3M Young Scientist Lab

Classroom Activity | Grades 3-5

Interaction at a Distance

GUIDING QUESTION

How strong are magnets and how can you increase the magnetic strength of a magnet?

LEARNING OBJECTIVES

Students will be able to:

- manipulate magnets so they attract and repel each other.
- collect data regarding the strength of magnetic attraction.
- construct a graph that shows magnetic strength vs. number of magnets.
- propose a rule that describes the pattern exhibited in their graph.

OVERVIEW

Students come in contact with and use magnets every day. They often don't consider that there are different types of magnets and are made for different purposes. In this activity students explore magnetic strength and how combining magnets can increase it. Students measure this strength using a stack of index cards, graph the data, and look for a pattern in their data.

Then, they will extend their learning at home to find out what types of magnets they have in their house and test their strength and attraction at a distance.

NEXT GENERATION SCIENCE STANDARDS

- PS2.B: Types of Interactions
  - Objects in contact exert forces on each other. (3-PS2-1)
  - Electric, and magnetic forces between a pair of objects do not require the objects to be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-3), (3-PS2-4)

- ETS1.A: Defining and Delimiting an Engineering Problem
  - Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) (secondary to 4-PS3-4).
- ETS1.B: Developing Possible Solutions
  - Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)
  - Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)
- ETS1.C: Optimizing the Design Solution
  - O Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) (secondary to 4-PS4-3)

LESSON TIME FRAME

Two Sessions:

- One 20-minute session to engage students and demonstrate the activity.
- One 50-minute session for students to carry out the investigation.

BACKGROUND INFORMATION

One of the unique and appealing properties about magnets is their ability to interact with each other and certain metals at a distance. The interaction can be an attractive force (opposite poles towards each other) or a repelling force (the same poles towards each other). Related to this property is the ability of the magnetic force to act through common materials such as wood or paper. Another property of magnets is their ability to combine their force (of attraction or repulsion) when they are stacked together. In this lesson students will utilize both properties to vary and measure the attractive force of a stack of magnets towards a single magnet.

Different types of magnets are made for different purposes and have different properties. Kitchen cabinet magnets are made to hold a heavy door in place and their magnetic field is noticeable from several centimeters away. Flat, thin, magnetic adhesive tape (which is the material from which “refrigerator” magnets are made) have just as strong a pull, but the noticeable force extends only millimeters away from them. The magnetic sheet is made of parallel lines of magnets like corduroy fabric.

MATERIALS

Teacher Materials/Prep

- Home Connection Resource
- Three flat magnets*
- One pack of index cards
- Demonstration table
- Print out copies of:
  - Interaction at a Distance Data Collection Student Capture Sheet
  - Home Connections (for students to take home)
- Print copies and cut out
  - Five Finger Summary Capture Sheet

Materials per Student Group

- Small rectangular magnets, approximately 10*
- Two packs of index cards (preferably different colors)
- Flat surface such as a counter or table
- Paper and pencil

*These magnets can be purchased at hardware stores. Either round or rectangular magnets will work as long as they are flat. The rectangular style magnets are often referred to as "cabinet latch magnets" since they are commonly used inside cabinets to hold a door shut. This style would be best to use in the classroom since they likely would be the style found in cabinets at home.

CLASSROOM ACTIVITY

Day 1

Engage

1. To gain understanding of your students' background knowledge, hold up two chalk erasers or other similarly shaped objects, one in each hand, and ask students to imagine that these erasers are magnets.
2. Slowly bring the two erasers together and invite discussion among and with students about what they think would happen if these were actual magnets. Be open to suggestions to turn one eraser (magnet) over and again, as directed by discussion, go through motions with your erasers. Use this opportunity to probe the students' conceptions about magnets and how they interact with other magnets.

3. Give each student a pair of magnets and allow them to explore their attractive and repulsive properties. Students will no doubt test their magnets on other items they might have in their desks or, if you permit, items around the classroom. For most students, the actions of the magnets will not be a surprise but a confirmation of past experience with magnets. Some students might even find that one magnet attracts another through a sheet of paper or even a thin notebook. Encourage such inquiry by placing some index cards on each student's desk. Let them discover that the magnets will attract (and repel) each other through index cards.

Day 2

Explain

1. Remind students about the magnets attracting and repelling each other through the index cards from the previous day. Discuss this phenomenon with students and tell them that scientists refer to this attracting and repelling force as an interaction at a distance. Evidence of this is that the magnets will attract each other through some index cards. Contrast this with other force interactions that require touching – actions like pushing a chair to get it to move or hitting a baseball with a bat. Mention the force of gravity and ask students which type of interaction that might be: interaction-at-a-distance or touching (Answer: interaction-at-a-distance).
2. Now place two magnets together so they attract each other and form a stack of two.
3. Ask students if they think two magnets together like this are stronger than a single magnet. Leave the question unanswered and tell students you are going to provide them with lots of magnets so they can find the answer to this question on their own.
4. Demonstrate the following technique to students.
    a. Place one magnet flat on a table.
    b. Put a second magnet on top of a stack of ten index cards and lower the stack over the table magnet so the magnets attract each other through the index cards.
    c. With the magnet sitting on top, lift the stack of index cards to confirm that the top magnet can lift the table magnet off the table.
5. Ask students what they think would happen if we increase the number of cards.
6. Pull the table magnet away from the index cards and set it back on the table.
7. Add a second stack of ten index cards of a second color to the first stack, creating a new stack that is 20 cards thick. By doing this, you are increasing the distance separating the two magnets when you place the stack on top of the table magnet.

***Teacher Note:** The reason for using a second color of index card is simply to reduce possible confusion in counting and keeping track of how many cards are in the entire stack. This activity can be done with a single color of index cards.

8. With the single magnet still sitting on the top of the new stack, again place the stack of index cards over the table magnet and see if it will lift the table magnet.
9. Repeat this process, alternating colors of ten index cards, until there are enough index cards in the stack so the two magnets no longer attract each other with enough force to lift the table magnet off the table.

***Teacher Note:** You can refine this separation distance by adding (or subtracting) individual index cards in the stack, allowing you to refine the distance down to the nearest index card. Record this number on the chalkboard. Tell students that in doing this, you have been able to measure how strongly the magnets attract each other.

10. Now add a second magnet to the magnet on top of the stack so the two magnets attract each other.
11. Ask students to predict how many index cards they think it would take this time to separate the stack of two magnets from the magnet on the table. Invite discussion of ideas and encourage students to offer explanations for their predictions. At this point, don't actually lift with the stack of two magnets but tell students you are inviting them to continue this procedure of adding magnets to the stack on top.
12. Wonder out loud if you think there will be any noticeable pattern in the number of index cards needed vs. the number of magnets in the stack.

Explore

1. Either provide a copy of the data table (below) to students or copy it to a board or chart paper so they can copy it in their science journals.
2. Group students according to the number of magnets you have available.
3. As you explain the data table, tell students they are to follow the procedure you demonstrated, beginning with one magnet and continuing up to 10 magnets.

***Teacher Note:** If you don't have enough magnets, groups could share. When you observe and assist groups as needed, challenge them to predict their next data point based on what they already measured and recorded.

4. Assist students so they can make a bar or line graph of their data with the number of magnets in the stack as the independent variable (x-axis) and the number of index cards used as the dependent variable (y-axis).
5. Once they have done this, gather them together to discuss results. Some questions you might pose to students include:
    a. Is there a pattern in this data? If so, can you describe that pattern?

b. Can you use that pattern to predict values beyond the number of magnets you used?

c. What reason can you offer to explain why the data looks the way it does? (Because additional magnets are farther away from the table magnet than the bottom magnet in the stack, their attraction will not be as strong. Once these top magnets are far enough away, they no longer attract the table magnet so the graph will level off.)

Elaborate

1. There is an opportunity at this point to make a connection in students' minds of how math (in the form of numbers, patterns, and graphs) logically connects with and supports science. Tell students that as they continue to learn more math and science in higher grades, they will discover that finding patterns in data is very important and the patterns can be surprising. Patterns can be turned into rules and rules that are called functions or equations. Mention to students that famous equations like E = mc2 and F = ma are examples of rules that scientists have created to explain phenomena in the natural world. Ask students if they've heard of these or other famous equations.
2. Ask if any students have magnets on their refrigerators at home and if so, what the magnets are used for.

***Teacher Note:** Some students might not have any experience with refrigerator magnets, so a brief discussion of their use and practicality could be useful here.

3. Have any students ever tried to attach something heavy, or thick, to the refrigerator with a magnet before? Encourage a discussion relating this everyday item (refrigerator magnets) to the topic of the lesson including solutions to the problem of getting something heavy or thick to stay stuck to a refrigerator (e.g. stacking magnets or using multiple magnets.)

Evaluate

***Teacher Note:** Have students answer the following questions on a piece of paper or in their science journal.

1. Describe what happens when two magnets are brought close to each other.
2. What evidence demonstrates that the attractive force of magnets can act across a distance?
3. Explain the data from the graph that shows the relationship between the number of magnets in a stack and the distance through which they can attract another magnet.

4. In describing the graph above (in question 3), which factor is the independent variable that you changed and which is the result of that change (dependent variable)?

Teacher Scoring Key for Evaluate

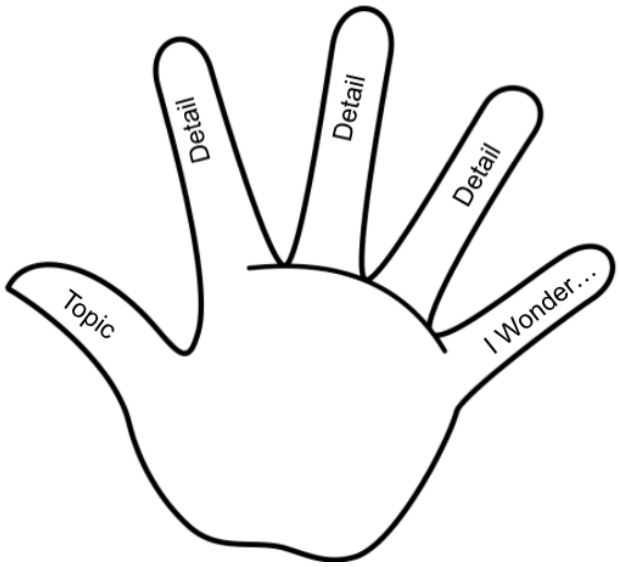
1. When two magnets are put near each other, two things can happen. They will both pull towards each other and then stick together or they will push apart from each other depending on how they are facing.
2. We saw that the magnets would still attract each other even when they were separated by lots of index cards. This shows that they can interact at a distance.
3. As the number of magnets in the stack increases, the distance to attract the single magnet increases in a fairly even pattern, but the distance stops increasing when there are about six or more magnets.
4. The independent variable is the number of magnets in the stack and the dependent variable is the distance between the stack and the single magnet.

This variable is the number of index cards that were used to separate the stack of magnets from the table magnet while still permitting the stack to lift the table magnet off the table. With one additional card, the stack would be too thick and the stack of magnets could not lift the table magnet.

REFLECTION

Students will reflect on their learning by completing the Five Finger Summary. Print off the Five Finger Summary Resource, cut them up, and distribute one to each student. Alternatively, students may trace their hand on a piece of paper or in their science journal.

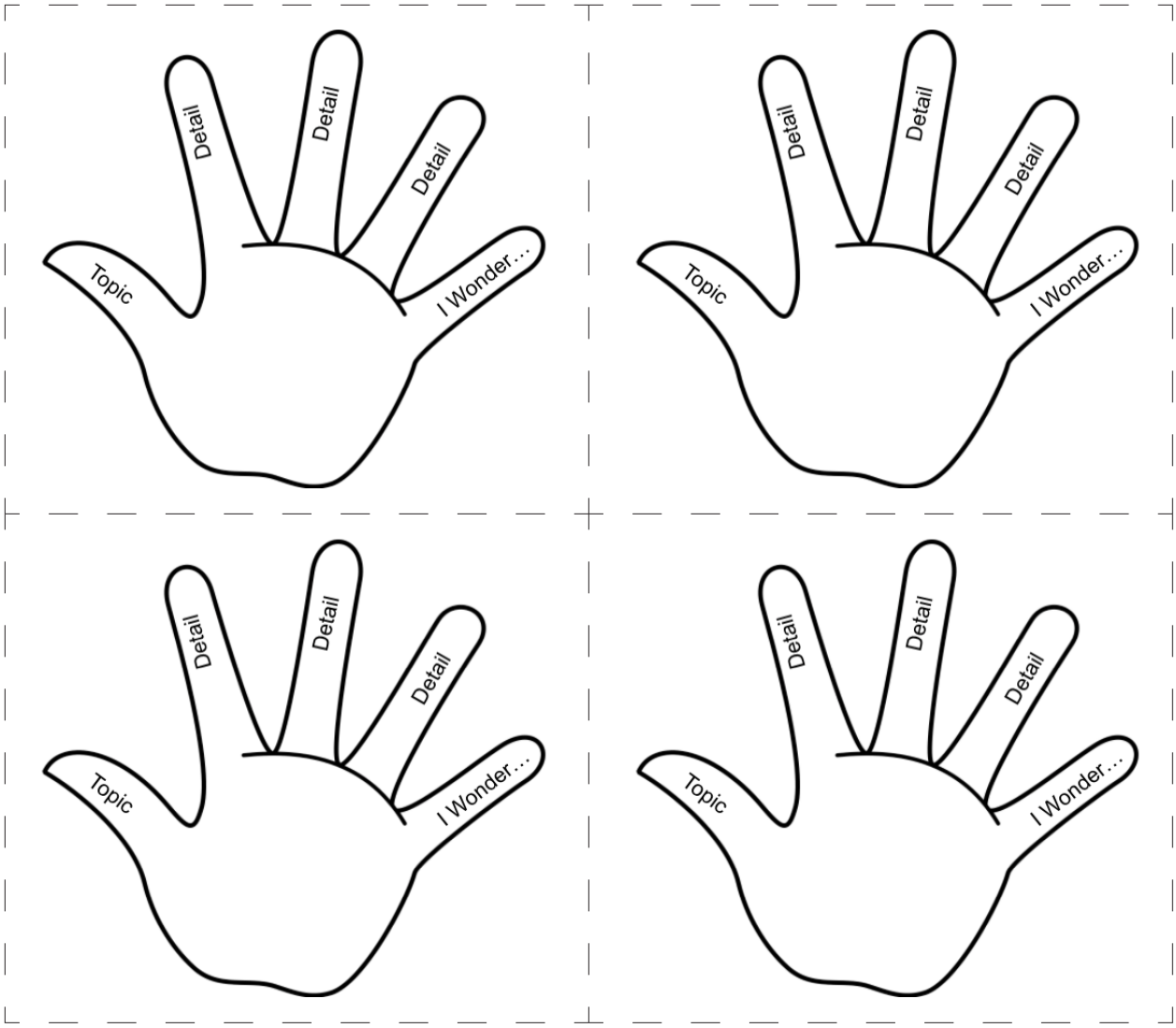
Students will fill in each finger as shown below:



INTERACTION AT A DISTANCE DATA COLLECTION

Number of Magnets in Stack	Number of Index Cards Used

FIVE FINGER SUMMARY



HOME CONNECTIONS

Parent/Guardian Background Information:

Magnets provide a simple way to explore force with students. The power of a magnet is somewhat like magic to them and requires exploration to understand. When forces act on or between objects, they do so in two significantly different ways. The first type of interaction involves touching; one object has to touch another object. Examples of this include a broom sweeping dry cereal on the floor, a bat hitting a ball, and a hand pulling on a doorknob. Most of our daily interactions involve this type of force: touching. The second type of interaction occurs over a distance. Examples of this include the Earth pulling on the moon, magnets attracting or repelling one another, and a charged balloon sticking to a wall. We certainly experience the force of gravity constantly in our daily lives and experience magnetic and electrostatic forces to a lesser degree. The activities listed below will allow you and your young scientist the opportunity to extend and apply what they have learned at school about magnetic forces.

Activities to do with your young scientist:

1. **Flat Magnet Activity:** One way for your young scientist to demonstrate and continue to explore the strength vs. distance phenomena involves the magnetic latches found on some cabinet doors. Help your young scientist unscrew a magnetic latch from a cabinet so you both can examine it. Even though you probably can't separate the magnet from its housing, your young scientist might be able to recognize the flat magnet that's bound inside the housing. Even in its housing, the magnet can be attached to steel objects and tested in a variety of ways to see how strong it is. Once you have taken the magnet off the cabinet, test its strength by trying to pick up various items (safety pin, screw, paperclip, etc.). Record your findings in a notebook or on a piece of paper.
2. **Cabinet Magnet Activity:** Most magnetic cabinet latches have adjustment screws that can be used to move the magnet closer or farther from the metal plate that is screwed to the door itself. Again with your supervision, have your young scientist vary this distance while pulling on the door to observe the change in force needed to pull the door open. Another factor that is easily changed is how much of the metal plate that is screwed to the cabinet door actually comes in contact with the magnet. Loosen the screw holding the plate to the door, rotate it to expose more or less of it to the magnet, and test each time to see how much force is needed to open the door. Record your findings in a notebook or on a piece of paper.
3. **Compass Magic Activity:** If a compass is available, you and your young scientist could begin to investigate the unique interaction between a magnet and compass. This could lead to discoveries about magnetic fields, polarity of magnets, and the strength of different types of magnets, if they are available.

HOME CONNECTIONS

4. **Magnetic Tape Activity:** Magnet Tape is adhesive on one side and magnetic on the other. Besides its practical use around the house, this tape could provide inquiry opportunities for your young scientist. If available, investigate the following:
    a. Can you increase its strength if you stack it in layers as your child did at school or you've perhaps done with the activity suggested above?
    b. Does putting two strips next to each other double the holding strength of one strip?
    c. Does a 20 cm length of this magnetic tape hold twice as much weight as a 10 cm length?