Magnetic Fields

Last lesson we took our first step into the strange world of magnetism. We learned that magnets do what they do because of the behavior of electrons. When a bunch of those crazy little guys get going in the same direction they create a magnetic field. So what's a magnetic field, you ask? That's what this lesson is all about.

Fields

So, what is a magnetic field? Well, I can't tell you. To be honest, nobody can. Magnetic fields, gravitational fields, electric fields are very mysterious and at this point there are still lots of questions about each one. A field is an area around a 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. 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 then 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!

Experiment One

Feel the Force

You need:

A fairly strong magnet

String or thread

Paper Clip

1. Cut about one foot of string or thread.
2. Tie the string or thread to the paper clip.
3. Put the magnet on the table.
4. Hold the end of the string and dangle the paper clip over the magnet.
5. Slowly bring the paper clip closer to the magnet.
6. Try to get the paper clip as close as possible without touching the magnet.
7. Pull the clip away slowly.
8. If you happen to have a spring scale you can tie the string to the scale and measure the amount of pull as you get closer to the magnet.

Could you feel it? As the paper clip got closer to the magnet, the pull of the magnetic force was stronger. This is typical of fields. The closer you get, the stronger the pull of the force gets. The farther you get, the weaker the pull of the force gets.

Magnetic Fields

Now that you know a little bit more about fields, let's take a closer look at this magnetic field thing. A magnetic field must come from a north pole of a magnet and go through a south pole of a magnet (or atoms that have turned to align themselves to the magnetic field like we talked about last lesson). You can think of a magnet as kind of a train station where the trains go in to the south end of the station and out the north end. They zip around the track and then come back to the south end only to zip back out the north end and do it all over again. "Uh, Jim...North Poles and South Poles. Isn't that where polar bears, penguins and Santa Claus live? What's that have to do with magnets?" Ahh, good point, I was almost getting ahead of myself there. Okay, all magnets have two poles. Officially, magnets can be called dipolar which means they have two poles. Remember, that the field must go in one end, out the other, and then come back again. You cannot have a magnet without two poles. Traditionally, those poles are called north and south poles. Why north and south? Because that's the way a magnet will point if it's allowed to move freely. The north end of a magnet will point to the North Pole of the Earth and the south end will point toward the South Pole. To be accurate, the magnetic poles of the Earth are not exactly the same as the North and South poles. The magnetic poles are off by quite a few degrees from the geologic poles, and, believe it or not, they can change over time. There is some evidence that they have actually reversed themselves in the past and may do so again in the future! Let's take a closer look at what magnetic fields are and we'll come back to the Earth's magnetic field in the next lesson.

Experiment 2

Play the Field

You can see how the compass needles are following the field lines.

You need:

Magnet (as strong as you have)

At least one compass.

Two pieces of paper

Pencil

Tape

1. Tape the two pieces of paper together along the long edge so that you have one large piece of paper.

2. Put the magnet in the middle of the paper.

3. Move the compass around the magnet and make sure that one end of the compass needle points to one end of the magnet and the other end of the needle points to the other end of the magnet. You want to make sure you have a north and south side of your magnet. If that doesn't seem to be happening you may need to put the magnet on its side.

4. Place the compass any place around the magnet. Draw an arrow in the direction the compass is pointing. The arrow point should be pointing the same way as the north side of the compass needle (the north side is usually colored).

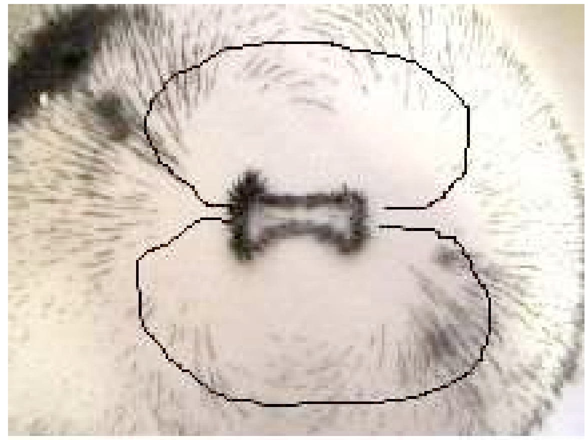
5. Do this at least 15 times all around the magnet. In front, in back, on the sides, near far and so forth. Try to get a good feeling for what the field looks like and how big it is.

6. If you have more, try this with other magnets. What does their fields look like?

Were you able to map out the field of the magnet? It kind of looks like two squished balls up next to the magnet, doesn't it? (Some magnets have strange fields, so don't worry about it if you get something a little different.) I like to think of a magnet as having two squished Nerf balls on each side of it. The Nerf balls represent the magnetic field. The stronger the magnet, the bigger the Nerf balls! Did you see how the compass needle followed the magnetic lines of force? Kind of like a train car on a train track, right? Out from one side of the station and into the other side of the station. Choo Chooo!

Experiment 3

See the Force



You can see the field lines coming from this magnet. I drew in lines to give you a bit of a guideline to see the field lines.

You need:

Magnet

Compass

Iron filings (you can get these from a teacher's store or you can take a metal file to an iron nail as well)

Paper or styrofoam plate

1. Put the magnet on the table.
2. Move the compass around the magnet and make sure that one end of the compass needle points to one end of the magnet and the other end of the needle points to the other end of the magnet. If that doesn't seem to be happening you may need to put the magnet on it's side. You want to make sure the north and south side of your magnet is showing.
3. Away from the magnet, spread a bit of iron filings on a plate.
4. Slowly, bring the plate over the magnet. With the plate a half inch or so over the magnet lightly tap the plate. The filings should form a pattern over the magnet.
5. Again, if you have more magnets, try different ones. Do you see different fields, stronger fields, weaker fields?

Hopefully, that experiment allowed you to really take a good look at the magnetic field lines. The little bits of iron line up right along the train tracks...whoops, I mean field lines to show you just what the magnetic field looks like.

Attraction and Repulsion

Remember, that the magnetic field must go from a north pole to a south pole. We've taken a look so far at the field doing that in one magnet but what if we have two magnets, or a magnet and something else?

Experiment 4

How Attractive! How Repulsive!

You need:

2 Magnets (two of the same kind work best)

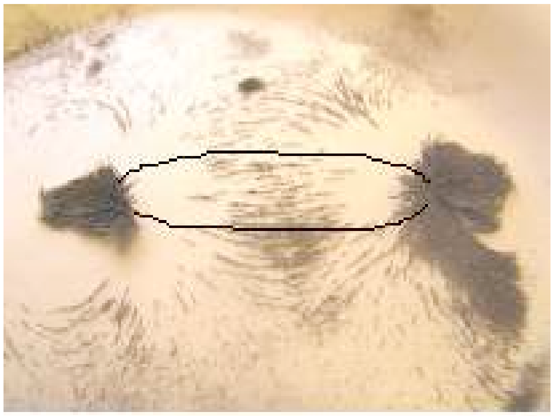
Compass

Iron filings (you can get these from a teacher's store or you can take a metal file to an iron nail as well)

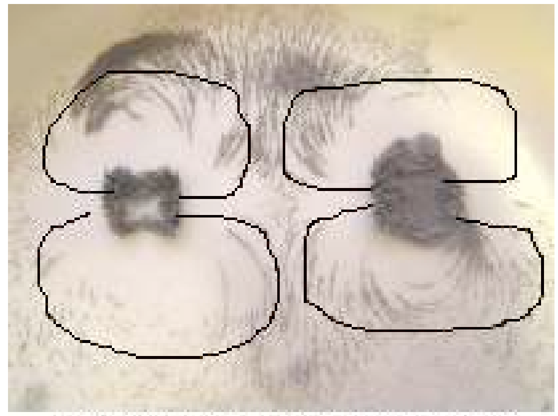
Paper or styrofoam plate

Tape

1. **Put the magnets on the table.**
2. **Put the magnets about half an inch away from one another. Opposite poles should be toward one another so that the magnets are attracted to one another. You may need to tape the magnets to the table so that they don't click together.**
3. **Away from the magnets, spread a bit of iron filings on a plate.**
4. **Slowly, bring the plate over the magnets. With the plate a half inch or so over the magnet lightly tap the plate. The filings should form a pattern over the magnets.**
5. **Move the magnets so that now the same poles are facing one another. The magnets should be repelling one another.**
6. **Repeat steps 3 and 4.**



You can see the field lines traveling from one magnet to the other. These magnets are attracting one another. (I drew in lines to help see the field lines.)



Here you can see the field lines avoiding one another. These magnets are repelling each other.

Could you see how the field went from the north end of one magnet to the south end of the other? What happened when you had two north ends or south ends facing one another? The fields got all squashed up as they tried to avoid one another right? Magnetic fields must travel from north to south. Now see what happens with a magnet and a paper clip. Do experiment 4 again but this time replace one of the magnets with a paper clip and do steps 1-4.

Do you remember from last lesson that a magnetic field can actually turn the atoms in some materials, forcing them to become magnets as well? Well, that's what happens here. The field from the magnet forced the little atoms in the paper clip to sit on the train tracks and face the right direction. Thus the magnetic field could go from north to south again just like with two magnets.

Next lesson we'll talk a bit more about these magnetic fields and we'll take a good look at the Earth's magnetic field.

In a Nutshell

- There's still a lot about fields that is unknown. Fields are an exciting area of physics where a lot is still left to be discovered.

- A field is an area around a 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.

- In fields, the closer something gets to the source of the field, the stronger the force of the field gets. This is called the inverse square law.

- A magnetic field must come from a north pole of a magnet and go to a south pole of a magnet (or atoms that have turned to the magnetic field.)

- All magnets have two poles. Magnets are called dipolar which means they have two poles.

- The two poles of a magnet are called north and south poles.

- The magnetic field comes from a north pole and goes to a south pole.

- Opposite poles will attract one another. Like poles will repel one another.

- Iron and a few other types of atoms will turn to align themselves with the magnetic field.

Did You Get It

1. I have two magnets but I just can't get them to stick together. Am I trying to put like poles or opposite poles together?
2. A magnetic field goes from what pole to what pole?
3. Why are magnetic poles called north and south?
4. What happens as I move something closer the the source of a field?
5. If I weigh myself while flying on a plane, will I weigh less or more then if I'm standing on the ground? Why?

Answers

1. Like poles. Like poles repel one another. Opposite poles attract.

2. Magnetic fields go from north to south poles.

3. The north pole of a magnet will point to the magnetic north pole of the Earth if it's allowed to move freely.

4. The closer something gets to the source of a field the stronger it is affected by that field.

5. I will weigh less. (Not a lot less, but a bit.) The farther I am away from the Earth's gravitation field the less the field affects me. So I weigh less!