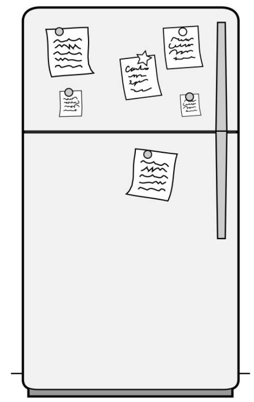
ACTIVITY 2: Exploring Magnetic Effects

Purpose

You are no doubt familiar with some magnetic phenomena, like using a magnet to hold paper on a refrigerator door, or using a compass to navigate. However, could you explain to someone else how these work? In this unit you will first investigate some phenomena involving magnets to establish their basic properties, and then develop a model that can explain your observations and be used to make predictions for new experiments.



What are some properties of magnetic interactions?

Initial Ideas

At some point in the past, you have probably played with a magnet and tried to use it to pick up various objects. You may also have played with a pair of magnets and observed how they interact with each other. Think back to those experiences and discuss with your group as you answer the following questions.

What materials do you think a magnet could pick up; all materials, only metals, or only some specific materials? Why do you think so?

If you were to hold a magnet in each of your hands and bring them close together, what do you think you would feel? Would your answer depend on which parts of the magnets were close to each other? Draw diagrams to illustrate your thinking.

Sketch your group's diagrams on a presentation board and participate in a whole class discussion about the answers to these questions. Make a note of any ideas that are different from those of your group.

Collecting and Interpreting Evidence

Your group will need:

- 1 bar magnet
- 2 disk magnets
- Set of different materials
- three nails
- small float
- aluminum pie tin or deep Styrofoam plate
- container for collecting and pouring water (or easy access to faucet/sink)
- compass

Please keep the three magnets far away from all the other materials until you are directed to use them. (On the floor would be a good place, but please don't drop them as they break easily)

Exploration #1: How do magnets interact with other materials and with each other?

In this exploration you will test various materials to determine if they interact with a magnet and also test how two magnets interact with each other.

STEP 1. Take one item from the set of materials, and record its name in Table I below. Bring each end of the bar magnet close to the material and record in the table whether the material is attracted to (A), repelled by (R), or shows no reaction to (O) each end of the bar magnet. Test all of the materials in your kit in the same way. You may also check other materials you are curious about.

Record your results in the Table.

Table I: Observations with Magnet and Materials

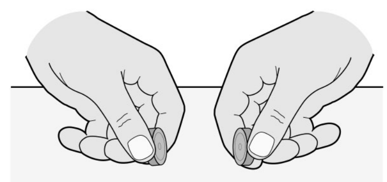
Material	Reaction to one end of magnet?	Reaction to other end of magnet?

STEP 2. Look over the data you recorded in Table I.

Are all metals attracted to a magnet? If not, what materials do seem to be attracted to a magnet? Does this result surprise you?

Scientists call materials that are attracted to a magnet, *ferromagnetic materials*. Iron is the most common ferromagnetic material, and objects or materials that include iron in them (like steel) are also ferromagnetic. (Nickel and cobalt are also examples of ferromagnetic materials.) Magnets themselves are also made of ferromagnetic materials.

STEP 3. Take the two small disk magnets in your hands and bring their faces together slowly, but try not to let them touch each other.



Describe what you feel as they approach each other.

Now turn **one** of the magnets over and bring them together again.

Do they behave in the same way as before, or do you feel something different? If so, what?

When scientists study the natural world they focus their attention on different types of interactions between objects. When two objects interact they *act on* or *influence* each other in some way. In this course you will be studying many different types of interactions. The interactions you saw above, between two magnets, and also between a magnet and a ferromagnetic material, are examples of what we will call a ***magnetic interaction***.

How is the magnetic interaction between two magnets different from the magnetic interaction between a single magnet and a ferromagnetic material that is not itself a magnet?

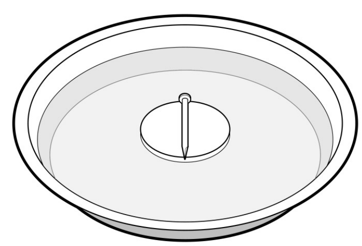
In the rest of this activity, you will use iron (or steel) nails to explore some important properties of the magnetic interaction. To start, you will check whether a nail can itself be turned into a magnet.

You will not need the two disk magnets or the sample materials for the rest of this activity, so it is best to put them away now.

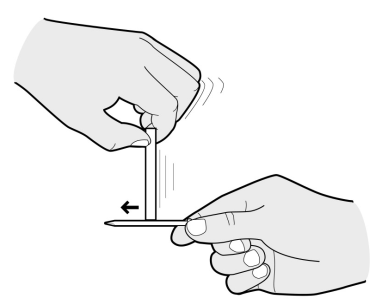
Exploration #2: What happens when a nail is rubbed with a magnet?

In this experiment you will distinguish between two types of nails: those that are rubbed with a magnet (called *rubbed*), and those that are not rubbed with a magnet (called *unrubbed*). Initially all your nails should be *unrubbed*.

Please keep the bar magnet far away from the iron nails until you are directed to use it. Once you rub a nail, it is no longer "unrubbed." Please do *not* rub the nails until you are asked to do so.



STEP 1. To make a sensitive detector, place the dish on the table with enough water in it to fill it to a depth of about one-half inch. Place the small float in the water and put one of the **unrubbed** nails on it. The nail may stick out more than the one shown here in the figure. (If it does not float freely you may need to add a little more water to the dish.)

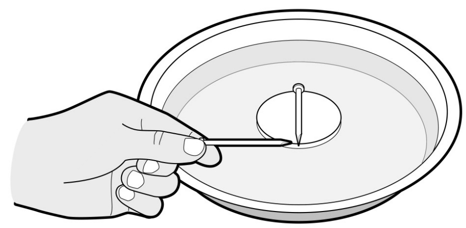


STEP 2. Now make a **rubbed** nail as follows. Far away from the floating nail, pick up a second **unrubbed** nail and hold it horizontally at its head end. (The end you would hit with a hammer.) Pick up the bar magnet, hold it at right angles to the

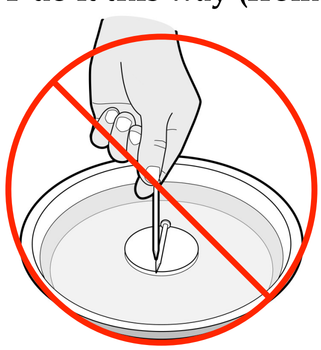
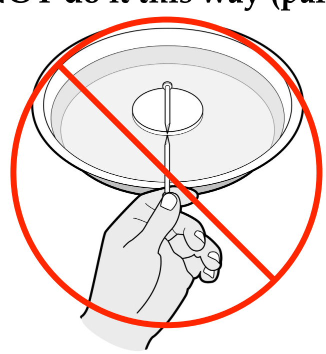
nail and slide one end of the magnet (either end is OK) **<u>all the way from the head to the point end of the nail</u>**. Then lift up the bar magnet and repeat this a few more times, always sliding it in the same direction (**<u>not</u>** back and forth). (Your instructor may demonstrate this technique for the class. If you are still not sure about how to do this ask for help.)

After you have rubbed the nail, be sure to place the magnet back in its 'safe' location.

STEP 3. You will now investigate how this rubbed nail interacts with the floating unrubbed nail by doing the following.
Hold the rubbed nail horizontally in your hand, and bring its tip **close to** (but not touching) the floating unrubbed nail. See picture to the right showing that the held nail should be **<u>horizontal</u>** (just above and parallel to the surface of the water) and at **<u>right angles</u>** to the floating nail.



Always test held and floating nails this way. Do not bring the held nail downward from above (picture below to the left), and do not bring it parallel to the floating nail (see picture below to the right).

Do NOT do it this way (from above)	**Do NOT do it this way (parallel)**
	

What, if anything, happens to the tip of the floating unrubbed nail? Is it attracted, repelled, or does it show no reaction? Record your observation in the appropriate box in Table II on the next page.

Next, bring the point end of the rubbed nail near the head end of the unrubbed nail and again record your observation in Table II.

Table II: Interactions between Rubbed and Unrubbed Nails (A, R or O)

	Point end of **unrubbed** nail	Head end of **unrubbed** nail
Point end of (held) magnet-rubbed nail		
Head end of (held) magnet-rubbed nail		

Finally, bring the head end of the rubbed nail near the point end of the unrubbed nail, and then bring it near the head end of the unrubbed nail. Again, record both observations in Table II.

Do the two ends of the **unrubbed nail** behave the same way or differently when each end of the magnet-rubbed nail is brought nearby?

STEP 4. Lay the rubbed nail aside for a moment. ***Imagine*** that you removed the floating nail, rubbed it with the magnet in **exactly the same way** that you rubbed the other nail, and then floated it again. (**DON'T DO IT YET!**) You would then have two rubbed nails—one held and one floating.

Predict what you think would happen if you were to bring the tip of the held **rubbed** nail near the tip of the floating **rubbed** nail.

Predict what you think would happen if you were to bring the tip of the held **rubbed** nail hear the head of the floating **rubbed** nail.

Now remove the floating nail, rub it with the magnet, and replace it on the floater. Then test your predictions.

Repeat the same set of four tests that you did in STEP 3 with the two rubbed nails. Record your observations in Table III below.

Table III: Interactions between Two Rubbed Nails (A, R or O)

	Point end of **magnet-rubbed** nail	Head end of **magnet-rubbed** nail
Point end of (held) magnet-rubbed nail		
Head end of (held) magnet-rubbed nail		

Do the two ends of the magnet-rubbed floating nail behave the same way or differently when each end of the magnet-rubbed nail is brought nearby?

Based on your observations, would you claim that rubbing a nail in the way you did turned it into a magnet, or does it still behave like a ferromagnetic material that is not itself a magnet? What evidence supports your answer?

When a nail (or any other object made of a ferromagnetic material) is rubbed with a magnet and behaves in the same way as you observed above, we say it is ***magnetized***. Therefore, from now on we will refer to a 'rubbed nail' as a 'magnetized nail,' and an 'unrubbed nail' as an 'unmagnetized nail.'

Some magnetized objects retain their magnetism for very long periods of time, and we call them *permanent magnets*. The bar magnet you are using is probably made from alnico, an alloy of iron with **al**uminum, **ni**ckel and **co**balt, that is a good permanent magnet. Other ferromagnetic materials, which tend to loose their magnetism easily after being magnetized are sometimes called *temporary magnets*.

STEP 5. Suppose you were to touch a magnetized nail all over with your fingers.

Do you think the nail would still be magnetized after you did this, or would it act more like an unmagnetized nail now? Why do you think so?

Now test your thinking by touching one of your magnetized nails all over with your fingers. Place it on the float and test its ends with your second magnetized nail.

Was the nail still magnetized after you touched it all over or not?

Now suppose you dropped a magnetized nail in water. Do you think the nail would still be magnetized after you did this, or not? Why do you think so?

Again, test your thinking by dropping one of your magnetized nails in your pan of water. Then place it on the float and test its ends with another magnetized nail.

Was the nail still magnetized after it was immersed in water, or not?

Exploration #3: Does a magnetized nail interact with anything when there is no other magnet or nail nearby?

In the previous experiment you discovered that a magnet-rubbed nail itself becomes magnetized. Consider floating such a magnetized nail. If you do not bring another nail or magnet nearby, does anything interesting happen to the floating magnetized nail? You will answer that question in this experiment.

STEP 1. Place a **magnetized** nail on the floater, making sure the other rubbed nail and the bar magnet are far away. Now do the following several times. (You may have to wait up to a minute each time for the nail to settle into a stable position.)

- Aim the floating nail in different directions in the middle of the pan, then release it and wait until it settles into a stable position. (Make sure the floater does not get 'stuck' against the side of the pan while this is happening.)

- Spin the floating rubbed nail gently, and again wait until it settles into a stable position.

Your instructor will point out the approximate directions for north, south, east and west.

Does the floating magnetized nail end up pointing in a different direction each time, or does it always seem to end up pointing in the same direction? If so, in which direction does the pointed end of the nail seem to 'want' to point?

Compare your observations with that of several other groups.

What is the same (if anything)? What is different (if anything)?

Whenever a rubbed nail, or any magnet, is allowed to rotate freely, without another magnet nearby, one end will always end up pointing (approximately) towards the geographical North Pole of the Earth. By mutual agreement, scientists **define** this end of the magnet as the ***north-seeking pole*** (or N-pole for short) of the magnet. The opposite end of the magnet, by definition, is called the ***south-seeking pole*** (S-pole). (Your bar magnet may already have its ends labeled as N and S to signify this.) Thus, when you rub your nail you turn it into a magnet with a N-pole and a S-pole.

Is the tip (pointed) end of your group's floating magnetized nail a N-Pole or a S-Pole? What about the head end?

STEP 2: Place your compass on the table, far away from the bar magnet and magnetized nails. The needle in the compass is made of a special ferromagnetic material that has been magnetized and retains its properties for a long time; i.e. it is a small permanent magnet.

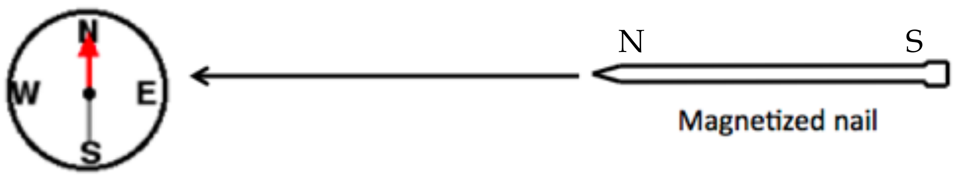
The compass needle is free to pivot, and so one end of the needle will always point towards geographic north—and by definition, that is the N-pole of the compass needle. (Notice that, in effect, your floating magnetized nail is also a compass needle.)

Which end of <u>**your**</u> compass needle is a N-pole, the colored tip or the uncolored tip? (Do not rely on the labels on the compass itself. Instead, use the directions indicated by your instructor in STEP 1 to help you.)

Exploration #4: How do the poles of two magnets interact with each other?

STEP 1: Lay your compass on the table and rotate it so that the N-pole end of the compass needle is aligned with the "N" marking (for the North direction) on the casing of the compass (as in the picture above).

Suppose you were to lay one of your magnetized nails on the table with its N-pole pointing towards the "E" (for East) label on the compass and then slide the nail toward the compass, as shown in the picture below. [***Note: Your magnetized nail may have its N-pole at its head end, in which case you would slide its head end toward the compass.***]



Predict what you think would happen to the compass needle when you do this. Will the **N-pole of the compass needle** rotate toward the nail, away from the nail, or not move at all? Why do you think so?

STEP 2. Now test your prediction by sliding the N-pole of your magnetized nail towards the East label on the compass needle.

What happens to the N-pole of the compass needle? Is it attracted to or repelled by the N-pole of the nail?

Move your magnetized nail away from the compass and turn it around so that its S-pole faces the E-label of the compass. Now slide it towards the compass again.

What happens to the N-pole of the compass needle now? What about the S-pole of the compass needle? Is this what you expected?

Do like poles (N-N or S-S) of the magnetized nail and compass needle attract or repel each other? Do unlike Poles (N-S, or S-N) attract or repel each other?

Check your conclusions with at least one other group to make sure you all agree. If not, repeat the observations.

Your statement about how like and unlike Poles interact with each other is known as the ***Law of Magnetic Poles***.

Summarizing Questions

Discuss these questions with your group and note your ideas. Leave space to add any different ideas that may emerge when the whole class discusses their thinking.

S1: An elementary school student asks you for advice about a science project she is doing on recycling. She suggests that a large permanent magnet could be used to separate metals from non-metals in the trash passing through a recycling station. What do you think of this idea?

S2. Because of the way its ends interact with a magnetized nail, scientists sometimes say that an unmagnetized nail is '***one-ended***', whereas a magnetized nail is '***two-ended***'. What do you think they mean by these terms?

S3. In this activity you magnetized a nail by rubbing its surface with a magnet. Do you think that whatever causes a nail to be magnetic also lies on its surface, or inside the nail? What evidence supports your thinking?