in this video? **Discuss: Real-world Problem - Hotel Card Key** How do you think the magnetic strip on the card key works? What would help keep the card key working? **Extension: Make a Binary Bracelet** What patterns do you notice about the binary alphabet? If we added another letter to the alphabet after Z, what do you think the binary translation would be? Justify your thinking. Decode each others' binary bracelets using the alphabet code.

WHAT'S GOING ON HERE?

Figure out what's causing this mysterious motion.

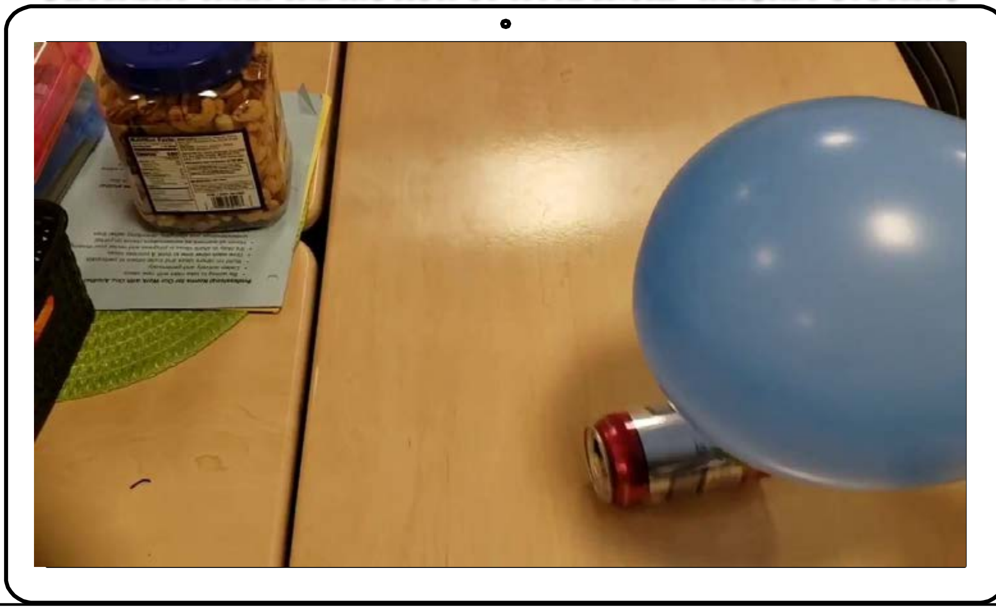
Extension A

COULD THE FORCE BETWEEN THE ALUMINUM CAN AND LATEX BALLOON BE MAGNETISM? WHY OR WHY NOT? HOW DO YOU KNOW? DEFEND YOUR POSITION WITH EVIDENCE.

Extension A

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

HOW IS THE MOTION OF THE CAN-BALLOON SYSTEM SIMILAR OR DIFFERENT THAN THE MOTION OF A PAPERCLIP-MAGNET SYSTEM?



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THANKFULLY, THE EARTH IS A BIG MAGNET!

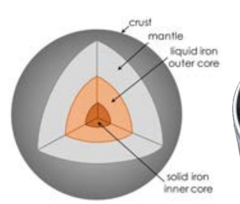
Wait, what?

Extension B

A SHORT READING...

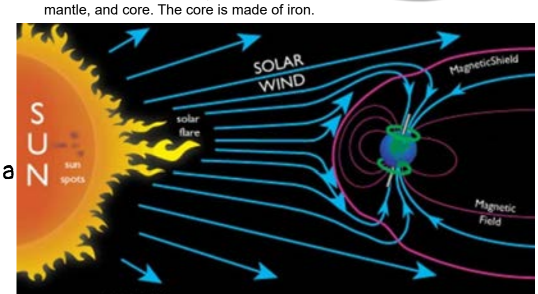
The Earth is a Giant Magnet

Our planet is a giant magnet. You can see this each time you use a compass. The core of the earth is made mostly of iron which makes Earth behave like a giant magnet.



The Earth has 3 main layers. The crust, mantle, and core. The core is made of iron.

Earth's invisible magnetic field is huge and extends far out into space to form a region we call the magnetosphere. The Earth's magnetosphere deflects harmful particles and rays to protect life on our planet. Not all planets are magnetic (but all planets do have a gravitational pull). Scientists think that one reason we have life on Earth is because we have the magnetosphere to protect us.

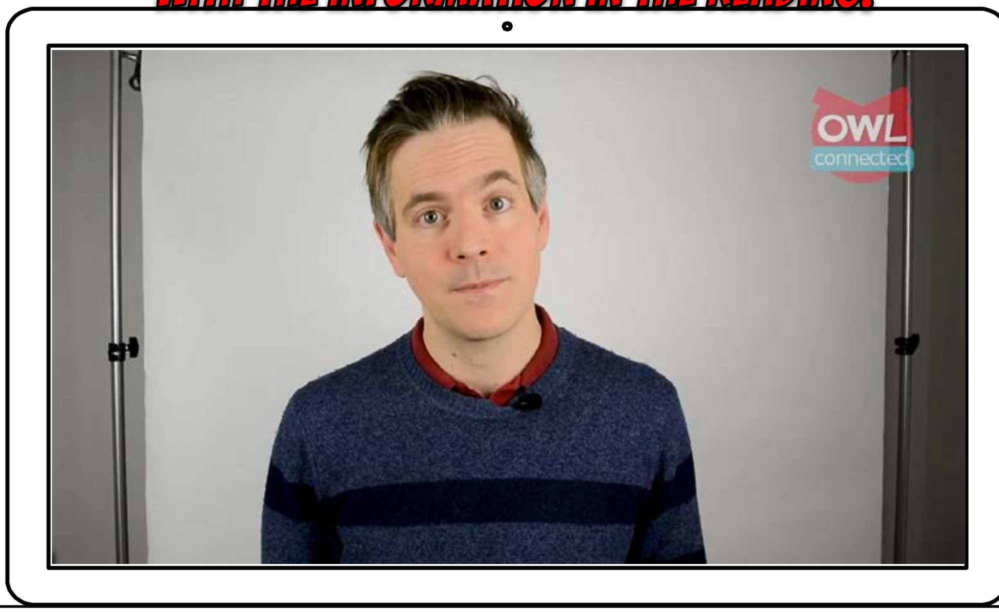


WHAT DO YOU WONDER NOW?

Sources: Jefferson Lab, Forbes, Scientific American, and Physics4Kids

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

COMPARE THE INFORMATION FROM THIS VIDEO WITH THE INFORMATION IN THE READING.



TRY THIS!

You need:

- water
- 1 non-metallic bowl
- 1 piece of cork
- 1 metal needle
- 1 magnet
- 1 small compass

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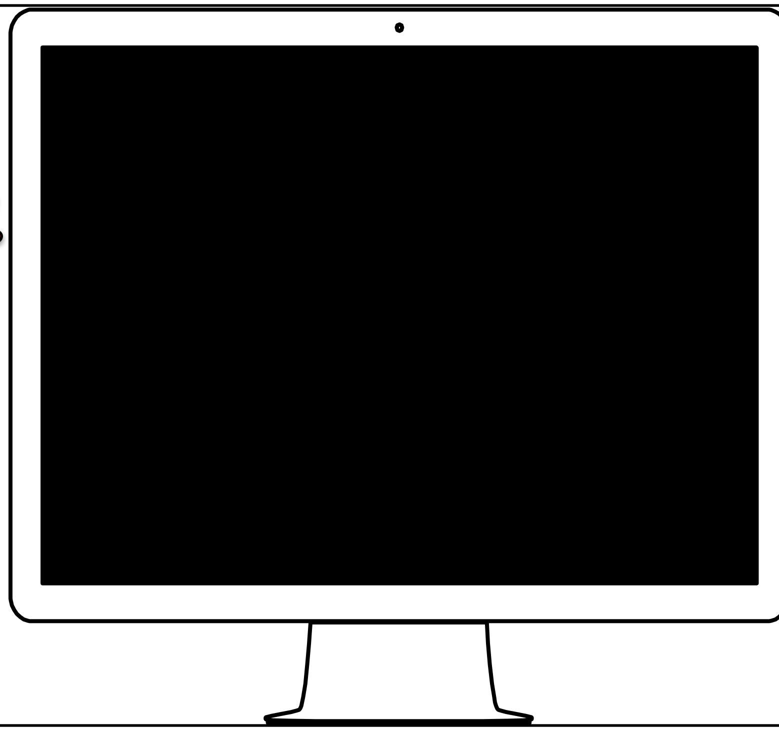
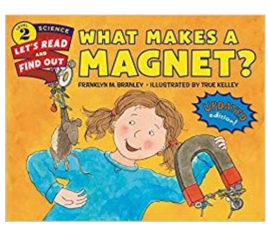
THE VIDEO MAKES A RACECAR COMPARISON.

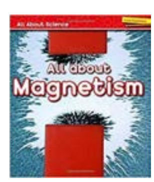
DOES THIS HELP YOU THINK ABOUT HOW WE MAGNETIZED THE NEEDLE?



MORE INFORMATION...



Pages 25–27



pages 12–13

Does the information help us answer today's question:

CAN WE MAKE SOMETHING TURN INTO A MAGNET?

WORD WISE

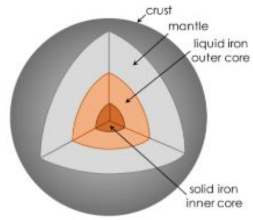
magnetic
magnetize
demagnetize
remagnetize
magnetization

Try these words out:

A piece of magnetic material can be magnetized by rubbing it with one pole of a magnet in one direction. Another way to magnetize a magnetic material is to run an electric current through it. If a magnetized object falls or is hit hard enough it may become demagnetized.

The Earth is a Giant Magnet

Our planet is a giant magnet. You can see this each time you use a compass. The core of the earth is made mostly of iron which makes Earth behave like a giant magnet.



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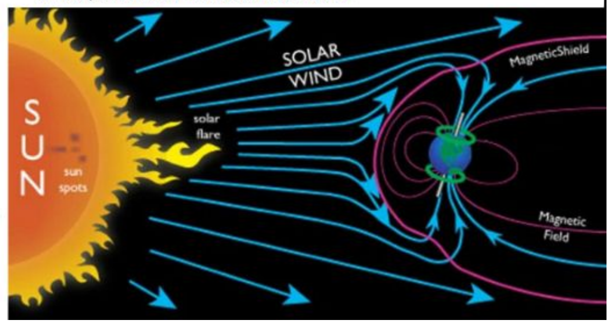

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The Earth is a Giant Magnet

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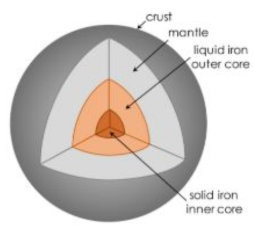
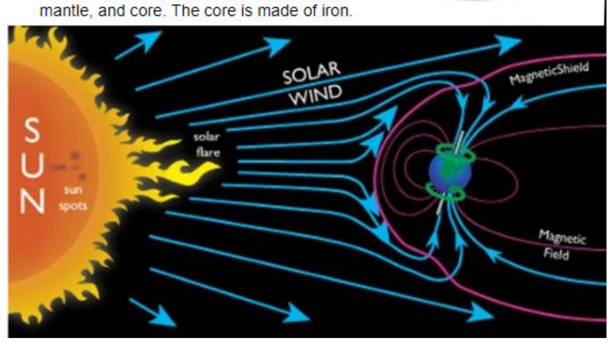


The Earth has 3 main layers. The crust, mantle, and core. The core is made of iron.



Earth's invisible magnetic field is huge and extends far out into space to form a region we call the magnetosphere. The Earth's magnetosphere deflects harmful particles and rays to protect life on our planet. Not all planets are magnetic (but all planets do have a gravitational pull). Scientists think that one reason we have life on Earth is because we have the magnetosphere to protect us.

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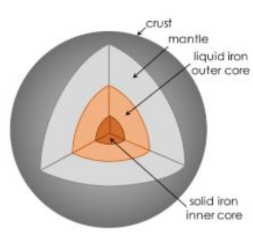

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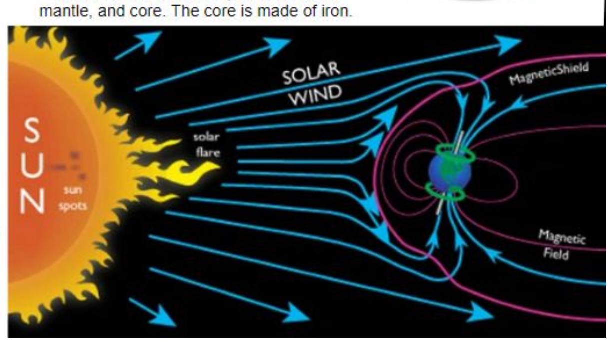

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WHY IS IT USEFUL TO REVERSE THE POLES OF A MAGNET?

And.... Why would we need to?

Extension C

WHAT DO THESE ITEMS HAVE IN COMMON?

cassette tape

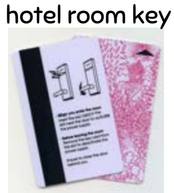
computer hard drive

old computer discs

VHS video tape

credit card

hotel room key



(Yes, these are all old.)

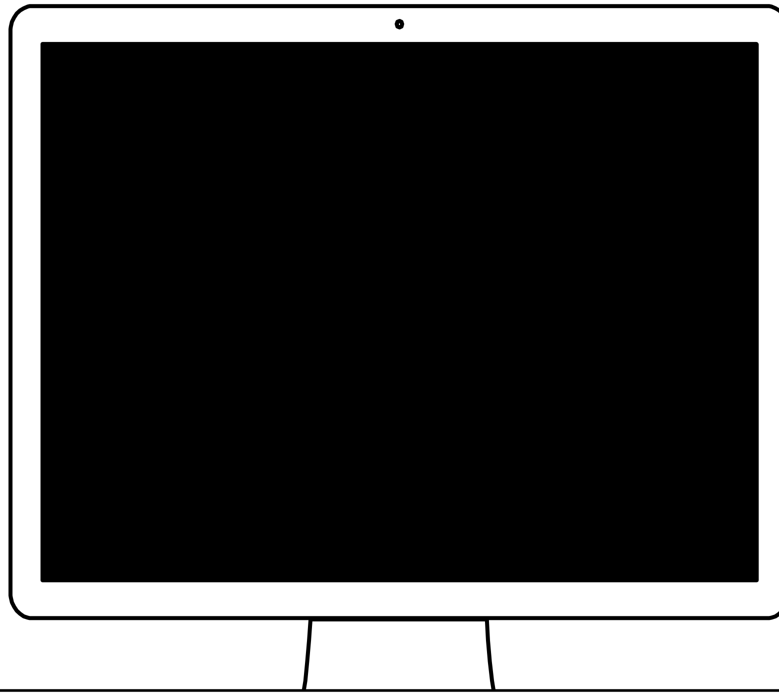
More importantly, they all use magnets to store information!

Extension C

Developed by C. Colley, PhD ccolley@rentonschools.us, with Grade 3 teachers and students at Sartori Elementary, Renton Public Schools

HOW CAN MAGNETS STORE DATA?

WHAT IS BINARY?



APPLY WHAT WE KNOW: REAL WORLD PROBLEM

Dr. Colley stayed at a hotel for a science conference. She kept her magnetic hotel key card in her phone case so she wouldn't lose it. When she returned to the room at the end of the day, the key card did not work! The front desk clerk remagnetized the room key card and she unlocked her door.

- How do you think the magnetic strip on the key card works?
- What could Dr. Colley do so her magnetic room key card will stay working?

EXTENSION: BINARY BRACELET

What do you notice?

A	■□■■ ■■■□	N	■□■■ □□□■
B	■□■■ ■■□■	O	■□■■ □□□□
C	■□■■ ■■□□	P	■□■□ ■■■■
D	■□■■ ■□■■	Q	■□■□ ■■■□
E	■□■■ ■□■□	R	■□■□ ■■□■
F	■□■■ ■□□■	S	■□■□ ■■□□
G	■□■■ ■□□□	T	■□■□ ■□■■
H	■□■■ □■■■	U	■□■□ ■□■□
I	■□■■ □■■□	V	■□■□ ■□□■
J	■□■■ □■□■	W	■□■□ ■□□□
K	■□■■ □■□□	X	■□■□ □■■■
L	■□■■ □□■■	Y	■□■□ □■■□
M	■□■■ □□■□	Z	■□■□ □■□■

FUN FACT

A group of four bits is called a **nibble**. A group of eight bits is called a **byte**. How many nibbles are in a byte?

What are the 3 letters represented here? What's the message?

■□■□ ■□■■ ■□■■ □■■■ ■□■□ □■■■

T H X

(Thx = Thanks!)

Use the beads to make a bracelet with 1, 2, or 3 letters. See if other students can figure out what your bracelet says.

Source: https://code.org/curriculum/course2/14/Teacher#Activity1