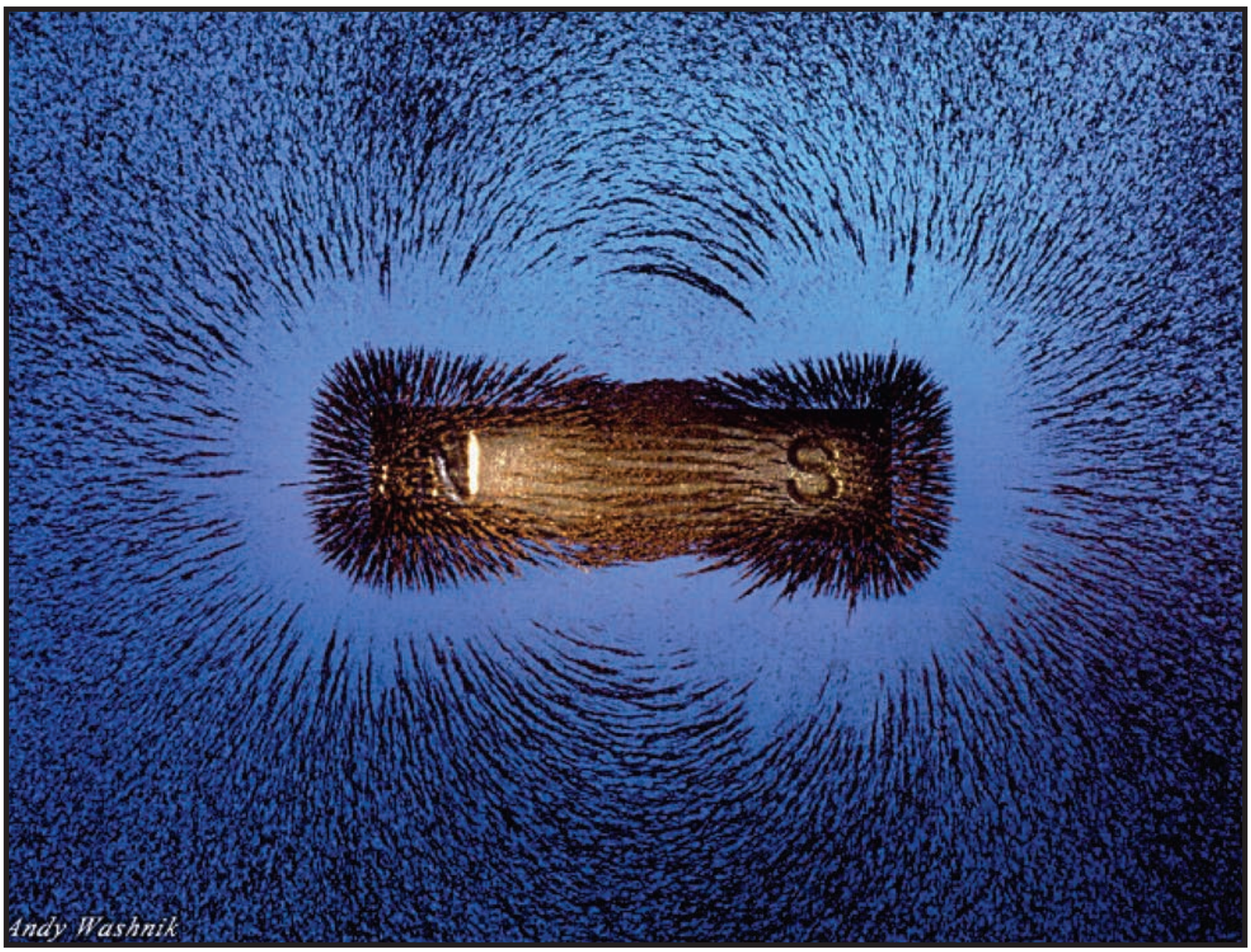
National Aeronautics and Space Administration

Mapping Magnetic Influence

An Educator's Guide with Activities in Physical Science



Educational Product	
Educators & Students	Grades 6-12

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http://son.nasa.gov/tass/pdf/Mapping_Magnetic_Influence.pdf

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Instructional Objectives

This lesson is designed to allow your students to explore magnets and to develop an operational definition of a magnetic “field” and an operational definition for magnetic “pole.”

Background

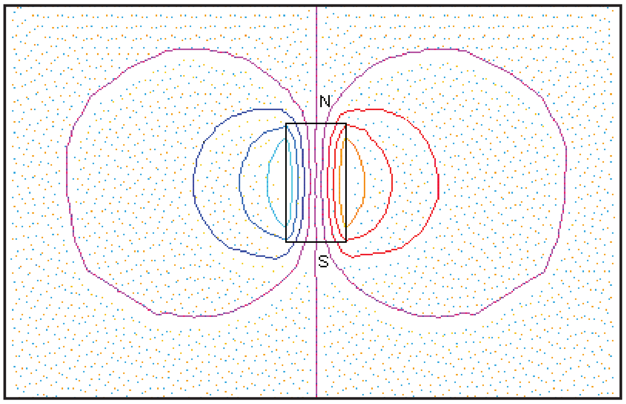
The picture on the cover shows fine iron filings oriented in the magnetic field surrounding a bar magnet. While this can be easily demonstrated for your class, many of the concepts associated with magnetism are difficult for many students. Many students do not understand what the magnet with iron filings is showing them.

Magnetism is one of a few fundamental phenomena in the universe. As we move a magnet slowly toward a metal surface, the attraction between the magnet and the metal can suddenly become very great. With a very strong magnet, the magnet and the metal may leap toward each other and be very difficult to separate. The strangest effect, however, is felt when two magnets are moved close together. Sometimes we feel the attraction, and sometimes there is an even stranger repulsion. When two ends of the magnets repel each other, it almost feels as if there is something between the magnets, pushing them apart. If we slowly move the repelling ends together, that mysterious repulsion gets stronger and can even push the magnets sideways rather than allow the magnets to touch. There is a force on the magnets, even though their surfaces never touch. This was called “action at a distance” in the 1600s and was very unsettling to many physicists including Sir Isaac Newton.

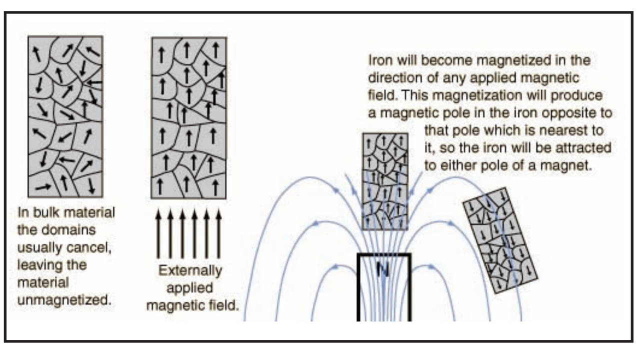
Most of us have experienced the strange effects of magnets, however, don’t assume that your students have. Research by Rosalind Driver (Driver, et al., p126–127) and Arnold Arons (Arons, p151) reveal that many students haven’t manipulated magnets and felt the effects with their own muscles and that very few students have experienced repulsion of two magnets. Moreover, your students will probably be as uncomfortable with “action at a distance” as the scientists in the 1600s were. Many students are very startled that magnets can exert a force on an object without physically touching the object (Arons, p65). The following explanation of magnetism is for you—not your students. They will need hands-on experiences like those of this lesson.

When you place a bar magnet under a sheet of glass or clear plastic and sprinkle iron filings on top of the glass, the very beautiful pattern on the cover of this lesson appears. The iron filings seem to follow certain lines in arcs from one end of the magnet to the other. Scientists began to recognize that there is a **region of influence** called a “field” in the space around a magnet. This invisible field is responsible for the “action at a distance”; that is, the magnet exerts a force on sensitive materials. The field is stronger near the magnet and weaker farther away. The field can be ‘felt’ or ‘seen’ when we push magnets together or sprinkle iron filings around the magnet. What we are really feeling is the force of repulsion or attraction, and what we see is the magnetic force causing the filings to move or rotate until they line up with the direction of the magnetic force in that location. But the field concept is useful and powerful.

Scientists began to draw this invisible field as lines around a magnet as in the drawing below. Scientists call the places where the field lines enter and emerge from the magnet the “poles of the magnet.” Scientists have agreed to an arbitrary convention that the field lines point from the north magnetic pole to the south magnetic pole. The field is strongest where the field lines are drawn closely together. The needle of a compass placed near this bar magnet will rotate until its north end points in the direction of the local magnetic field line and tangent to the line.



The above model is for a permanent magnet, such as a bar magnet. Bar magnets are examples of ferromagnets. The name comes from iron (ferric), the most common element to display this behavior, yet nickel, cobalt, chromium, and a few other elements are also ferromagnetic. While any atom with an unpaired electron can have a magnetic field, the atoms of these special elements act together in groups called "domains," locking together their magnetic poles. Each domain, ranging in size from 0.1 mm to 1.0 mm, is a tiny magnet. When an external magnetic field is applied under the right conditions, all of these domains are induced to line up creating a large magnet. In addition, ferromagnets tend to stay magnetized long after the external field is removed.



Courtesy of C.R. Nave (http://hyperphysics.phy-astr.gsu.edu/hbase/solids/ferro.html#2c)

Note: While you are working through these activities with your students, do not use the words 'field' or 'pole'. These words have very little meaning for your students. At the completion of the "Magnetic Map" activity you will be able to help your students to develop an operational definition of 'field' and 'pole'. Instead of 'magnetic field' this lesson uses the term 'magnetic influence'. Influence is a much more understandable term.

National Standards

Benchmarks for Scientific Literacy

- Without touching them, a magnet pulls on all things made of iron and either pushes or pulls on other magnets. 4G/2 (3–5)
  (Note: this is a prerequisite Bench mark for this lesson.)
- Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have. 4F/1 (3–5)
  (Note: this is a prerequisite Bench mark for this lesson.)
- Electric currents and **magnets can exert a force on each other**. 4G/3 (6–8)

National Science Education Standards

Grades K–4 (prerequisite standards for this lesson) Physical Science: Light, heat, electricity, and magnetism

- **Magnets attract and repel each other and certain kinds of other materials.**

Preparing for the Activities

Overview of Student Assignments

1. **Seeing Magnetism** is a journal assignment to start your students thinking about magnetic influence, which they will explore in more detail in this lesson. The students will react to a classroom demonstration of the effect of magnets on iron filings. It will reveal some of your students' ideas about magnetic influence.
2. **What Do You Know About Magnets** asks students to make predictions about magnets and magnetism. Students then test their predictions in very simple experiments. An important aspect of this activity is that students reflect on their predictions. This is an activity that exposes some of the critical ideas your students have about magnets and magnetism.
3. **Magnet Map** is the central activity of the lesson. Students will map the magnetic region around a source magnet and develop a better understanding of magnetic influence and develop an operational definition of a magnetic field and a magnetic pole.
4. **Model a Magnet** is an evaluative exercise to determine the students' understanding of magnetic influence. This activity is also an extension of the magnetic field concept.
5. **NASA Student Observation Network (SON)** These activities are designed to support the *Magnetosphere* program of the *Tracking a Solar Storm* module of *Student Observation Network*. <http://son.nasa.gov>. You may begin with SON as an engagement and theme to unite many scientific concepts, or you may choose to use SON as an extension of *Mapping Magnetic Influence*.

Materials List

Seeing Magnetism

Make your own 2-D overhead magnetic field demonstrator

- 15–30 cubic centimeters (2–3 tablespoons) iron filings (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** for $5.00 for a 1 pound bag)
- Bar magnet or cow magnet (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** $5 to $6)
- Plate of glass (at least 6"x6") or a heavy duty vinyl sheet protector (8.5" x 11")
- Overhead projector

What Do You Know About Magnets

- You will need to select an assortment of common materials. Include metals that are magnetic and some that are not, plastic, and natural products. You might have tacks, nails, pennies, straws, paper, corks, pieces of wood, paper clips, plastic spoons, etc.
- Bar magnet or cow magnet (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** $5 to $6)
- Nail (one that has never been magnetized)
- Paper clip
- Plastic, aluminum, or glass bowl
- Sewing needle
- Flat cork or small piece of Styrofoam
- Water

Magnetic Map (per group)

- Bar magnet or cow magnet (source magnet)
- Magnaprobe (test magnet) (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** $15)
- Large sheet of paper, at least 2 feet on edge
- Tape
- Wooden pencil

Model a Magnet (per group)

- 5–10 cubic centimeters of iron filings
- Compass
- Bar or cow magnet
- Test tube and cork stopper

Seeing Magnetism: Journal Assignment

Purpose

This journal assignment is designed to encourage your students to think about what they know about magnetism. It is also designed to help you to know the commonly held ideas of your students. This journal assignment and the following prediction activity, **What Do You Know About Magnetism**, should reveal much to you about their previous experience with magnetism and the ideas they have about magnets. The central activity of this lesson, **Magnet Map**, will allow them to explore the region of influence around a magnet. After the activity, students should have a better idea why the iron filings line up around the magnet. *Don't explain the demonstration to them!* You can come back to the demonstration and their journals at the end of the lesson and discuss what they have learned and how their ideas may have changed. Note the prerequisite standards for this activity!

Materials (choose one of the following)

Make your own 2-D overhead magnetic field demonstrator

- 15–30 cubic centimeters (2–3 tablespoons) iron filings (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** for $5.00 for a 1 pound bag)
- Bar magnet or cow magnet (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** $5 to $6)
- Plate of glass (at least 6"x6") or a heavy duty vinyl sheet protector (8.5" x 11")
- Overhead projector

Purchase 2-D magnetic field demonstrator

- 25 cm x 21 cm x 2 cm sturdy transparent acrylic case holds iron filings in a viscous fluid (available from Sargent-Welch 1-800-727-4368 catalog #CP30113-00 $37)

Purchase 3-D Magnetic Field Visualizer

- Closed transparent box with a transparent tube through the center. The box contains iron filings suspended in a viscous fluid. The magnet can be placed in center tube (available from Sargent-Welch 1-800-727-4368 catalog #CP31946-00 $112).

Procedure

Note: *It is absolutely essential that you* ***do not*** *set up the demonstration before the students are ready. The students must see the movement of the filings as the filings respond to the magnetic force. This is critical for them to realize that magnetism is a force (force causes change of motion).* ***Do not*** *give them answers. The journal is designed to get them to think through the connections.*

Hand out the journal assignment, **Seeing Magnetism**. Demonstrate the magnetic influence around the magnet. You will be able to project an image similar to the one on the front cover of the lesson. This can be easily accomplished by placing a piece of glass on top of the overhead projector and gently sprinkling fine iron filings on the glass. Because this can be messy if the iron filings get onto the magnet, you can also confine the filings in an 8.5” x 11” vinyl sheet protector and place that on top of the overhead projector instead of the glass. When the students are ready, place the bar magnet under the glass plate or sheet protector. The iron filings should **move** to line up with the magnetic field. You may have to gently tap the glass or sheet protector. If you use the 2-D demonstrator purchased from Sargent-Welch or a similar source, the 2-D demonstrator takes the place of the filings and glass plate or sheet protector. The glycerin in the demonstrator makes it easier for the filings to move when you place the magnet under the demonstrator.

You can also show that the magnetic influence surrounds the magnet by making a 3-D display or purchasing a 3-D Magnetic Field Visualizer. To make your own, get a test tube just a little bigger than your bar or cow magnet and a 16-oz soda bottle. Make sure the test tube has a beaded rim just a little larger than the bottle. Fill the soda bottle with mineral oil, glycerin, or baby oil and about 15 cubic centimeters (a tablespoon) of iron filings. Lower the test tube into the soda bottle. You may wish to seal the test tube bead to the test tube, between the test tube and the mouth of the bottle. Shake the bottle to distribute the iron filings. Slide the cow magnet carefully into the test tube. (If you drop the magnet into the test tube, you may break the bottom of the test tube.) Watch the iron filings line up all around the magnet, but outside the test tube.

After the students have observed carefully, have them complete the journal assignment. They may wish to have the demonstration repeated or to see the materials up close, so leave the demonstration in view while they work.

What Do You Know About Magnets?

Purpose

This activity will reveal much about your students’ previous experience with magnets and the ideas and knowledge they bring to this lesson. The activity also allows them to check their ideas experimentally. You should compare their responses to prerequisite Benchmarks or Standards and with common pre-conceptions that students hold about magnets (see Background). The activity is reproduced below. Normal text indicates what the student will read. The text in italics indicates notes for you.

Materials

- You will need to select an assortment of common materials. Include metals that are magnetic and some that are not, plastic, and natural products. You might have tacks, nails, pennies, straws, paper, corks, pieces of wood, paper clips, plastic spoons, etc.
- Bar magnet or cow magnet (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** $5 to $6)
- Nail (one that has never been magnetized)
- Paper clip
- Plastic, aluminum, or glass bowl
- Sewing needle
- Flat cork or small piece of Styrofoam
- Water

Note: The text in normal print, below, is for the students and the text in italics signifies notes to you.

What Do You Know About Magnets?

Predictions

The following several questions will help you to understand what you think about magnets and magnetism. After each question you will be asked to make a prediction. Don't do any research on the question. Don't experiment with magnets. Just make your prediction. In addition, you will be asked to explain why you think your prediction is true. You will only be graded on the completeness and thoroughness of your explanation. Whether your prediction is correct or not isn't important to your grade.

What materials will a magnet pick up?

You will need to select an assortment of common materials. Include metals that are magnetic and some that are not, plastic, and natural products. You might have tacks, nails, pennies, straws, paper, corks, pieces of wood, paper clips, plastic spoons, etc.

1. Use the list of materials provided to you to predict whether the object will be attracted to a magnet or not. Write the name of the object followed by **Yes** if it will be attracted to the magnet and **No** if it will not be attracted to the magnet.

   a. _______________ ________
   b. _______________ ________
   c. _______________ ________
   d. _______________ ________
   e. _______________ ________
   f. _______________ ________
   g. _______________ ________
   h. _______________ ________

2. Why are certain materials magnetic (attracted) and others are not?

   You are looking to see how well they have internalized prerequisite standards that they know there are special metals that have magnetic properties or are sensitive to magnets. The students might know that a magnet can influence iron-containing materials. They might even know about nickel and cobalt (AlNiCo magnets) or rare Earth magnets. While you might enjoy hearing your students discuss domains and unpaired electrons, they shouldn't have been exposed to these ideas yet (and they probably won't be exposed to them until A.P. Physics).

3. Explain why you think your predictions are true.

   You just want them to supply reasons. You want to understand what they are thinking and how they know what they know.

How can you make a magnet?

1. If you were given a bar magnet and a nail, how would you make the nail into a magnet? Describe your predicted method for making the nail a magnet.

   You can magnetize the nail by stroking the nail with the magnet or stroking the nail on the magnet. The directions given to the students in the experiment part of this activity are as follows:

   Lay the nail lengthwise on the magnet and stroke the nail along the magnet in one direction. Repeat this about 40 times. Be careful to only stroke the nail across the magnet in one direction! Don't move the nail back and forth. So, if you are stroking to the left, complete the stroke, then move the nail away from the magnet and move it to the right side of the magnet and stroke to the left again. You will be making a looping motion. Also, be sure that you don't turn the nail around. If the head of the nail is pointed left, make sure it always points left.

Some students may tell you that they can make the nail a magnet by wrapping the nail with electrical wire and connecting the ends of the wire to the terminals of a battery. They can make an electromagnet this way, and the class can explore this method after this lesson. It is very important for them to learn about the connection between moving electrical charges and magnetism, but this should wait. While acknowledging their knowledge as valid and important, make certain that they understand the method presented in this activity.

2. Explain why you think your predicted method will work. Did you hear or read it somewhere? Have you done it?

How can you make a compass?

1. Describe your predicted method for making a compass. Describe what materials you will need and how you would use it.

   Students often do not know that the needle of a compass is a magnet. The next activity explores the reaction of a magnet to the magnetic influence of a source magnet. This is exactly how a compass works. The magnetic needle of the compass is reacting to the magnetic influence of the Earth. If students suggested a different way to make a compass, have them test their method. They might find North by putting a stick in the ground and plotting the shadow of the stick through the day. The position of the shortest shadow will be North of the stick; however, this North and magnetic north may vary (depending on your location). Praise them for very clever thinking, and then stress the method developed in the experiment.

2. Explain why you think your prediction is true.

Magnet Map

Purpose

The students will discover how a test magnet acts in the region around a source magnet. They will learn that magnets exert a force on a magnetically sensitive object without coming into direct contact. They will learn that the test object will change its position until it is pointed in a particular direction. They will learn that that particular direction is different in different locations around the magnet. Students will create a map of the direction of the magnetic force around the magnet. They may even be able to discover that the magnetic force decreases as the test magnet is moved away from the source magnet. Careful investigation and thought will also lead the student to realize that the magnetic influence of the Earth dominates at some distance from the source magnet.

Materials (per group)

- Bar magnet or cow magnet (source magnet)
- Magnaprobe (test magnet) (available from Educational Innovations, 1-888-912-7474 or **www.teachersource.com** $15)
- Large sheet of paper, at least 2 feet on edge

- Tape
- **Wooden** pencil

Procedure

*The text in normal print, below, is from the student assignment. The text in italics signifies notes to you, and the **bolded italic** text indicates suggested correct student responses. It is strongly recommended that you lead the students through steps #1–11 and ask students to respond orally to questions posed in steps #1–7. It is also recommended that you use the text as a script—at least until you are very familiar with the language. Certain language is used and avoided to prevent misconceptions and to promote understanding. For example, it is imperative that you do not use the word 'field' until after the exploration is complete. Make certain that your students don't have magnetic metals near the Magnaprobe as they use it. Watches, jewelry, and pens can cause anomalies.*

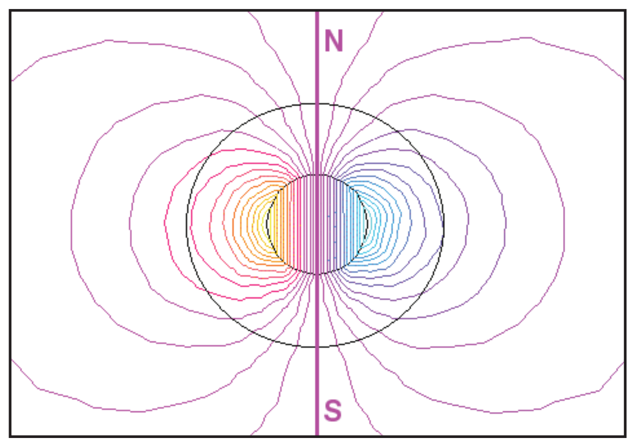
Exploring the properties of the Magnaprobe (Gently!)

1. The small piece of metal (red paint on one end and blue on the other) will be our test magnet. How do you know it is a magnet? ***It is a magnet because it attracts metal such as a paper clip.*** *Use the terminology 'test magnet' as much as possible and ask them to use that language also. This will help them to follow directions and interpret questions later.*

2. Hold the Magnaprobe with the handle horizontal and the pivoting parts free to move. Make certain that the Magnaprobe is well away from the source magnet. Describe the position and orientation of the test magnet in the Magnaprobe. Is it horizontal, vertical, or angled? Which way is the red end? ***The red end of the test magnet will point north and downward at an angle.*** *The students may only say that it points downward. Question them about direction, but let them supply the answers.*

3. Slowly rotate the handle to a vertical position watching the test magnet carefully. What happens to the orientation of the red end of the test magnet? ***The angle and orientation of the test magnet will remain the same as the handle of the Magnaprobe moves about.***

4. Propose a reason for the orientation of the test magnet in the Magnaprobe. ***The magnetism of the Earth is causing the test magnet to point North like the needle of a compass.*** *We generally think of the Earth's magnetic field as horizontal, but that is only because of the design of a compass.*



The drawing above represents the Earth and its magnetic field. The lines are horizontal only near the equator. Closer to the North Pole the lines dip downward. Students may propose that there is some magnetic source somewhere in or under the floor. This might be true if you have strong currents flowing in cables in your classroom. Ask them what that source might be.

If you have time, go outside and observe the orientation of the test magnet. Lead them gently to the understanding that the test magnet is responding to Earth's magnetic influence.

5. Holding the Magnaprobe with the handle horizontal, slowly bring one end of the source magnet (the cow magnet or bar magnet) toward the Magnaprobe. Describe what happens to the test magnet. *Students will have different responses to this question. For some the response will be, **"The red end points toward the source magnet."** For others the response will be, **"The blue end points toward the source magnet."***

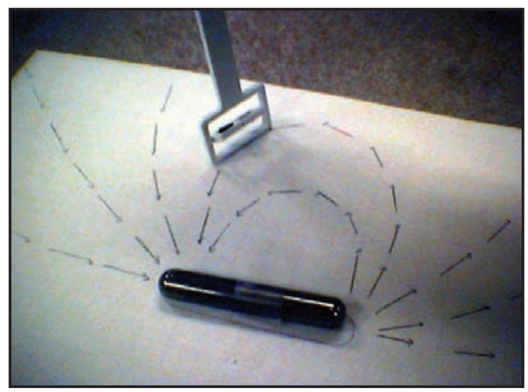
6. Now bring the other end of the source magnet toward the Magnaprobe. Describe what happens. ***The test magnet will flip over.***

7. Hold the source magnet horizontal and hold the Magnaprobe about 1–2 inches from the source magnet. Then move the Magnaprobe around, over, and under the source magnet. Describe what happens to the test magnet in the Magnaprobe. ***The test magnet will move around.** The test magnet is tracing out the magnetic field lines of the source magnet. Don't bring this up. Let the activity develop the concept. It is important that the students notice that the magnetic influence is all around the source magnet.*

8. Lay the large sheet of paper on a table. Make certain that you don't have any metal or extra sources of magnetism under the table. *Metal supports, computers, and lights or other current-carrying wires can be a problem. You should check for these influences by moving the Magnaprobe over the surfaces before the activity. Any sudden movement or change in the orientation of the test magnet means you have something that could interfere. (You may have to use the floor.)* Tape the paper securely to the surface. Put tape on the table at the corners of the paper so that you can place another paper in exactly the same location.

9. Draw an arrow on the paper pointing directly to some obvious landmark in the room and next to the arrow to indicate the object to which the arrow is pointing (for example, "the arrow is pointing to the clock").

10. Place the source magnet horizontally in the center of the paper. Tape it to the paper. Outline the position of the source magnet. The orientation you choose is not important.



The picture above shows the correct orientation of the Magnaprobe and a few sample lines. This Magnaprobe has a square frame; less expensive models have an oval frame. Demonstrate the correct orientation for your class. The edge of the large oval makes a good straight edge to draw the short line.

11. For the sake of continuity, we will call the red end of the test magnet the "front." Hold the Magnaprobe with the handle pointing toward the ceiling and the large oval resting on the paper near the source magnet. Keep the handle pointed to the

ceiling and turn the Magnaprobe until the large oval is parallel to the **test** magnet. Don't let your test magnet "hang out" of the oval—consider the oval to be the test magnet's "house" and don't let the test magnet get out of its house. (Only use a wooden pencil for this next operation.) Draw a short (1 centimeter) straight arrow pointing in the direction of the test magnet using the edge of the large oval that touches the paper. (Remember we chose the red end as the front.)

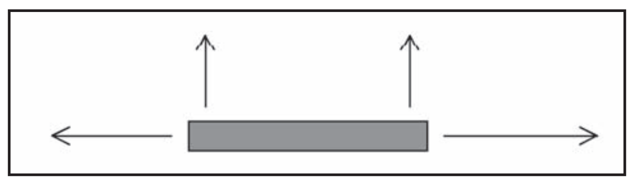
12. Move the Magnaprobe about 1 centimeter and repeat the process. Then move the Magnaprobe 1 centimeter again and repeat. Continue to do this for 20–30 minutes. You are trying to map the entire region around the source magnet, so make certain that you map all around the source magnet. If you have time left after you have mapped all around the source magnet, fill in the spaces between the arrows you have already drawn with more arrows obtained in the same way. A pattern should be apparent. If any arrows don't seem to fit the pattern, test that region again.

13. Hold the Magnaprobe away from the source magnet and lightly grasp the test magnet, small oval, and large oval between your thumb and forefinger. This will hold the test magnet parallel to the large oval. Place the large oval **perpendicular** to an arrow on the paper and let go of the test magnet. Do this several times in different places on your map.

    a. What happens?
    The test magnet quickly moves until it becomes parallel to the line. No matter where they place the Magnaprobe, the test magnet will end up aligned with the map line.

    b. Propose a reason.
    The source magnet exerts a force on the test magnet. Because the test magnet can only rotate, it will rotate until the force is in the same direction as the test magnet. The map line indicates the direction of the force. The assumption is being made that students have met the Benchmark. 4F/1 (3–5) (Changes in speed or direction of motion are caused by forces.) This step of the Procedure and Question #7 of the Data Analysis asks the student to make the connection between force causing a change in direction and what happens to the test magnet.

14. Start with the Magnaprobe near one end of the source magnet and move the Magnaprobe slowly away from the source magnet. Do this in several directions as indicated by the arrows in this drawing. (Note: this drawing is a view looking **down** on the source magnet.)



    Does the test magnet change direction at any point(s)? Is there any reason the test magnet might change direction? If there is any place where the test magnet changes direction, is this change indicated by the arrows on your map?

15. What happened in step 14 when the Magnaprobe got far from the source magnet (1 to 2 feet)? Were there any changes not consistent with the pattern around the source magnet? Propose a reason for this.

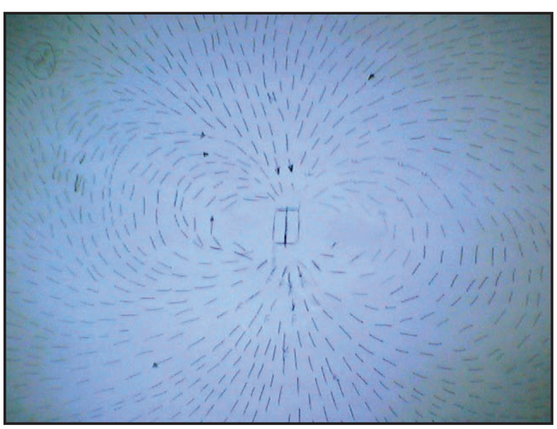
The magnetic influence of the source magnet will decrease as the test probe moves away from it. As the magnetic influence of the source magnet decreases, the influence of Earth's magnetism becomes more dominant. The Earth's magnetic influence doesn't go away near the source magnet; it just isn't as dominant. In addition, there may be other magnetic sources in the room as well. When two or more forces are applied to an object, the forces add together. Because forces are vectors, the forces add as vectors. If vectors are part of your curriculum, this would be a time to reinforce vector concepts. This reasoning applies to Questions #3, 4, and 5 of Data Analysis.

Data Analysis:

Write the answers to the following questions in your lab notebook.

1. Are all of the arrows on your map pointing in the same direction? Why or why not?

2. What is the general pattern? Describe the pattern as accurately and as completely as you can. Where do the lines start and end? *Use this question to develop an operational definition of a magnetic pole.*



This picture shows a completed map. Only a few lines show the arrow; your students' map will have an arrow at the end of every line. The upper left corner shows a region where the Earth's magnetic field dominated that of the source magnet.

3. Are there any arrows that don't seem to fit the pattern? Where are they and how would you account for the lack of fit?

4. Are there any other magnetic influences in the area of the source magnet (besides the source magnet)? What is/are the source(s) of this magnetic influence? (Hint: Think of steps #2, #3, #4, and #14 in the Procedure.)

5. What do you think would be the result of two sources of magnetism in the same region?

6. The arrows make a map. What is it a map of? *When you discuss the Data Analysis, this is a good time to introduce the concept of a field as a region of influence. The lines show the direction the test magnet will point. The source magnet exerts an influence or force on the test magnet. The map shows the direction of the force.*

7. In step #13 of the Procedure, the test magnet changed its direction when it was put near the source magnet. What is necessary for an object to change its direction? What does this tell you about a magnet? *A force is necessary to change the speed and direction of an object. The magnet exerts a force on magnetic materials.*

Conclusion

The arrows you drew, and the map they made, constitute data. Write a conclusion that interprets your data. Use answers to questions asked in the Procedure and in the Data Analysis to help you think about the Conclusion. In your Conclusion, you should be able to explain the region around a magnet.

Model a Magnet

Purpose

Students will use what they have learned in previous activities to explain this activity. Students will construct a model of a magnet. Students will show how aligning the domains creates a magnet. Students will prove that the aligned domains are a magnet, and by destroying the alignment, the magnetic effects are also destroyed. They are expected to explain using field concepts.

Materials (per group)

- 5–10 cubic centimeters of iron filings
- Compass
- Bar or cow magnet
- Test tube and cork stopper.

Procedure

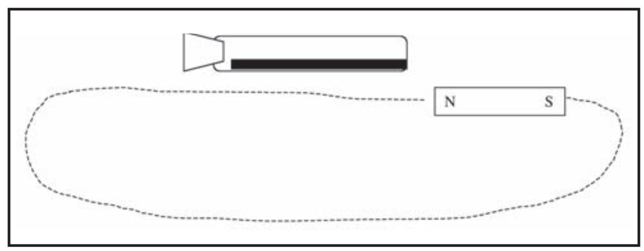
The following is meant to be a sample of a teacher-led classroom discussion. You as the teacher will probably need to demonstrate the procedure to the students. Specific questions you should ask are indicated by the word "Ask" with the question in quotation marks. Correct student responses are indicated by bold italic type.

Add about 2 centimeters of iron filings to the test tube. Seal the end of the test tube with a stopper. Hold the test tube horizontal (level) and carefully shake the tube until the iron filings are lying evenly along the bottom. While keeping the tube level, bring the tube near the compass. How is the compass needle affected by the test tube of iron filings? ***The compass is not affected.***

Move the test tube around near the compass. Do you see any effects? ***No***.

Describe the way that the filings lay along the test tube. ***The filings are randomly arranged.***

While the test tube is still held level, hold a bar magnet under the test tube and pass it from one end of the test to the other. Start with the north pole of the bar magnet near the end of the test tube and move the length of the magnet along the test tube until it is well past the other end of the test tube. Then loop the bar magnet around to its original position without turning the magnet. Do this 10 times. Continue to hold the test tube level and don't shake it!



What did you notice happening to the iron filings? Describe the way the filings are laying. ***The filings are all parallel to the length of the test tube.***

Without shaking or tilting the test tube, bring it near the compass. Ask, "What effect does the test tube have on the compass now? Try both ends of the test tube near both the north and south pointer of the compass." ***The test tube will now act as a magnet.***

Next, shake up the test tube and then with it level, shake the filings along the bottom again as you had them initially. Bring the test tube near the compass again. Ask, "Are the iron filings now acting like a magnet?” ***No, the compass is not unaffected.***

Students will now explain what is happening in writing. This is an evaluation of their understanding of the concepts explored. *See the Purpose and pages 3 and 4 for explanation.*

Bibliography

Arons, Arnold B. A *Guide to Introductory Physics Teaching*. New York: John Wiley & Sons, 1990.

Driver, R., Squires, A., Rushworth, P., Wood-Robinson, V., *Making Sense of Secondary Science: Research into Children’s Ideas*, UK: RoutledgeFalmer, 1994.

Draft for field testing

All lessons have been field tested over several years in a high school classroom. In addition, Mapping Magnetic Influence has been presented to many groups of teachers. We hope, however, that your comments and suggestions will help us to improve the instructional value of this unit. Please contact Don Robinson-Boonstra at **Donald.W.Robinson-Boonst.1@gsfc.nasa.gov** with comments and questions.

National Aeronautics and Space Administration

Mapping Magnetic Influence

An Educator's Guide with Activities in Physical Science

Educational Product	
Educators & Students	Grades 6-12

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Seeing Magnetism

Please answer the following questions in your journal as completely as you can. Your entry will be evaluated on the thoughtfulness of your answer and the reasoning you give in support of your answer.

Your teacher will demonstrate the interaction of very fine bits of iron called “iron filings” and a magnet. Draw and briefly describe what you see. Please observe closely and answer these questions.

1. Something is required to change the speed or direction of any object. That something is required to make a car go faster. It is required to make a baseball slow down when it hits the bat and then go in the opposite direction. It is required for the Earth to move in a (nearly) circular orbit around the Sun instead of flying off in a straight line into space. What is the something required to change the speed and direction of any object?

2. What is required to make the iron filings react as they did when they are brought near the magnet?

3. Is anything touching the iron filings and making them react around the magnet?

4. Why do the iron filings act the way they do around the magnet?

What Do You Know About Magnets?

Predictions

The following several questions will help you to understand what you think about magnets and magnetism. After each question you will be asked to make a prediction. Don't do any research on the question. Don't experiment with magnets. Just make your prediction. In addition, you will be asked to explain why you think your prediction is true. You will only be graded on the completeness and thoroughness of your explanation. Whether your prediction is correct or not isn't important to your grade.

What materials will a magnet pick up?

1. Use the list of materials provided to you to predict whether the object will be attracted to a magnet or not. Write the name of the object followed by **Yes** if it will be attracted to the magnet and **No** if it will not be attracted to the magnet.

   a. ______________ ________
   b. ______________ ________
   c. ______________ ________
   d. ______________ ________
   e. ______________ ________
   f. ______________ ________
   g. ______________ ________
   h. ______________ ________

2. Why are certain materials magnetic (attracted) and others are not?

   ____
   ____
   ____
   ____

3. Explain why you think your predictions are true.

   ____
   ____
   ____
   ____

How can you make a magnet?

4. If you were given a bar magnet and a nail, how would you make the nail into a magnet? Describe your predicted method for making the nail a magnet.

5. Explain why you think your predicted method will work. Did you hear or read it somewhere? Have you done it?

How can you make a compass?

6. Describe your predicted method for making a compass. Describe what materials you will need and how you would use it.

7. Explain why you think your prediction is true.

Prediction Reflection

Now perform some experiments to determine if your prediction is correct. It isn't so important that you were right or wrong, however, it can be very helpful to your understanding of the concepts if you understand why your prediction matched or did not match the experimental outcome.

What materials will a magnet pick up?

Materials

- Materials from the original list
- Bar magnet

Procedure

1. Collect the materials

2. Touch the bar magnet to each object. Is the object attracted? That is, does the object "stick" to the magnet? Write the name of the object below followed by **Yes** if it is attracted to the magnet and **No** if it is not attracted to the magnet.

   a. ______________ ________
   b. ______________ ________
   c. ______________ ________
   d. ______________ ________
   e. ______________ ________
   f. ______________ ________
   g. ______________ ________
   h. ______________ ________

Were your predictions correct? If any predictions were not correct, why do you think you made an incorrect prediction? What experience or information led you to an incorrect prediction? What experiences led you to make the correct predictions?

How can you make a magnet?

Materials

- Bar magnet
- Nail (one that has never been magnetized)
- Paper clip

Procedure

1. Touch the nail to the paper clip to see if they are attracted to each other. (If they are, get a new nail.)

2. Lay the bar magnet on the table.

3. Lay the nail lengthwise on the magnet and stroke the nail along the magnet in one direction. Repeat this about 40 times. Be careful to only stroke the nail across the magnet in one direction! Don't move the nail back and forth. So, if you are stroking to the left, complete the stroke, then move the nail away from the magnet and move it to the right side of the magnet and stroke to the left again. You will be making a looping motion. In addition, be sure that you don't flip the nail around. If the head of the nail is pointed left, make sure it always points left.

4. Now try picking up the paper clip with the nail.

5. Does it work? What does that tell you about the nail?

Is this the procedure you predicted? ______________________________

Is this very close to the procedure you predicted? ______________________________

Try your procedure with a new nail. Does your procedure work? ______________________________

What does your prediction tell you about your ideas about magnetism? (Remember, it is all right to predict a procedure that doesn't work. This just helps you to understand what you know and don't know about magnetism.)

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How can you make a compass?

Materials

- Plastic, aluminum, or glass bowl
- Sewing needle
- Flat cork or small piece of Styrofoam
- Bar magnet
- Water

Procedure

1. Fill the bowl with enough water to easily float the cork or Styrofoam.

2. Lay the needle on the cork or Styrofoam and make sure it floats and balances on the cork or Styrofoam.

3. Gently point the needle in various directions, waiting for it to settle. What happens?

4. Take the needle off the cork or Styrofoam and stroke the needle on the magnet about 40 times the same way you did with the nail in the last experiment.

5. Repeat steps #2 and #3.

6. What have you made? Why? ______________________________

____

____

Is this the procedure you predicted?______________________________

Does your procedure work? Did you test it? ______________________________

What does your prediction tell you about your ideas about magnetism?

____

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Magnet Map

Question

How does a test magnet act in the region around a source magnet? What does the reaction of the test magnet tell you about the region around the source magnet?

Materials (per group)

- Bar magnet or cow magnet (source magnet)
- Magnaprobe (test magnet)
- Large sheet of paper, at least 2 feet on edge
- Tape
- Pencil

Procedure

Exploring the properties of the Magnaprobe (Gently!)

1. The small piece of metal (red paint on one end and blue on the other) will be our test magnet. How do you know it is a magnet?

___

___

___

2. Hold the Magnaprobe with the handle horizontal and the pivoting parts free to move. Make certain that the Magnaprobe is well away from the source magnet. Describe the position and orientation of the test magnet in the Magnaprobe. Is it horizontal, vertical, or angled? Which way is the red end?

___

___

___

3. Slowly rotate the handle to a vertical position watching the test magnet carefully. What happens to the orientation of the red end of the test magnet?

___

___

___

4. Propose a reason for the orientation of the test magnet in the Magnaprobe.

5. Holding the Magnaprobe with the handle horizontal, slowly bring one end of the source magnet (the cow magnet or bar magnet) toward the Magnaprobe. Describe what happens to the test magnet.

6. Now bring the other end of the source magnet toward the Magnaprobe. Describe what happens.

7. Hold the source magnet horizontal and hold the Magnaprobe about 1–2 inches from the source magnet. Then move the Magnaprobe around, over, and under the source magnet. Describe what happens to the test magnet in the Magnaprobe.

8. Lay the large sheet of paper on a table. Make certain that you don't have any metal or extra sources of magnetic fields under the table. You can check for these influences by moving the Magnaprobe over the surface of the paper. Any sudden movement or change in the orientation of the test magnet means you have something under your paper that could interfere. Move your paper to avoid this. (You may have to use the floor.) Tape the paper securely to the surface. Put tape on the table at the corners of the paper so that you can place another paper in exactly the same location.

9. Draw an arrow on the paper pointing directly to some obvious landmark in the room and next to the arrow to indicate the object to which the arrow is pointing (for example, "the arrow is pointing to the clock").

10. Place the source magnet horizontally in the center of the paper. Tape it to the paper. Outline the position of the source magnet. The orientation you choose is not important.

11. For the sake of continuity we will call the red end of the test magnet the front. Hold the Magnaprobe with the handle pointing toward the ceiling and the large oval resting on the paper near the source magnet. Keep the handle pointed to the ceiling and turn the Magnaprobe until the large oval is parallel to the **test** magnet. Don't let your test magnet "hang out" of the oval. (Only use a wooden pencil for this next operation.) Draw a short (1 centimeter) straight arrow pointing in the direction of the test magnet using the edge of the large oval that touches the paper. (Remember we chose the red end as the front.)

12. Move the Magnaprobe about 1 centimeter and repeat the process. Then move the Magnaprobe 1 centimeter again and repeat. Continue to do this for 20–30 minutes. You are trying to map the entire region around the source magnet, so make certain that you map all around the source magnet. If you have time left after you have mapped all around the source magnet, fill in the spaces between the arrows you have already drawn with more arrows obtained in the same way. A pattern should be apparent. If any arrows don't seem to fit the pattern, test that region again.

13. Hold the Magnaprobe away from the source magnet and lightly grasp the test magnet, small oval, and large oval between your thumb and forefinger. This will immobilize the test magnet in a position parallel to the large oval. Place the large oval *perpendicular* to an arrow on the paper and let go of the test magnet. Do this several times in different places on your map.

    a. What happens? ____

    ____

    ____

    b. Propose a reason. ____

    ____

    ____

14. Start with the Magnaprobe near one end of the source magnet and move the Magnaprobe slowly away from the source magnet. Do this in several directions as indicated by the arrows in this drawing. (Note: this drawing is a view looking **down** on the source magnet.)

Does the test magnet change direction at any point(s)? Is there any reason the test magnet might change direction? If there is any place where the test magnet changes direction, is this change indicated by the arrows?

15. What happened in step 14 when the Magnaprobe got far from the source magnet (1 to 2 feet)? Were there any changes not consistent with the pattern around the source magnet? Propose a reason for the change in direction, if there is one.

Data Analysis

Write the answers to the following questions in your lab notebook.

1. Are all of the arrows on your map pointing in the same direction? Why or why not?

2. What is the general pattern? Describe the pattern as accurately and as completely as you can. Where do the lines start and end?

3. Are there any arrows that don't seem to fit the pattern? Where are they and how would you account for the lack of fit?

4. Are there any other magnetic influences in the area of the source magnet (besides the source magnet)? What is/are the source(s) of this magnetic influence? (Hint: Think of steps #2, #3, #4, and #14 in the Procedure.)

5. What do you think would be the result of two sources of magnetism in the same region?

6. The arrows make a map. What is it a map of?

7. In step #13 of the Procedure, the test magnet changed its motion when it was put near the source magnet. What is necessary for an object to change its motion? What does this tell you about a magnet?

Conclusion

The arrows you drew, and the map they made, constitute data. Write a conclusion that interprets your data. Use answers to questions asked in the Procedure and in the Data Analysis to help you think about the Conclusion. In your Conclusion, you should be able to explain the region around a magnet.

Model a Magnet

Purpose

Use what you have learned in this lesson to explain this activity.

Materials

- Iron filings
- Compass
- Bar or cow magnet
- Test tube and cork stopper

Procedure

Follow your teacher's demonstration and observe carefully. You will be asked to explain what is happening.

1. Add about 2 centimeters of iron filings to the test tube. Seal the end of the test tube with a stopper.

2. Hold the test tube horizontal (level) and carefully shake the tube until the iron filings are lying evenly along the bottom. While keeping the tube level bring the tube near the compass.

How is the compass needle affected by the test tube of iron filings?

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3. Move the test tube around near the compass.

Do you see any effects? ______________________________

Describe the way that the filings lay along the test tube.

____

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4. While the test tube is still held level, hold a bar magnet under the test tube and pass it from one end of the test to the other. Start with the north pole of the bar magnet near the end of the test tube and move the length of the magnet along the test tube until it is well past the other end of the test tube. Then loop the bar magnet around to its original position without turning the magnet. Do this 10 times. Continue to hold the test tube level and don't shake it!

What did you notice happening to the iron filings? Describe the way the filings are laying.

5. Without shaking or tilting the test tube, bring it near the compass.

What effect does the test tube have on the compass now? Try both ends of the test tube near both the north and south pointer of the compass.

6. Shake up the test tube, and then with it level, shake the filings along the bottom again as you had them initially. Bring the test tube near the compass again.

Are the iron filings now acting like a magnet? ______________________________

Explanation

Use your experience from the last several activities to explain what happened in this activity. You will be evaluated on the completeness and thoroughness of your answer and how well you use the concepts you have developed in the lesson on Magnetic Mapping.