8.5.1: Electromagnet

Figure 19.1.1

One of the most famous electric car companies is Tesla, named after Nikola Tesla. These electric cars, and all others, require an electromagnet to run the engine.

Electromagnets

A long coil of wire consisting of many loops of wire and making a complete circuit is called a **solenoid**. The magnetic field within a solenoid can be quite large since it is the sum of the fields due to the current in each individual loop.

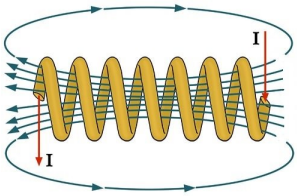

Figure 19.1.2

The magnetic field around the wire is determined by a hand rule. Since this description doesn't mention electron flow, we must assume that the current indicated by *I* is conventional current (positive). Therefore, we would use a right hand rule. We grasp a section of wire with our right hand pointing the thumb in the direction of the current flow and our fingers will curl around the wire in the direction of the magnetic field. Therefore, the field points down the cavity in these loops from right to left as shown in the sketch.

If a piece of iron is placed inside the coil of wire, the magnetic field is greatly increased because the domains of the iron are aligned by the magnetic field of the current. The resulting magnetic field is hundreds of time stronger than the field from the current alone. This arrangement is called an **electromagnet**. The picture below shows an electromagnet with an iron bar inside a coil.

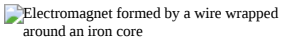

Figure 19.1.3

Our knowledge of electromagnets developed from a series of observations. In 1820, Hans Oersted discovered that a current-carrying wire produced a magnetic field. Later in the same year, André-Marie Ampere discovered that a coil of wire acted like a permanent magnet and François Arago found that an iron bar could be magnetized by putting it inside of a coil of current-carrying wire. Finally, William Sturgeon found that leaving the iron bar inside the coil greatly increased the magnetic field.

Two major advantages of electromagnets are that they are extremely strong magnetic fields, and that the magnetic field can be turned on and off. When the current flows through the coil, it is a powerful magnet, but when the current is turned off, the magnetic field essentially disappears.

A telegraph is one example of a device that utilizes an electromagnet and its ability to be turned on and off to transmit information very long distances. When the electromagnet is on, it creates a click. When it is off, there is no click. We translate the language of clicks and no-clicks into alphabet characters, known as Morse Code. Launch the Telegraph simulation below and click on a letter in the Morse code chart. Then, press play to hear how the telegraph communicates this letter using electromagnets:

Electromagnets find use in many practical applications. Electromagnets are used to lift large masses of magnetic materials such as scrap iron, rolls of steel, and auto parts.

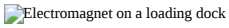

Figure 19.1.4

The overhead portion of this machine (painted yellow) is a lifting electromagnet. It is lowered to the deck where steel pipe is stored and it picks up a length of pipe and moves it to another machine where it is set upright and lowered into an oil well drill hole.

Electromagnets are essential to the design of the electric generator and electric motor and are also employed in circuit breakers, television receivers, loudspeakers, electric dead bolts, car starters, clothes washers, atomic particle accelerators, and electromagnetic brakes and clutches. Electromagnets are commonly used as switches in electrical machines or even a simple doorbell. Launch the Doorbell simulation below to learn more:

Summary

- A solenoid is a long coil of wire consisting of many loops of wire that makes a complete circuit.
- An electromagnet is a piece of iron inside a solenoid.
- While the magnetic field of a solenoid may be quite large, an electromagnet has a significantly larger magnetic field.
- Electromagnets' magnetic fields can be easily turned off by just halting the current.

Review

1. Magnetism is always present when electric charges _____.
2. What happens to the strength of an electromagnet if the number of loops of wire is increased?
3. What happens to the strength of an electromagnet if the current in the wire is increased?
4. Which direction does the magnetic field point in the solenoid sketched here?

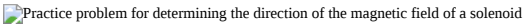

Figure 19.1.5

Explore More

Use this resource to answer the questions that follow.

1. What components are needed to make a homemade electromagnet?
2. What objects were attracted by the electromagnet in the video?

Additional Resources

Study Guide: Magnetism Study Guide

Real World Application: Lucky Discovery

Videos: