THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

How Strong is My Magnet?

How does the number of magnets I use affect how many cards I can pick up?

GRADE 3

Physical Science

VAN ANDEL EDUCATION INSTITUTE
VAEI.ORG

INQUIRY-BASED SCIENCE

Physical

How Strong is My Magnet?

Grade Level/Content	3/Physical Science
Lesson Summary	In this lesson students will first discover which objects are magnetic and which are not. Students will then determine the strength of a magnetic force with magnets that are not in direct contact.
Estimated Time	3, 45-minute class periods
Materials	round magnets with 1 inch hole in middle (two for each student), squares of cardstock, assorted magnets, unsharpened pencil with a base (i.e. Play-Doh), washers (steel and zinc), magnetic and non-magnetic materials, Investigation Plan, journal
Secondary Resources	Magnets: Pulling Together, Pushing Apart (Amazing Science) by Natalie M. Rosinsky What Makes a Magnet? (Let's-Read-and-Find-Out Science 2) by Franklyn M. Branley Science Kids: Fun Magnet Facts for Kids Easy Science for Kids: All About Magnetism and How it Works MakeMeGenius Video: Magnets and Magnetism for Kids First4Magnets: Magnet Facts Explain that Stuff: Magnetism
NGSS Connection	**3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
Learning Objectives	• Students will discover how various objects respond to a magnet using the terms *attracted* and *repelled*. • Students will use the orientation of two magnets to determine whether the force between the magnets is attractive or repulsive. • Students will collect data to determine how the number of magnets affects the magnetic force between magnets. • Students will provide evidence of how increasing the number of magnets on one side changes the number of cardstock pieces that can be picked up between two magnets.
Cross-Curricular Project Connections	Hands Free!, I'm Lost and Siri Can't Help!

How does the number of magnets I use affect how many cards I can pick up?

Magnetism is one of the first forces students are exposed to. Magnets are easy to obtain and use, and are found in many common items such as compasses, televisions, computers, medical devices…the list is endless. Even the Earth is a magnet! Although many of us are exposed to magnets on a daily basis, the science behind magnetic forces remains an enigma. In this investigation, students will be investigating one of the many factors that affects the strength of magnetic force.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science. In all investigations:

Students don't know the "answer" they are supposed to get.

Students play a driving role in determining the process for learning.

Teachers and students construct meaning together by journaling.

Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Supply students with the following materials: (Materials will vary if students are creating their own question.)

- Round magnets with 1-inch hole (4 per group)
- Squares of cardstock
- Steel washers
- Unsharpened pencil in a base (i.e. Play-Doh)
- Assorted magnets
- Variety of magnetic and non-magnetic objects:
  - magnets—with different shapes
  - fabric
  - common nails-steel
  - aluminum nails
  - plastics
  - safety pins
  - paper
  - other metals (copper, lead, aluminum, etc.)
  - wood
  - nuts and bolts
  - yarn
- Investigation Plan
- Journal

Part 2

INVESTIGATION FACILITATION

Before you introduce the investigation question, conduct a mini-investigation (**Messing About**) for students to develop the knowledge and skills required to perform the investigation. Ask students: *What effect do magnets have on objects made from different materials?*

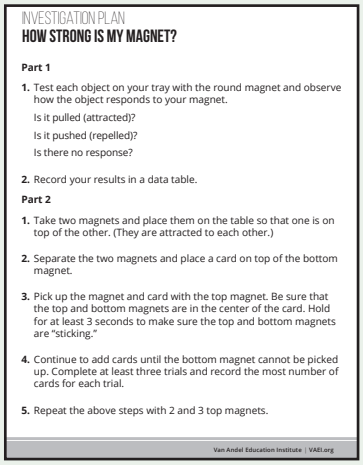
Investigation Plan

Students discover how various objects respond to a magnet.

- Review the materials as a whole class.
- Divide students into teams of 2. Give each team a few of the materials. Have students complete Part 1 of the Investigation Plan.
- Instruct students to use the round magnet to test the items on the tray.
- Students will test each object to see how it responds to the magnet. Is it pulled (attracted), pushed (repelled), or is there no response?
- Students will then record their results in a class data table.

CURIOSITY

Encourage students to test other items in the room or possibly bring items in from home to test. This can be added to the class list. *Caution: Students should be cautioned to keep magnets away from computers and other electronics.*



INVESTIGATION PLAN

HOW STRONG IS MY MAGNET?

Part 1

1. Test each object on your tray with the round magnet and observe how the object responds to your magnet.
   - Is it pulled (attracted)?
   - Is it pushed (repelled)?
   - Is there no response?
2. Record your results in a data table.

Part 2

1. Take two magnets and place them on the table so that one is on top of the other. (They are attracted to each other.)
2. Separate the two magnets and place a card on top of the bottom magnet.
3. Pick up the magnet and card with the top magnet. Be sure that the top and bottom magnets are in the center of the card. Hold for at least 3 seconds to make sure the top and bottom magnets are "sticking."
4. Continue to add cards until the bottom magnet cannot be picked up. Complete at least three trials and record the most number of cards for each trial.
5. Repeat the above steps with 2 and 3 top magnets.

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Investigation Plan

Observation

Students record how various objects respond to a magnet.

Have students add their findings to a class data table.

Magnet Data Table

Item	Attracted to magnet	Repelled by magnet	No response to magnet	Other Observations
common nail - steel	X			nail moved to the magnet
aluminum nail			X	
t-shirt			X	
pen	X		X	the clip was attracted to the magnet, but the rest of the pen was not
pencil			X	
plastic			X	
safety pin	X			
paper			X	
a different magnet	X	X		there was a push when the magnet faced one direction and a pull when it faced the other direction
metal - iron	X			

Data Table 1 Example

OPENNESS TO NEW IDEAS

Some of the objects will surprise the students. For instance, the aluminum nails will look very similar to steel nails, but aluminum is not attracted to a magnet.

CONSTRUCTION OF MEANING

Have students discuss their observations with other groups as they begin to negotiate the meaning of magnetism. Ask a few groups to share their observations.

During this investigation time students should experience the force of attraction (pull) between magnets and magnetic materials. They may also experience the repulsion (push) force between like charged magnet poles.

If there are bar magnets for students to use, they will find that holding both North poles (or both South poles) of the two magnets together will cause a push (they repel each other.) Holding two oppositely charged poles together (North and South) will produce a pull (they are attracted to each other).

Data Analysis

Students make sense of the class data by organizing it and representing it visually.

As a class, analyze the data together. You may wish to use the Data Analysis prompt as a guide.

- **Evaluate** the data for trustworthiness.
- Then, analyze the data to find patterns and trends. You may **organize** the data and/or **represent** it visually to construct meaning.
- Finally, interpret what the identified patterns or trends mean.

After completing this **Messing About**, students should be able to explain that magnets are only attracted to metals, but not all metals (i.e., aluminum, brass, bronze, etc.). Once this has been completed, students are now ready to move on with the investigation.

Question

Introduce the investigation question.

How does the number of magnets I use affect how many cards I can pick up?

STUDENT ENGAGEMENT

Before students begin their investigation, have them experiment with an unsharpened pencil in a Play-Doh base and two round magnets to determine:

- How do the magnets relate to each other when they are both placed around the pencil?
- What happens if you remove the top magnet and turn it over before placing it back on the pencil?

Have each pair of students perform this demonstration in order to observe the phenomenon of attraction and repulsion in regard to magnetic forces. Then, introduce the investigation question.

Personal Knowledge

Students capture what they already know about magnetism.

- Find out what students already know about magnets and magnetic forces.
- Generate a class list. *(List may include: magnets attract each other, magnets repel each other, paper clips are attracted to magnets, etc.)*

DISCOURSE

Conduct a *Pass the Paper* with students working in pairs. One student writes "Magnets" at the top of their paper and the other student writes "Force" at the top of another piece of paper. Each student writes something they know about the word and passes it to their partner. They then add ideas to their partner's list. Students continue to pass back and forth until the time is up.

RISK-TAKING

Add all ideas, even misconceptions, to the class list. If students question an idea, place a question next to it and explain that you will revisit it later. Telling students their personal knowledge is incorrect does not cause them to change it. Instead, confront misconceptions at the appropriate time in the investigation. Often this will be during data analysis and explanation.

Prediction

Students communicate an expected outcome, based on prior knowledge.

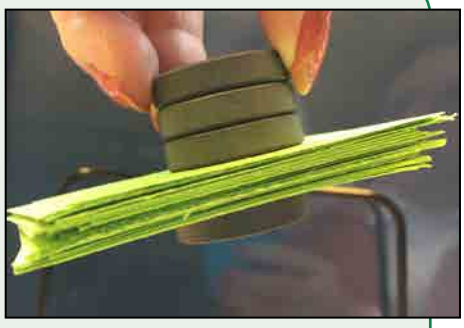
Have students make a prediction based on the investigation question using the following format:

I predict that _____ *because* _____.

Investigation Plan

Students perform trials to determine how the number of magnets affects the magnetic force.

- Review the materials as a whole class.
- Divide students into teams of 2. Give each team their materials.
- Have students follow the **Investigation Plan Part 2**. Instruct students to place the magnets in the center of the cards and count to "three" each time to ensure that the magnets are "sticking."
- Challenge teams to create a data table to record their results showing the number of card pieces they were able to pick up during each trial.
- Students continue to collect data until they have at least 3 trials for 1, 2, and 3 top magnets.



Three Top Magnets

CREATIVE THINKING

Encourage students, in conjunction with you, to determine their own investigation plan or create one as a class depending on your instructional objectives.

Another option is to have students see how many paper clips they can pick up with 1,2, and 3 top magnets.

Observation

Students record the number of cardstock pieces for 1, 2, and 3 top magnets.

Have students create a data table to record their findings.

STUDENT CHOICE

Allow students to determine how they want to collect and record their data either within their group or as a class.

Number of Cards between the Magnets

Trial/Number of Magnets on Top	Trial 1	Trial 2	Trial 3
1 Magnet	29	27	29
2 Magnets	36	35	35
3 Magnets	41	38	41

Data Table 2 Example

Part 3

INVESTIGATION ANALYSIS AND DEVELOPMENT OF CLAIM

Data Analysis

Students make sense of their data by organizing it and representing it visually.

Have students analyze their data. They may wish to use the Data Analysis prompt as a guide.

- Have students **evaluate** their data for trustworthiness.
- Then, have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning. They may use math if appropriate *(average number of cardstock pieces, etc.)*.
- They should show that the number of cardstock squares increases as the number of top magnets increases.
- Have students **interpret** what the identified patterns or trends mean.
- Ensure they have enough data that it can be used as evidence to support a claim.

CRITICAL THINKING

Have students decide how to organize and represent the data. Guide them as needed in determining the most effective organization and representations. Ask questions such as, "Would that be clear to someone from another team?" and "Is there anything in your representation that might be confusing?"

Secondary Knowledge

Students use secondary sources to understand how adding more magnets affects the magnetic force.

Help students prepare a summary of important science concepts using secondary resources (possible resources are listed below). Have students use these science concepts in their reasoning to support their claim.

Possible resources:

Magnets: Pulling Together, Pushing Apart (Amazing Science) by Natalie M. Rosinsky

What Makes a Magnet? (Let's-Read-and-Find-Out Science 2) by Franklyn M. Branley

Science Kids: Fun Magnet Facts for Kids

Easy Science for Kids: All About Magnetism and How it Works

MakeMeGenius Video: Magnets and Magnetism for Kids

First4Magnets: Magnet Facts

Explain that Stuff: Magnetism

Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data to write an explanation that answers their investigation question. Students may wish to use the Explanation prompt as a guide. Have them write their explanation in their Lab Journal.
- Have students develop a **Claim** to answer the question: How does the number of magnets I use affect how many cards I can pick up?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Claim

We claim that by adding more magnets to one side of the cardstock pile, we can pick up more cardstock pieces.

Evidence

When we added one more magnet to the top (total of 2 magnets), we picked up an additional 7 cards on average. When we had 3 magnets on top, we picked up an average of 5 more cards than with 2 magnets.

Reasoning

Investigation: We did at least 3 trials for 1, 2 and 3 magnets. We followed the investigation plan the same for each trial and carefully recorded our data. We closely looked at our data and found that it was trustworthy. We used a graph to represent our data and make sense of what the data means.

Science: We found an article online that stated that when you add more magnets together the magnetic force is stronger. But, two magnets don't make the magnets twice as strong as one magnet. It said that was because the top magnet is farther away from the object.

- Once the explanation is written, have students discuss their results using a Present and Defend.

DISCOURSE

Have students conduct a Present and Defend to develop presentation skills as well as audience participation. Research teams present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Research teams defend their explanation with evidence and reasoning. If students are doing the same investigation plan, choose 1 or 2 groups to share.

Evaluation

Students reflect on the investigation.

- Ask students what surprised them.
- Ask students how confident they are in their results.
- Ask students what question they would like to do next.

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Application

Students demonstrate understanding of magnetic force by designing and conducting an open investigation.

- Have students apply their learning by developing their own question they would like to investigate. (This question may come from the evaluation component.) You may have each group create their own question, develop a class question, or brainstorm questions that groups can pick from to investigate.

  Example ideas:
  What affect does distance between two magnets have on the pushing (repelling) force between two magnets? What materials around the room can the magnetic force pass through?
- Now that students understand the basics of magnetic force between two objects not in direct contact, they can use that knowledge to explore different project ideas: https://nationalmaglab.org/education/magnet-academy/try-at-home.

Assessment

1. Students provide an explanation (**claim, evidence** and **reasoning**) that clarifies the cause and effect relationship of the force between two magnets that are not in direct contact with each other.
2. Students generate an investigation question that clarifies the cause and effect relationship between:
   a. The sizes of the forces on the two interacting objects due to the distance between the two objects.
      or
   b. The relative orientation of two magnets and whether the force between the magnets is attractive or repulsive.

Take This Lesson Across the Curriculum

Hands Free!

The custodian at your school has been out sick due to a terribly sore back from picking up all the paper clips on the floor. Your principal has asked your class to design and build a device that will pick up paper clips without having to bend down.

Reading/Language Arts	Math	Science	Social Studies
Pick Me! Write an opinion piece that supports why your principal should invest in your design. CCSS.ELA-LITERACY.W.3.1.A	**Make It Count** Use your understanding of numbers to make your design pick up the most paper clips in the shortest amount of time. CCSS.MATH.CONTENT.3.MS.A.1	**How Strong Is My Magnet?** We need magnets to pick up the paper clips. Let's understand how magnets work to ensure the custodian will not need to bend down for a paper clip ever again! NGSS: 3-PS2-3	**Saving Dough** In order to use your device in other schools, it needs to be designed at a low cost. Communicate how you will keep costs low. D2.Eco.1.3-5.

I'm Lost and Siri Can't Help!

Your class is taking a camping trip with one of the Kindergarten classes at your school. On one of your nature hikes, the teacher becomes lost and needs your help guiding everyone back to camp before dark. There are no cell phones or GPS devices handy. All you have is a compass and a few maps with measurements made in footsteps.

Reading/Language Arts	Math	Science	Social Studies
Lost! Write a narrative about your adventure. CCSS.ELA-LITERACY.W.3.3	**One Step at a Time** Use the number of footsteps to determine how far you need to walk to get back to camp. CCSS.MATH.CONTENT.3.MD.A.2	**How Strong Is My Magnet?** In order to use a compass, you will need to understand how a compass needle changes based on your location. NGSS: 3-PS2-3	**MapQuest** Use maps to determine which direction you need to travel to get back to camp. D2.Geo.2.3-5

For additional lessons or to customize this lesson, go to www.nexgeninquiry.org.

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INVESTIGATION PLAN

HOW STRONG IS MY MAGNET?

Part 1

1. Test each object on your tray with the round magnet and observe how the object responds to your magnet.

   Is it pulled (attracted)?

   Is it pushed (repelled)?

   Is there no response?

2. Record your results in a data table.

Part 2

1. Take two magnets and place them on the table so that one is on top of the other. (They are attracted to each other.)

2. Separate the two magnets and place a card on top of the bottom magnet.

3. Pick up the magnet and card with the top magnet. Be sure that the top and bottom magnets are in the center of the card. Hold for at least 3 seconds to make sure the top and bottom magnets are "sticking."

4. Continue to add cards until the bottom magnet cannot be picked up. Complete at least three trials and record the most number of cards for each trial.

5. Repeat the above steps with 2 and 3 top magnets.