



# Magnetic Sleuth



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## Overview

You know that magnets can push or pull on objects without touching them, but how is this possible? And why are some magnets “stickier” than others? In this activity, you can investigate these questions and more.

## Doing the activity

Pick one of the magnets from your kit (you have refrigerator magnets, ring magnets, and a neodymium magnet — be careful with that one!). Place the magnetic view film over the magnet. What do you notice? Try a different magnet. How is its magnetic field similar? How is it different? What do you see if you stack two ring magnets or two refrigerator magnets together? Try investigating other items you have around. Many speakers, including those in laptops and cell phones, contain magnets. What other interesting things can you find?

### Necessary materials:

- green magnetic view film
- refrigerator magnets, ring magnets, neodymium magnet\*
- anything else you’d like to investigate

**\*Be careful with this magnet!** It’s very strong, and can wipe credit cards, do bad things to cell phones, break if it “jumps” to a surface, etc.

## What’s happening

Magnets make *magnetic fields*, and these fields are what exert forces (pushes and pulls) on other magnets and magnetizable materials (such as iron). A field is a rather strange concept, but it’s definitely real. It’s a sort of alteration of the space around the magnet, and its properties allow us to predict and understand the behavior of the magnet. For example, a stronger field will exert larger forces than a weaker one. Different magnets have different field structures. The green magnetic view film included in your kit allows you to see these field shapes. The film contains iron filings, which will experience forces from magnetic fields. These forces make the iron filings line up with the magnetic field, creating a pattern of darker and lighter areas that correspond to variations in the magnetic field.

## Summing up

The magnetic field is a rather strange concept, but it is definitely real and a fundamental fact about magnets. Understanding the magnetic field gives us some insight into why magnets do what they do. The magnetic view paper lets us see magnetic fields, and so gives us a new way to investigate the world.

## For more information

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# Refrigerator Magnets



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## Overview

How do refrigerator magnets stick to refrigerators? What's special about these magnets? We'll investigate.

## Doing the activity

Try placing the printed sides of the refrigerator magnets together, then try placing the black sides together. What differences do you notice? Next, try sliding the printed sides of the magnets across one another. Now, try sliding the black sides of the magnets across each other, both horizontally and vertically. What do you observe?

### Necessary materials:

- 2 refrigerator magnets (from the kit; also feel free to experiment with some of your own!)
- green magnetic view film

## What's happening

If you haven't done the *Magnetic Sleuth* activity with the green magnetic view film yet, you may want to check that one out now. It goes a bit deeper into the idea of *magnetic fields*, which can help us understand what's up with refrigerator magnets. Many, many observations of magnetic fields have shown us that all magnets have two *poles*, which we call "north" and "south". The magnetic field sort of scrunches together at the poles, but it does this in opposite ways at the north pole than at the south pole (we say the field goes "out of" a north pole and "into" a south pole). Because of the different field structures at each pole, the north pole of one magnet will be attracted to the south pole of another magnet, but the two north poles will repel each other. The magnetic fields create forces that pull north and south poles together, and the fields also create forces that push north poles away from other north poles (and south poles away from other south poles).

The printed sides of the refrigerator magnets are not magnetized, so they won't experience or exert magnetic forces. However, the black sides are magnetized, and they are magnetized in a very specific way: Their magnetic field structure creates lines of alternating north and south poles. You can observe this using the green magnetic view paper. The alternating poles are responsible for the "buzzing" you feel when you slide the magnets across one another — as you slide the magnets, you move a south pole close to a north (attractive force), then close to a south (repulsive force), then another north... Additionally, this magnetic field is very strong close to the magnet (which is good for sticking to refrigerators), but its strength drops off quickly with distance, so it's not going to be pulling forks out of your hand while you're trying to eat dinner.

## Summing up

Refrigerator magnets have a special magnetic field that lets them do their one job quite well!

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# Magnetic Surprises



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## Overview

Why does a magnet stick to a refrigerator, but not a drinking glass? What's the difference between objects that magnets stick to and those they don't? And are there any magnetic surprises out there in the world? Let's do some investigating.

## Doing the activity

Gather the plastic bags of graphite, sand, and crushed cereal from your kit. Lay the bags flat on a table or other surface (stay away from your computer, cell phone, wallet, and other items the neodymium magnet could damage), and move the neodymium magnet over the surface of the bag. Does anything in the bag stick to the magnet? Is anything surprising happening?

## What's happening

Certain materials are *ferromagnetic*. These materials aren't permanent magnets on their own, but they can be *magnetized* by a strong magnetic field (check out the *Magnetic Sleuth* activity for more details on magnetic fields). Because the way a ferromagnetic object gets magnetized depends on the field it's situated within, ferromagnetic objects will be attracted to the magnetizing magnet. If a ferromagnetic object is near the south pole of a strong magnet, a north pole will be induced in the region of the object closest to the magnet (see the *Refrigerator Magnets* activity for more details on magnetic poles). Iron and iron-containing compounds (such as steel) are ferromagnetic. As you probably guessed, iron filings contain iron, and so are attracted to the magnet. Iron filings are also very small and light, and so are particularly good at helping you "see" the magnetic field. Certain cereals, such as the one in the kit, contain added iron, since humans need a certain amount of iron in their diets to be healthy. Many types of sand also contain iron and other ferromagnetic materials, and you can pull these out of the sand using the magnet.

## Summing up

Objects that aren't magnets can interact with magnets in interesting ways. There may be more of these magnetizable materials in your life than you'd think!

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### Necessary materials:

- neodymium magnet\*
- bag of iron filings
- bag of sand
- bag of crushed cereal

**\*Be careful with this magnet!** It's very strong, and can wipe credit cards, do bad things to cell phones, break if it "jumps" to a surface, etc.



# Levitating Magnets



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## Overview

Magnets can certainly push and pull on each other, but can they push hard enough to levitate? As you may have guessed from the title of this activity, the answer is 'yes', and it's pretty great.

## Doing the activity

Arrange your ring magnets on the dowel so that all the magnets push each other apart. We've had good luck getting this set up by holding the bottom end of the dowel and dropping the magnets down from the top end, but figure out what works best for you! Once you have the magnets in place, give the top magnet a quick downward push. What happens to the other magnets? Take some time to experiment and explore!

### Necessary materials:

- ring magnets
- dowel

## What's happening

As we discussed in the *Refrigerator Magnets* activity, all magnets have two *poles*: "north" and "south". The poles are places where the the magnetic field gets all scrunched together (check out the *Magnetic Sleuth* activity for more details on magnetic fields). However, the field scrunches in opposite ways at north and south poles — by convention, we say the field goes "out of" a north pole and "into" a south pole. Since the field is strong (due to the scrunching) and has a particular orientation at each magnetic pole, there is an attractive force between north and south poles (opposite poles get pulled together), but a repulsive force between north and north or south and south poles (similar poles get pushed apart).

The ring magnets have a north pole on one wide flat side and a south pole on the other wide flat side. To make the magnets levitate, you arranged them so that the north pole of one magnet was facing the north pole of the magnet above it, and then the south pole of that magnet was facing the south pole of the magnet above it, and so on. You probably noticed that if you flip one of the magnets, it sticks to the magnet below it; flipping the magnet would put its north pole next to the south pole of the magnet below it (or vice-versa). That leads to an attractive force rather than a repulsive one.

## Summing up

Magnetic poles are a way of understanding why magnets stick together in certain orientations and push each other apart in other orientations. To investigate further, try combining this activity with the *Magnetic Sleuth* and *Refrigerator Magnets* activities!

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## Making and Breaking Magnets



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### Overview

Can you turn a paper clip into a magnet? If you create a magnet, can you then take away the magnetic-ness? The answer to both questions is 'yes'; let's investigate how and why.

### Doing the activity

Carefully unwrap the neodymium magnet (keep it away from credit cards, cell phones, computers, other magnets, etc.); you have two paper clips included in the bag with this magnet. If you just touch the paper clips together, can you pick one up using the other? Now, tap the end of one of the paper clips against the neodymium magnet about 10 times. Try picking up the other paperclip again — what happens now? If you drop the paper clip you tapped against the magnet onto a hard surface, does anything change when you try to pick up the other paper clip?

#### Necessary materials:

- neodymium magnet\*
- paper clips

**\*Be careful with this magnet!** It's very strong, and can wipe credit cards, do bad things to cell phones, break if it "jumps" to a surface, etc.

### What's happening

The paper clips are made of steel, which is *ferromagnetic* because it contains iron. As we discussed in the *Magnetic Surprises* activity, ferromagnetic materials aren't permanent magnets on their own, the way the neodymium magnet is, but they can be *magnetized* by a strong magnetic field. Ferromagnetic objects contain lots of little magnetic subunits called *magnetic domains*. When the object isn't in a magnetic field, these domains aren't organized in any particular way. The north and south poles of the domains all point in different directions, so overall, the material doesn't act like a magnet (for more on magnetic poles, see the *Refrigerator Magnets* activity).

There are domains inside the paper clips. The field from the neodymium magnet makes the domains that line up with the field get bigger; as these aligned domains grow, they make the domains that don't line up shrink. Now the domains aren't randomly scrambled anymore, and so the paper clip acts like a magnet overall — it has been magnetized. The big domains give the paperclip distinct north and south poles. Because the other paper clip is also ferromagnetic, it's attracted to the magnetized paper clip just like it would be to any other magnet! However, you can re-scramble the domains. Dropping the paper clip jostles all the little iron particles in the domains, which breaks the organization. When the domains are no longer organized, the paper clip is no longer magnetized.

### Summing up

Some things can be made into magnets, but their magnetism can be broken. Can you re-magnetize the paper clip?

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# The World's Simplest Motor



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## Overview

What's going on when electric motors power devices like fans? Just what does it take to create such a motor, and what makes it go? Let's find out.

## Doing the activity

First, stick one of the flat ends of the neodymium magnet to the flat end of the nail (stay away from your computer, cell phone, wallet, and other items the neodymium magnet could damage). The nail will now be magnetized, so you can stick the sharp end of the nail to one end of the battery (you can start with either the positive or the negative end). Now, hold one end of the copper wire on the other end of the battery, and gently touch the free end of the wire to the magnet. What do you observe? **(Be careful; if you hold the wire in place for a while, it and the motor components will get hot!)**

*Note:* If nothing is happening, try fanning out the different strands of the wire to make a flat brush and holding it very gently against the magnet. Also, make sure the nail is hanging freely from its point; if the nail moves to the rim of the battery end, it tends to get stuck.

## What's happening

Electricity and magnetism are very closely linked. A flowing electric current will create a magnetic field (for more on magnetic fields, check out the *Magnetic Sleuth* activity). For electric current to flow, you need a full circuit (complete conducting path), and using the wire to connect one end of the battery to the magnet forms just such a circuit! The electric current flowing through the wire creates a magnetic field around the wire. The interaction of this magnetic field and the field of the neodymium magnet creates a force that makes the magnet and nail spin. As the magnet spins, electric energy in the current is being transformed into rotational kinetic energy in the magnet and nail, as well as into thermal energy. Even though electric motors can get pretty complicated, this is the basic principle on which they all function!

## Summing up

Motors, which are essential elements of daily life for most folks, rely on the fundamental connections between electricity and magnetism to work. If you flip the battery upside-down, what happens in your motor?

## For more information

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### Necessary materials:

- neodymium magnet\*
- AA battery
- steel nail
- copper wire

**\*Be careful with this magnet!** It's very strong, and can wipe credit cards, do bad things to cell phones, break if it "jumps" to a surface, etc.