THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Magnetism: Force and Distance

What effect does distance have on the repelling force between magnets?

GRADES 6–8

Physical Science

VAN ANDEL EDUCATION INSTITUTE

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INQUIRY-BASED SCIENCE

Physical

Magnetism: Force and Distance

Grade Level/ Content	6–8/Physical Science
Lesson Summary	In this lesson, students determine how distance affects the strength of the magnetic force between magnets.
Estimated Time	2, 45–minute class periods
Materials	round magnets, meter sticks, ring stand with clamps, ruler (cm), electronic balances, double-sided tape, Investigation Plan, journal
NGSS Connection	**MS-PS2-3** Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
Learning Objectives	• Students develop a hypothesis to predict the strength of the magnetic force due to changes in distance between magnets. • Students collect and analyze data to determine how distance affects the magnetic force strength between magnets. • Students design and conduct an investigation to determine the effect of a chosen variable on magnetic force strength.

What effect does distance have on the repelling force between magnets?

Over 2,000 years ago, ancient Greek philosophers wrote about lodestone (the magnetic form of the mineral magnetite) and the "magical" properties this natural material possesses, from curing illnesses to scaring away evil spirits. Our understanding of magnets and magnetic force has evolved considerably in the past 2,000 years. In the 18th century, Frenchman Charles Coulomb determined the inverse square law of force, which states that the attractive force between two magnetized objects is directly proportional to the product of their individual fields and inversely proportional to the square of the distances between them.

Historically, scientists believed that electricity and magnetism were two different forces. However, by the late 1800s, research had shown that positive and negative charges were controlled by only one force—magnetism! Since this revelation, electromagnets have been constructed using electrical currents to produce and control magnetic fields.

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 a 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

Students will need the following materials to complete this investigation:

- Round magnets
- Meter sticks
- Ring stand with clamps
- Ruler (cm)
- Electronic balances
- Double-sided tape
- Investigation Plan
- Journal

Part 2

INVESTIGATION FACILITATION

Question

Introduce the investigation question.

What effect does distance have on the repelling force between magnets?

Personal Knowledge

Students capture what they already know about magnets, magnetic force, and the effect of distance on magnetic force.

- Have students list their prior knowledge in their journal.
- Share ideas to create a class list. (List may include: *magnets have north and south poles; when alike poles are together, the magnets repel; the force between magnets gets bigger as they get closer together.)*

DISCOURSE

Have students participate in a *Take 10 Steps* activity to promote discourse and collaboration. Give students two minutes to think and respond to the prompt. Then, have them walk 10 steps in any direction. They will share their list with the person closest to them. They will continue this process until time is up. Students will share their ideas with the class.

Prediction

Students write a hypothesis about what they think will happen based on prior knowledge.

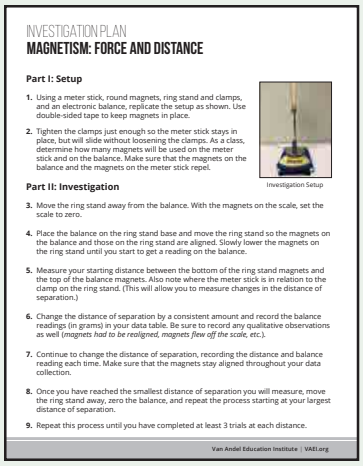
If *[independent variable]*, **then** *[dependent variable]*, **because** _____.

If the distance between two magnets with like poles gets smaller, then the repelling force between them will get bigger, because the force between two magnets gets stronger as they get closer together, and weaker as they get farther apart.

Investigation Plan

Students conduct trials to determine how distance affects the magnetic force between magnets.

- Divide students into teams based on your availability of electronic balances. Give each team their materials and their Investigation Plan.
- Review the materials and investigation setup. As a class, determine how many magnets will be used on the meter stick and on the balance. Let each group decide the set distance change they will test (*1cm, 2cm, 5cm, etc* ...). Remind students that they will keep that distance change consistent across all trials.
- Have students follow the **Investigation Plan**. Have students record their balance readings (in grams) for each distance and any qualitative observations (*magnets had to be realigned, magnets flew off the balance, etc.*). Their balance reading in grams will translate to the force at each separation of distance.
- Students conduct at least 3 trials for each distance.



INVESTIGATION PLAN

MAGNETISM: FORCE AND DISTANCE

Part I: Setup

1. Using a meter stick, round magnets, ring stand and clamps, and an electronic balance, replicate the setup as shown. Use double-sided tape to keep magnets in place.
2. Tighten the clamps just enough so the meter stick stays in place, but will slide without loosening the clamps. As a class, determine how many magnets will be used on the meter stick and on the balance. Make sure that the magnets on the balance and the magnets on the meter stick repel.

Investigation Setup

Part II: Investigation

3. Move the ring stand away from the balance. With the magnets on the scale, set the scale to zero.
4. Place the balance on the ring stand base and move the ring stand so the magnets on the balance and those on the ring stand are aligned. Slowly lower the magnets on the ring stand until you start to get a reading on the balance.
5. Measure your starting distance between the bottom of the ring stand magnets and the top of the balance magnets. Also note where the meter stick is in relation to the clamp on the ring stand. (This will allow you to measure changes in the distance of separation.)
6. Change the distance of separation by a consistent amount and record the balance readings (in grams) in your data table. Be sure to record any qualitative observations as well (*magnets had to be realigned, magnets flew off the scale, etc.*).
7. Continue to change the distance of separation, recording the distance and balance reading each time. Make sure that the magnets stay aligned throughout your data collection.
8. Once you have reached the smallest distance of separation you will measure, move the ring stand away, zero the balance, and repeat the process starting at your largest distance of separation.
9. Repeat this process until you have completed at least 3 trials at each distance.

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Investigation Plan

CRITICAL THINKING

Use the Fair Test checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a test that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they will be in their results.

STUDENT CHOICE

Let students decide how many magnets will be used in their setup and how much to change the distance. Offering students choices within set parameters lets them take a leadership role in their learning without losing focus of your learning objectives.

Observation

Students record their findings.

Have students create a data table to record their findings.

PERSEVERANCE

Encourage students to remain focused throughout the investigation. Curiosity may drive them to do additional trials (beyond the minimum of 3).

Magnetism: Force and Distance Data Table

Separation Distance (cm)	Trial 1 mass (g)	Trial 2 mass (g)	Trial 3 mass (g)	Trial 4 mass (g)	Trial 5 mass (g)	Qualitative Observations
14.5	.3	.3	.3	.3	.4	
12.5	.5	.5	.5	.5	.6	
10.5	.9	.9	1.0	.9	1.0	
8.5	1.7	1.8	1.8	1.7	1.9	
6.5	3.7	3.9	3.8	3.8	4.0	had to realign the magnets in a few trials
4.5	9.3	9.8	9.6	9.6	10.3	
2.5	32.0	32.6	32.4	33.5	32.4	
0.5						magnets flew off scale

Sample Data Table

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. Have students highlight any data that they wonder about. Ask them to reflect on their confidence level of their data.
- Then, have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning. Have students use math where appropriate (*average grams for each distance, etc.*). Depending on your students, you may have them calculate the actual force in Newtons (F=mg). Note: Students will need to convert their mass into kg.
- Have students **interpret** what the identified patterns or trends mean.
- They should show that the mass recorded on the balance increases as the distance between the magnets decreases.
- Ensure they have enough data that it can be used as evidence to support a claim.

Secondary Knowledge

Students use secondary sources to deepen understanding.

- Discuss with students that magnetic forces can be attractive or repulsive, and their size depends on the magnitude of the magnetic strength involved and on the distance between interacting objects.
- As students analyze their data, they may recognize that the mass is not increasing steadily as the distance decreases. Most middle school students will not recognize this as an inverse square relationship, but they will notice that this is not a linear relationship. Highlight the concept that mathematical relationships in naturally occurring phenomena don't always follow a linear relationship.

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 journal.
- Have students develop a **Claim** to answer the question: What effect does distance have on the repelling force between magnets?
- 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 as the distance between magnets gets smaller, the repelling force gets bigger.

Continued

Evidence

Our data showed that as the distance between the magnets got smaller, the repelling force got bigger. For example, when the magnets started 14.5cm apart, the repelling force was .3g or .0029N. When we reduced the distance to 6.5cm, the force increased to 3.84g or .038N. We saw even bigger changes as the magnets got closer together. For example, at 2.5cm separation the force was 32.58g or .32N.

Reasoning

Investigation: We followed our investigation plan carefully. We did 5 trials at seven different distances of separation and we reset the balance to zero between all but the first and second trials. We decreased the distance of separation by 2cm each time. We did our best to read the markings on the meter stick so our changes were accurate.

Science: From our class discussions and experiments we had done before, we knew that the force would get bigger when we moved the magnets closer together. However, we did not expect the force to change as much as it did when we got them really close together. We looked online and found out that it is an inverse square law, but we are not sure exactly what that means.

- 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 one or two groups to share.

Evaluation

Students reflect on the investigation.

Ask students:

- *Did your claim support or contradict your prediction?*
- *How did the results of the investigation change your thinking about magnetic force and distance?*
- *What other question(s) would you like to investigate about magnetism?*

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 questions:

What effect does the number of magnets have on the magnetic force between two objects not in direct contact?
What effect does distance have on the force of attraction between magnets?
What effect does the type of magnet have on the repelling force between magnets?

Assessment

Evaluate how well students:

- develop a hypothesis to predict the strength of the magnetic force due to changes in distance between magnets.
- collect and analyze data to determine how distance affects the magnetic force strength between magnets.
- design and conduct an investigation to determine the effect of a chosen variable on magnetic force strength.

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

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INVESTIGATION PLAN

MAGNETISM: FORCE AND DISTANCE

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Investigation Setup

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