Lab 6: Magnetic Fields

Experiment for Physics 212 Lab at CSU Fullerton.

What You Need To Know:

The Physics

So far in Physics 211 and Physics 212 you've been dealing with two naturally occurring fields: the gravitational field and the electric field. Now, you will be dealing with the *magnetic field*. A naturally occurring field is caused by a particle with a specific property. For a gravitational field, the particle must have *mass*. For an electric field, the particle must have a *charge.* For a magnetic field, the particle must have charge *and* it must be *moving*.

You've been dealing with moving charge for the past couple of labs. You've been calling this moving charge *current*. So, all you need is a wire with current running through it and you have a magnetic field. For example, say you are on a hike. You have a compass and you get near some power lines. The compass will no longer point to the north because the magnetic field from the power lines is interfering with the Earth's magnetic field.

In the lab Equipotential Surfaces, you derived what the electric field lines look like for two point charges. The field lines started at the positive charge and ended at the negative charge. Magnetic field lines are different in that they have no beginning and no end. They are continuous loops.

Let's say that you take some wire and wrap it into a short coil like in [Figure 1](). This coil configuration is called a *solenoid*. If a current was running through the solenoid, it would generate a magnetic field that has field lines like in [Figure 1](). Notice that the field lines don't have a beginning point or an end point. They are continuous from the inside of the solenoid to the outside.

To determine the direction that the magnetic field lines are pointing you would use the Right Hand Rule: Using your right hand, point your fingers in the direction that the current (conventional) is flowing through the solenoid. The current is flowing up into the solenoid at the left. It then continues up over the top and then down the backside of the solenoid. So, curl your right hand up over the top and then down the backside. Your thumb should be pointing towards the left. Thus, the field is pointing to the left, but only for the inside of the solenoid. Since the field lines are continuous they turn around and point in the other direction on the outside of the solenoid.

Figure 1 – A solenoid with magnetic field lines

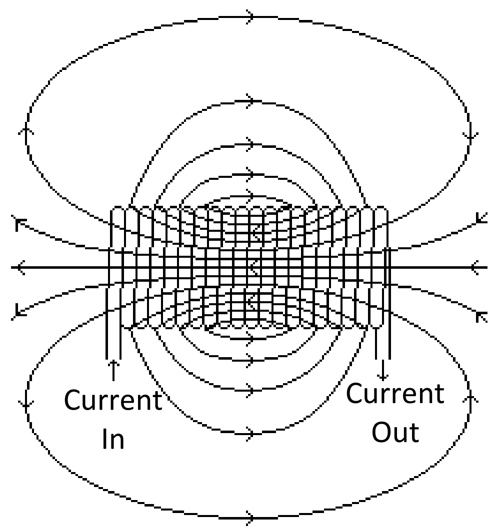
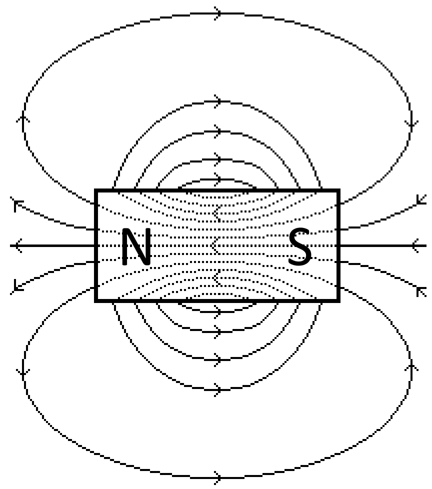


Figure 2 – A bar magnet with magnetic field lines



If currents cause magnetic fields then what is a bar magnet? It's just a hunk of metal, right? Well, yes, but it's a special kind of metal that has a property called *ferromagnetism*. In the atoms of the metal there are electrons (charge) moving around in the orbits. Each electron creates a small magnetic field which is randomly oriented, making the total magnetic field weak. If field lines are "lined-up", pointing in the same direction (like in a magnet), you'd have a large magnetic field. For example, in a bar magnet, you would get magnetic field lines like those shown in *Figure 2*.

Permanent magnets have a north pole and a south pole. The field lines point away from the north pole and towards the south pole. Notice that the field lines of the bar magnet are very similar to those of the solenoid.

A common misconception about a bar magnet is that the field lines begin at the north pole and end at the south pole. As you saw for the solenoid, the field lines don't begin or end, they are continuous. As you can see in *Figure 2*, the same is true for a bar magnet. The field lines are inside the magnet as well.

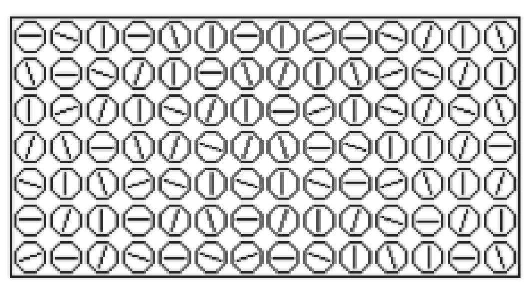
One of the things you will be doing in today's lab is drawing the magnetic field lines for two different types of magnets. You will also show in which direction the field lines are pointing. To do this you will use the following facts. If you bring the north (or south) poles of two magnets together they will repel and if you bring opposite poles together they will attract each other.

The Equipment

You should have four magnets for this lab. One magnet is hanging from a stand by some string. One end of the magnet has red tape and the other end has white tape. The *red* tape signifies the *north pole* and the *white* tape signifies the *south pole*. The other three magnets have the following shapes: a small cylinder, a big cylinder (cow pill), and a disc. Two of the magnets have a piece of tape on them as a reference point. **DO NOT WRITE ON THE TAPE. Also, DO NOT DROP THE MAGNETS**. Dropping a magnet can cause the magnetic field to change.

You should also have a Magnetic Field Detector (MFD). See *Figure 3*. The MFD is a flat clear piece of plastic that has 98 cells in a 7 by 14 array. Each cell contains a small pellet that is free to move inside the cell. When you bring a magnet near the MFD the pellets line up along the magnetic field lines.

Figure 3 – A Magnetic Field Detector (in a random pattern)



You also have a solenoid, some cables with alligator clips, a power supply, and a galvanometer. A galvanometer has many applications. In this lab, you will use it to determine if you have a current

What You Need To Do:

Part 1 – Ranking the Magnets

Using any of the equipment on your table, determine which of the three loose magnets has the strongest field. Describe what equipment you are using and also describe your method in determining this. Also, rank the magnets from the strongest to the weakest.

Part 2 – Mapping Magnetic Fields

You are now going to use the MFD to map out the magnetic field lines for the cow pill and the disc. Your mapping should be similar in style to *Figure 2*. Use a clean sheet of paper (no lines) that your TA will distribute. Try to fill the page as much as possible with your mappings. Decide for yourself in what orientation you want to draw the magnet so that it is as descriptive as possible (i.e. front-view, side-view, top-view, etc). Include in your mapping …

- the magnetic field lines outside the magnet AND what you think they look like *inside* the magnet.
- a note showing the north and south poles on each magnet (relative to the side that has tape, i.e. show which side has tape in your diagram).

NOTE: Please do not write on the tape which pole it is. (You want to make the other students work for it too, don't ya?) Thanks!

- a note showing the direction of the magnetic field lines.

Question 1

How did you determine each of the things asked for in your mappings?

Part 3 – A Solenoid For A Field

In class you should have learned that a current in a solenoid creates a magnetic field down the center of the solenoid. You are going to examine this effect doing the following.

NOTE: Please don't set the solenoid on the table with the cable side down. The cables should always be pointing away from the table. Thanks!

A) With the power supply OFF, hook up the solenoid to the power supply using the cables. One end of each cable should go into OUTPUT 1. The other end of each cable should plug into the solenoid.

B) Turn on the power supply and set it to 6 V.

C) Compare the strength of the magnetic field of the solenoid to that of the cow pill and the small cylindrical magnet. NOTE: If you aren't getting the solenoid to show a magnetic field with your method from *Part 1 – Ranking the Magnets* then you need to think of a better method.

Question 2

How do you think you could increase the strength of the magnetic field? (There are two ways.)

D) Determine two different ways that you can tell in which direction the magnetic field is pointing along the center of the solenoid. Describe each method.

E) Place the solenoid on the table (cable side up) and try to levitate the small cylindrical magnet by inserting it down the center of the solenoid.

Question 3

How is the magnet being levitated? Explain.

F) With small magnet levitating, raise the solenoid off the table about an inch. Push the magnet down and observe what happens.

Question 4

What happened to the magnet when you pushed it down? Explain why this happens.

Part 4 – A Solenoid For A Current

It is possible to generate a current using a solenoid and a magnet. You are going to examine this phenomenon by doing the following.

A) Turn off the power supply and disconnect the cables going to it. Reconnect the cables to the galvanometer. It doesn't matter which wire is connected to red or black.

Recall that the galvanometer measures current. Notice that it reads 0 down the center. If the needle swings to the left, the current is flowing in one direction and if it swings to the right, the current is flowing in the other.

B) Insert the small cylindrical magnet into the solenoid. Describe in detail what happens.

Question 5

Under what conditions does the needle move?

Question 6

Under what conditions does the needle move to a particular side? (The answer to this question is different than the previous one.)

C) Theorize why a current is generated. You will be graded on how well you investigate this phenomenon.

D) You may or may not have talked about this phenomenon in class. If you think you have, then name the phenomenon.

What You Need To Turn In:

Turn in your own mappings. Make sure they fill as much of the page as possible. Turn in all of your descriptions and answers to questions. Make sure your descriptions and answers are under a labeled section heading on your paper.