Magnetic Fields

Overview: Today you get to make your own compass to detect the Earth's magnetic field.

What to Learn: Not only how to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field, but also how *not* to build a compass.

Materials

- Needle or pin
- Strongest magnet
- Small piece of foam (like a packing peanut)
- Disposable cup
- Water
- Compass

Lab Time

1. Fill a cup with water. You don't need much – just enough to float a piece of foam in.
2. Take your needle and wipe it several times on all sides with the magnet. Make sure you're only contacting the pin and stroking it in one direction. You're getting the electrons to all spin in the same direction, like lining up all those tiny magnets in the virtual shoebox we talked about before.
3. Pierce a piece of foam with the pin. Stick it right through the middle.
4. Place the needle carefully in the water. If you splash around, you're going to have to wait a while for the system to settle down before you take a reading.
5. Look at your homemade compass. Which way is the needle pointing?
6. Compare it with your ready-made store-bought compass. Are they both telling you the same thing? (If not, you'll need to remove the pin from the foam and repeat step 3 again.)
7. Fill out the data table.

Magnetic Fields Data Table

Magnetizing the Needle	**Does it align with the compass?**
Wiped in one direction for 20 strokes	
Wiped in one direction for 50 strokes	
Wiped in other direction for 50 strokes	
Rubbed back and forth in both directions for 20 strokes	
Laying it on the magnet for one minute (no wiping or stroking)	

Lesson Reading

Remember how we learned that the Earth is a gigantic magnet? We did an experiment where we mapped the magnetic field lines back in *Experiment 3.* Do you also recall how magnetism is caused by electron spin? So the question is… where does the Earth's magnetic field come from?

At this point, folks are still trying to figure that out. The most widely accepted theory is that the magnetic field comes from the Earth's core. The core of the Earth is solid, but around that core is a liquid. The liquid is basically molten iron, nickel and a few other elements. It is the flowing of the electrons in this liquid metal that probably causes the Earth's magnetic field.

So, yes, the Earth is a magnet, but not a very strong one. You probably couldn't even stick it to a sun-sized refrigerator. The Earth has a magnetic pull 100 times weaker then the magnets on your fridge. The Earth, by the way, is not the only giant magnet in the solar system. The Sun, Jupiter, Saturn, Uranus, Mercury and Neptune are also magnets.

"Oh, yeah. Now I remember. That's the deal with the North and South Poles right?"

Well, yes and no. To confuse things a bit, there are two sets of North and South Poles. There are the geographic North and South Poles and the magnetic North and South Poles. (To be completely honest, there are EIGHT magnetic poles on the Earth, but we'll just focus on the two strongest one for now to cut down on the confusion.)

The geographic poles are located at the axis of the Earth. The axis is where the Earth turns day after day. The magnetic poles are close to the geographic poles, but they are off by quite a bit. (The South Pole isn't even in Antarctica – it's in the ocean.) In fact, the north and south magnetic poles of the Earth move from year to year and have completely flipped a couple of times. If you were to connect the Earth's most prominent north and south poles, they wouldn't cut through the planet, since they are both on the same side.

In this experiment, we're going to make our own compass by magnetizing a needle so that it acts like a tiny magnet. By floating the needle in a cup, it will be able to easily turn to align itself with the magnetic field of the Earth.

The North Magnetic Pole in 2001 was near Ellesmere Island in northern Canada at 81.3°N 110.8°W. As of 2012, the pole is projected to have moved beyond the Canadian Arctic territorial claim to 85.9°N 147.0°W. This pole is moving toward Russia at a rate of 34-37 miles per year.

The South Magnetic Pole is constantly shifting due to changes in the Earth's magnetic field. As of 2005 it was calculated to lie at 64°31′48″S 137°51′36″E just off the coast of Adelie Land, French Antarctica. That point lies outside the Antarctic Circle. Due to polar drift, the pole is moving northwest by about 10 to 15 kilometers per year.

Exercises:

1. Why can't you simply rub the needle back and forth with the magnet? Why do you have to stroke it in one direction?
2. What other objects/materials can you use to make a compass?
3. How do you know that the needle is magnetized?
4. Why did we float the needle in water?

Answers to Exercises: Magnetic Fields

1. Why can't you simply rub the needle back and forth with the magnet? Why do you have to stroke it in one direction? (When you rub the needle with the magnet, you line up the iron atoms all in the same direction. If you rub in both directions, then the atoms get lined up every which way.)
2. What other objects/materials can you use to make a compass? (Anything with iron, nickel, or cobalt in it, and put it in a low-friction environment like the end of a pin or floating in water.)
3. How do you know that the needle is magnetized? (When it's aligned with the compass needle.)
4. Why did we float the needle in water? (To keep the friction low, so the needle is free to move and align with the Earth's magnetic field.)