GSC International Inc.
Phone: 417.374.7431
Fax: 417.374.7442
service@gosciencecrazy.com
2076 James River Court
Nixa, Missouri 65714

Warning:

- **GSC's products are intended for use in labs and classroom settings under the supervision of qualified professionals.**
- **The products are not toys and are not intended for children under the age of 13.**
- **This item may include latex.**
- **This item contains small parts.**

#505-3 Electromagnet

Electromagnetism was discovered in 1820 by Oersted. His discovery was as a result of observing that a magnetic field was surrounding an electrical conductor as an electric current traveled through it. He also discovered that the direction of flow of the current affected the direction of the magnetic field and that it was perpendicular to the wire.

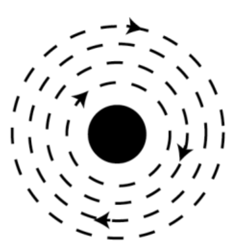
For example, take a look at the accompanying illustrations. The circles surrounding the wire in the illustration represent the magnetic field set up by the current. In the first drawing the electrical current is traveling toward you and as you can see the magnetic lines are traveling in a counter-clockwise direction. In the second drawing the electric current is traveling away from you and as you can see, the magnetic lines of force are traveling in a clockwise rotation.

The strength of the magnetic field created due to an electric current flow can be calculated by Ampere using the formula

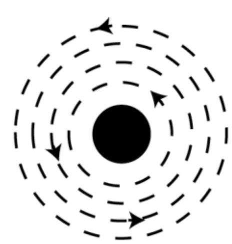
$$\Delta H = \frac{I \sin\theta \Delta s}{r^2}$$

We find using the mathematical formulas as well as through experiments that the intensity of the magnetic field varies inversely to the square of the distance from a wire that is creating it. We also find that by doubling the current we in turn double the strength of the magnetic field. Further study even suggests that doubling the length of the element will also double the intensity of the field.

You will find that a conductor with current traveling through it will experience a force acting on it when this conductor is located within a magnetic field. This principle is used in many practical applications such as voltmeters, ammeters, galvanometers and switches etc. By using what you have just learned you should also reason that the direction of this force will be determined by the direction of the flow of both the current in the conductor as well as the current traveling through the coil.

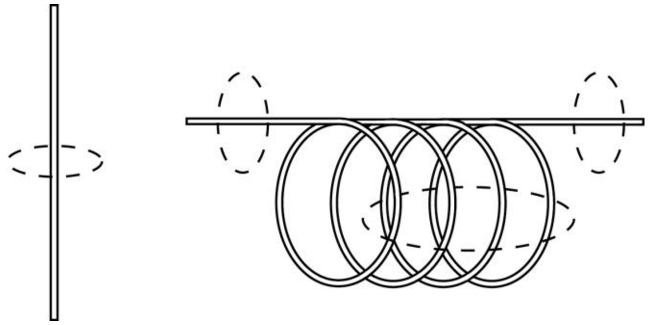


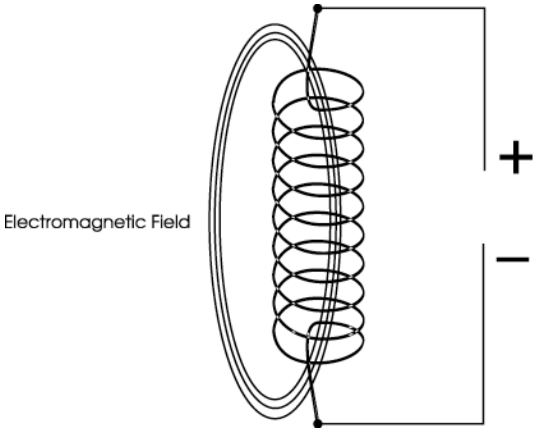
Current going away from you



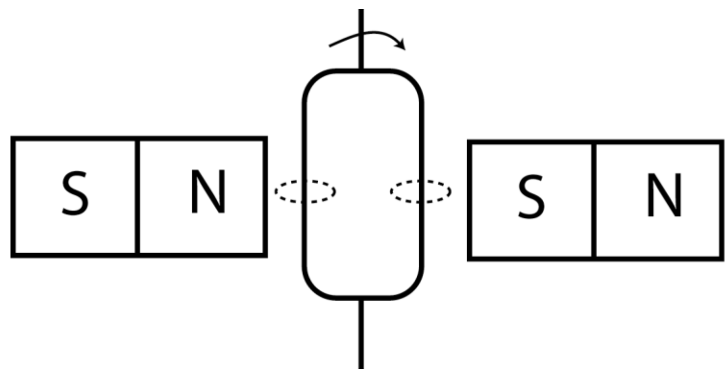
Current coming toward you

The following illustration depicts a simple form of a galvanometer. The coil in the middle lies between two permanent magnets.





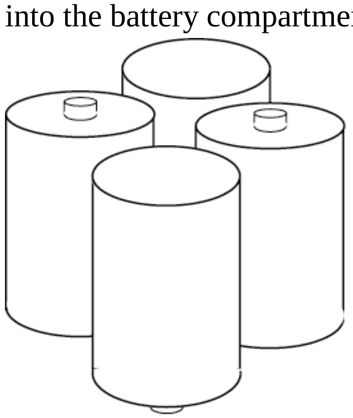
As current flows through the coil a magnetic field is set up that either is attracted to or repelled by the permanent magnet, depending on the direction of current flow. A needle

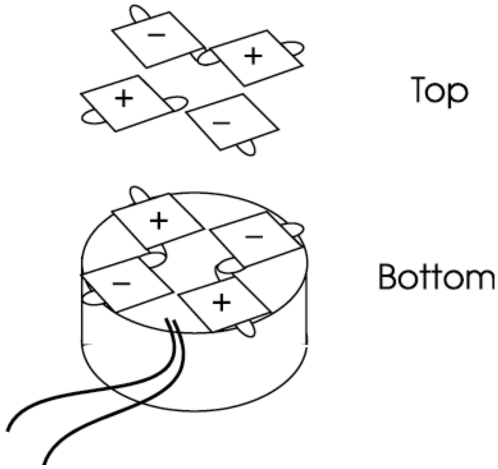


attached to this coil will indicate the amount of movement of the coil and hence the strength of the magnetic field can be determined.

Examining your new electromagnet

You will be amazed at the strength of this compact electromagnet. What is even more amazing is the power that it derives using only four 1 1/2 volt "C" size batteries. It is important to place these batteries into the battery compartment with the polarity correct. Please take note of the accompanying illustration.





If you place the yoke (the small plate with a hook) against the surface of the core and hook up the cables as shown, you will immediately see the strength that this magnet possesses. Try pulling the yoke from the core. You could even hook the yoke up to weights and measure the strength in this manner. However if you were to unhook the cables to release the yoke and then hook the power back up, something interesting will be discovered. With the power on bring the yoke plates surface close to the surface of the core. One would think that the plate would be pulled from ones hand, but it is not. As a matter of fact there seems to be very little if any pull at all. The polished ground surface actually reduces the amount of energy required to pick up and hold an object. It is imperative that you keep the matching surfaces of the core and yoke clean and free of dents or other imperfections.

Other Experiments:

Besides measuring the amount of weight that you can lift with the electromagnet, you can also use it to demonstrate the magnetic lines of force. For this you will need a sheet of white paper and about a table spoon of iron filings. Have someone hold the paper parallel to the floor while someone else holds the magnet upside down and with the polished surface against the paper. You will not need the yoke for this experiment. Turn on the power and then sprinkle the top surface of the paper with the iron fillings. You will see a pattern emerge. The powdered iron gets caught in the magnetic field and so aligns itself with the magnetic lines of force. You should be able to witness how the lines of force travel out from the center of the core and back to its circumference. These lines of force are called magnetic flux.

The unit of measure for magnetic flux is the "*maxwell*". This is named after the English physicist, J. Clark Maxwell (1831 - 1879). The symbol xxxxx is used to represent the total amount of flux that travels through a specific area. One "*maxwell*" equals one line of magnetic flux. Also the number of lines of magnetic flux that pass perpendicularly through an area one square centimeter is referred to as the "*flux density*" and its symbol is "*B*". The unit of flux density is referred to as the "*gauss*". This was named after the German mathematician and physicist Karl F. Gauss (1777 - 1855). A *gauss* is the flux density of one maxwell per square centimeter.

If the flux over an area of "*x*" square meters and it has a number of lines "*B*" perpendicular through each square centimeter then the total flux throughout the area is $\Phi = Bx$

The ability to cause the magnet to turn on and off with simply the use of a switch has thousands of applications in electrical and mechanical machines. The ease of constructions accounts for its long use in industry. The use of magnetic cranes to lift cars is one of the first uses that comes to many peoples minds, but there are many more uses that go unnoticed to most individuals. For example, electromagnets are used in vending machines and arcade games quite liberally. Because of the ability to attract certain metals, they are used in productions equipment to filter out and to separate metals form other sluge and liquids. Audio and video tape players use electromagnets to impose and electromagnetic signal on tape which can later be used to induce a magnetic signal back into the machine for reproducing signals.

An electromagnet that uses a moving yoke to slide back and forth within the core is called a solenoid and solenoids are used to engage the starter in your car, electronic locks and security systems, electric bells, and even super powerful punches for punching out metal shapes.

The electric motor is simply a revolving electric solenoid and what would this world be without an electric motor?