Magnetic Boats

Overview: Today you get to splash around with several compasses at once as you discover how magnets can both repel and attract each other at the same time.

What to Learn: Notice how the magnet boats repel each other when they get too close, yet they hold each other in a pattern. Atoms do the same thing – they repel each other when you try to squish them together, yet hold together to form molecules.

Materials

- Shallow dish or pie tin
- Water
- Foam blocks
- 6-10 small magnets
- Large magnet
- Hot glue gun

Lab Time

1. Place the magnets in a tall stack.
2. Break the foam into small pieces, about 1-2" square.
3. Using the hot glue gun, place a dab of hot glue in the center of a foam block.
4. Working quickly, remove one magnet from the stack and place it right onto the foam. Glue the magnet to the foam.
5. Repeat for the rest of the magnets, making sure that they are all facing the same way (same pole facing up if the top surface is one pole).
6. Place three of the magnets in a shallow dish of water so they are free to float. What happens?
7. Now take a large magnet and move it toward the floating magnets. Can you keep them in a straight line using the large magnet?
8. Complete the data table.

Magnet Boats Data Table

Number of Magnets	How are magnets distributed? (What shape do they make?)
2	
3	
4	
5	
6	
7	
8	

Reading

What's a magnetic field? Well, I can't tell you. To be honest, nobody can. Magnetic fields, gravitational fields and electric fields are very mysterious, and at this point there are still lots of questions about each one.

A field is an area around an electrical, magnetic or gravitational source that will create a force on another electrical, magnetic or gravitational source that comes within the reach of the field. (Now you can see why there's still so much mystery about them!)

A gravitational field, for example, comes from a body of some sort. The larger the body, the greater the force will be. A planet, for example, is a large body with a large gravitational force. If another body gets within the gravitational field of the planet, it will be affected by the force.

What creates the force? What's pulling or pushing? Nobody knows! We just know that it happens.

Another thing about forces is that the farther something gets away from the source, the less and less the force works on that object. A fancy term for this is the inverse square law. Something quite far from the Earth will feel no tug from the Earth's gravitational pull. If it gets closer, it will feel a slight tug. Closer still, a stronger tug will be felt. The closer something gets to the source of a field (gravitational, magnetic or electric) the stronger the pull of the field force is. If you're standing on top of the Sears Tower in Chicago, you are actually going to weigh less than if you're standing in the street.

Weight depends on the pull of gravity. The farther you are from the Earth, the less gravity pulls on you and the less you will weigh! There's an instant diet plan for you!

When you build the little boats, remember that you kept all the poles the same (all north pointed up, for example). The floating magnets repel each other because they have the same pole oriented up.

But notice that when you bring the larger magnet close, they are all attracted to it and also make geometric patterns! When you bring the larger magnet in closer, the size of your pattern changes, doesn't it? Most patterns have at least one (sometimes two) stable patterns, each of which is a local minimum energy pattern. The patterns that the little boats make are very similar to the crystal structures in solids.

Notice how the magnet boats repel each other when they get too close, yet they hold each other in a pattern. Atoms do the same thing – they repel each other when you try to squish them together, yet hold together to form molecules.

Exercises

1. What shape do three magnets give? Why is this different from the shape that four magnets make?
2. Why do the magnets flip over when you first place them in the water?
3. How many magnets make a hexagon?
4. How is this experiment like the compass experiments we've done so far?
5. Why do the boats repel each other, yet still hold in a pattern?

Answers to Exercises: Magnetic Boats

1. What shape do three magnets give? Why is this different from the shape that four magnets make? (Equilateral triangle. Four makes a square, because this is the minimum energy pattern.)
2. Why do the magnets flip over when you first place them in the water? (Because they are heavier on the bottom and lighter on top, unless your foam is large enough to prevent them from flipping over.)
3. How many magnets make a hexagon? (Six and seven – the seventh one is in the middle of the hexagon.)
4. How is this experiment like the compass experiments we've done so far? (The magnetized needle is like a tiny magnet floating in the cup of water, just like these are. When you bring a large magnet close, the floating magnets align themselves with the large magnet.)
5. Why do the boats repel each other, yet still hold in a pattern? (The floating magnets repel each other because they have the same pole oriented up. Yet the hold each other in a pattern because of their interacting magnetic fields.)