Experiments with magnets and our surroundings

How strong are magnets?

Typical Values

Here is a list of how strong some magnetic fields can be:

Smallest value in a magnetically shielded room	10^-14 Tesla	10^-10 Gauss
Interstellar space	10^-10 Tesla	10^-6 Gauss
Earth's magnetic field	0.00005 Tesla	0.5 Gauss
Small bar magnet	0.01 Tesla	100 Gauss
Within a sunspot	0.15 Tesla	1500 Gauss
Small NIB magnet	0.2 Tesla	2000 Gauss
Big electromagnet	1.5 Tesla	15,000 Gauss
Strong lab magnet	10 Tesla	100,000 Gauss
Surface of neutron star	100,000,000 Tesla	10^12 Gauss
Magstar	100,000,000,000 Tesla	10^15 Gauss

What is a Tesla? It is a unit of magnetic flux density. It is also equivalent to these other units:
1 weber per square meter
10,000 Gauss (10 kilogauss)
10,000 magnetic field lines per square centimeter
65,000 magnetic field lines per square inch.

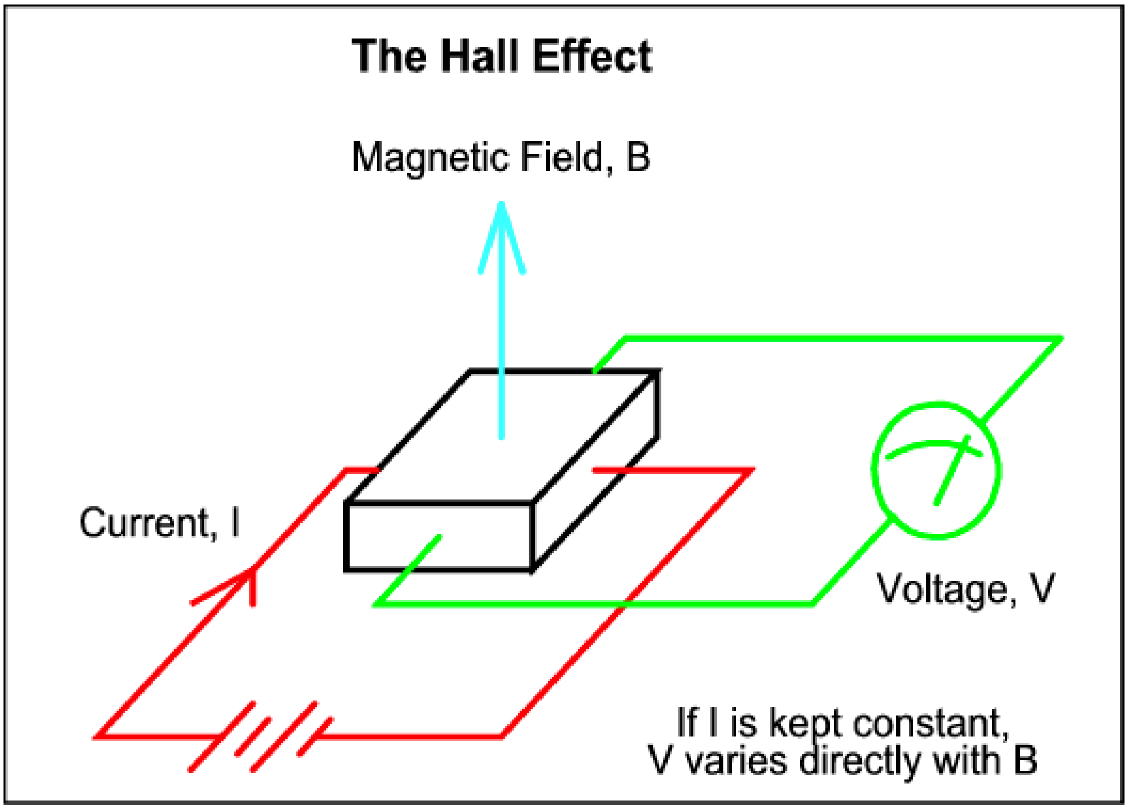
Now, 1Gauss is about 6.5 magnetic field lines per square inch.

If you place the tip of your index finger to the tip of your thumb, enclosing approximately 1 square inch, four magnetic field lines would pass through that hole due to the earth's magnetic field!

Measuring the strength of magnets

1. Hall-Effect Devices

A Hall-effect device is a piece of material which is affected by a magnetic field. By passing a constant amount of current through it in one direction, and by placing it in a magnetic field in another direction, we can measure a voltage across it in the third direction. This voltage is proportional to the strength of the magnetic field. This can be calibrated to provide a certain mV change for every Gauss of magnetic field. This effect was discovered by Edwin Hall in 1917. The materials often used today in these devices are indium arsenide or gallium arsenide. There are also superconducting devices which can measure minute magnetic fields, called SQUIDS.



What can you do with a Hall-effect device? Build an electronic circuit which will amplify the voltage across the device and calibrate it so you can measure a voltage and translate that into a Gauss measurement. For such a unit, check out the page on building a Gaussmeter.

2. Helmholz Coils or Assembly EXPT

A Helmholz assembly is actually a specific configuration of two coils. Each coil has the same radius. Also, the coils are placed parallel to each other. The distance between the coils is the same as the radius of each coil. What makes this assembly special is that if each coil has the same current flowing through each other (by connecting them in series) and the direction of current is the same, the magnetic field within the center of the two coils changes very little as you move along the center line from one coil to the other. This is a way to create a volume with a fairly constant magnetic field throughout that volume of space.

More can be done with this. If a magnet is placed within the center of the Helmholz assembly, pulsing the coils and reading the response will tell you the strength of the magnet.

There are some great articles describing how to build a supersensitive magnetometer using such an assembly, especially for tracking changes in the earth's magnetic field due to magnetic storms on the sun. Check out:

http://www.eden.com/~rcbaker/magnetometer.htm (dead link)
http://www.scientificamerican.com/2000/0300issue/0300amsci.html (dead link)
http://www.netdenizen.com/emagnet/ for details on calculating the field within a Helmholz coil assembly

3. Halbach Array

A Halbach array is an arrangement of permanent magnets in order to achieve a fairly uniform magnetic field within a volume of space, similar to the idea behind the Helmholz coils assembly.

For more information, please refer to these sites:
Magnets, Markets, and Magic Cylinders, by Michael Coey and Denis Weaire
A Permanent-Magnet Based Vector Vibrating Sample Magnetometer, by J.M.D. Coey, David Hurley, and Farid Bengrid
Design of an electrical machine with integrated flywheel, by Colotti Alberto, and Reichert Konrad
http://www.iem.ee.ethz.ch/

4. Paper clips and ball bearings EXPT

If you don't have a way to build a gaussmeter or magnetometer in order to measure the strength of the magnetic flux density of a magnet, then what else could you do? Try this.
1. Count how many paperclips or staples you can attach end to end from the north pole to the south pole.
2. Count how many paperclips or staples you can attach end to end hanging from one of the magnet's poles.
3. Have a big pile of paperclips or staples on the table and count how many will stick to the magnet, all over the magnet.
4. Have a big pile of small (1 to 2mm in diameter, or 1/32 to 1/16" diameter) steel ball bearings or BBs in a plastic container, and count how many will stick to the magnet after you place the magnet into the middle of the pile and try to completely cover it with the ball bearings. Remove the magnet all covered with ball bearings, and take it to another plastic

container to pull off and count the number of ball bearings that the magnet was able to attract to itself.

5. Magnetometer

This is a meter my brother had purchased in order to insure there was no residual magnetic field left on some equipment. It would show polarity and magnitude. It was made by Anno Instruments in Indianapolis. It is very sensitive. The area at the bottom of the meter is placed near the magnetic field to be measured.

What appears to be a good book on this subject is:
The Magnetic Measurements Handbook, by J.M. Janicke
Magnetic Research, Inc.

Answers to the rod problems:

Two rods
It is fairly easy to determine which rod is a magnet and which is not. I suspect that if you actually had those two rods in front of you, you would be able to figure it out. Here's a straightforward method to determine that. Let's call one rod A and the other rod B. (Perhaps you could keep one in the left hand and the other in the right hand).
Next, touch the end of A to the middle of B.
If it sticks, then A is the magnet and B is iron.
If it does not stick, then B is the magnet and A is iron.
To double check this, touch the end of B to the middle of A.
If it sticks, then B is the magnet and A is iron.
If it does not stick, then A is the magnet and B is iron.
Why does this work?
In the center between the poles of a magnet, there is very little magnetic field or flux outside the magnet. All of the flux is inside the magnet itself. Because of this, iron is weakly attracted to the middle of the magnet if at all. However, the end or pole of a magnet will easily stick to any part of an iron rod.

Three rods
The solution to this is similar to the one above, but it just requires a little more work.
Let's call one rod A, one rod B, and the last rod C. Have them lined up on the floor in that sequence.
First, touch the end of A to the middle of B.
If it sticks, then A is the magnet, B is iron, and C is brass.
If it does not stick, continue.

Next, touch the end of A to the middle of C.
If it sticks, then A is the magnet, C is iron, and B is brass.
If it does not stick, continue.
Next, touch the end of B to the middle of A.
If it sticks, then B is the magnet, A is iron, and C is brass.
If it does not stick, continue.
Next, touch the end of B to the middle of C.
If it sticks, then B is the magnet, C is iron, and A is brass.
If it does not stick, continue.
Next, touch the end of C to the middle of A.
If it sticks, then C is the magnet, A is iron, and B is brass.
If it does not stick, continue.
Lastly, touch the end of C to the middle of B.
If it sticks, then C is the magnet, B is iron, and A is brass.
If it does not stick, something is wrong and you should try it all again.

Why does this work?

In the center between the poles of a magnet, there is very little magnetic field or flux outside the magnet. All of the flux is inside the magnet itself. Because of this, iron is weakly attracted to the middle of the magnet if at all. However, the end or pole of a magnet will easily stick to any part of an iron rod. Also, brass is not attracted to a magnet, so it will never stick to a magnet.

Prev Home Next