Creating An Electromagnet: Grades 3 to 5

YOUR MISSION

In this activity, you will learn basic electrical engineering principles by building small electromagnetics. You will alter your electromagnet design to determine what setups create the strongest magnetic field. Your design is tested based on how many paper clips your electromagnet can pick-up.

Click here to watch a quick introduction and tutorial for this activity.

WHAT'S GOING ON

Engineers are problem solvers and they come up with solutions to problems to better the lives of everyone around them. They do this by coming up with designs, products, technologies, innovations, procedures and systems to make the world a better place.

Electrical engineers design and develop electrical systems and electronics. This can include many things, such as computers and networks to robotics, smartphones and video games. They design **electromagnets** for a variety of applications we use in our everyday life.

In fact, electromagnets are the basis of the **electric motor** and are essential to many of the things we use on a daily basis. The electric motor is used to power vacuums, refrigerators, food blenders, microwaves, electric toothbrushes, the power seats in your car, many toys that move, the disk drives in our computers and much more! An electric motor takes **electrical energy** and uses magnets to turn that electrical energy in motion.

How exactly do these electromagnets work and why are they so important? Before we get to that, here are some key terms that you need to know and will learn about while you are doing this activity and that are essential to building your own electromagnet.

KEY TERMS

- **Electromagnet**: A magnet produced by running an electrical current through coiled wire.
- **Electrical energy**: A form of energy resulting from the flow of electric charge.
- **Electric Motor**: A machine powered by an electromagnet to convert electrical energy into mechanical energy (make things move).
- **Electrical Current**: The flow of charged particles from a positive to a negative source.
- **Coil**: An object arranged in spirals or rings. For instance, you can wrap wire around your finger to create a coil.
- **Magnetic Core**: A piece of magnetic material placed inside the coils of an electromagnetic to guide the magnetic field (makes the magnetic field strongest at the core).

Now that you are familiar with these terms, let's find out how electromagnets work!

When an **electrical current** passes through a **coiled** wire, a magnetic field is generated and this system is known as an electromagnet. The magnetic field may be turned on and off by disconnecting the electric current.

The strength of the electromagnet varies based on:

- the material used for the wire
- the number of coils in the wire
- the amount of electric current

The strength can be further increased by placing a **magnetic core** inside of the coiled wire. Electrical engineers have designed electromagnets strong enough to pick up entire cars!

Today, you will use a small battery to provide an electrical current through a piece of insulated wire wrapped around a magnetic core (iron nail). Just like electrical engineers, you will alter your design to make your magnet stronger.

Now that you know how these electromagnets work and have a general idea what they can be used for, you can see why they are an important part to the many different things that we use every day. You can build your own by following the next steps.

MATERIALS NEEDED

Before you design and build your own electromagnet, here are the materials you will need. Ask a parent or teacher to help you gather these materials.

- 1 D-Cell battery
- 1 nail (3.5 inches or longer, made of iron, steel, or zinc)
- 75 cm insulated copper wire
- 75 cm insulated aluminum wire
- 1 pair of wire strippers
- 1 roll of tape (regular clear tape)
- 15 or more metal paper clips

WHAT YOU NEED TO DO

1. Before you get started, have your parent or teacher strip roughly 2 cm of insulation from both ends of each type of wire (both copper and aluminum). Bend the ends of the wire into a small hoop.

2. Tightly wrap the insulated copper wire around the nail 20 times, make sure that there are no gaps between the wire and the nail. Be careful to ensure that no wires are overlapping.

3. Connect one end of the copper wire to the positive end of the battery, and the other end of the wire to the negative end of the battery (Fig. 1(a)). Secure the wires to the ends using a small piece of clear tape (Fig. 1(b)).

4. Your electromagnet is ready for testing! Place 15 or more metal paper clips on a flat surface. Test the strength of your electromagnet by seeing how many paper clips it can pick up (Fig. 1(c)). Record your results. NOTE: Disconnect the wires from the battery immediately after testing. If the wires are connected for long periods of time they can begin to get hot.

5. Increase the number of coils to 30 and repeat steps 3 and 4. Try again by increasing the number of coils to 40.

6. Repeat steps 2 to 5 with the insulated aluminum wire.

Fig. 1(a) General electromagnet set-up

Fig. 1(b) Battery to wire connection secured with tape

Fig. 1(c) Electromagnet testing: magnet holding paper clip

FURTHER REFLECTIONS

1. What happened when you increased the number of coils in the insulated copper wire? Did it increase the strength of the magnet (pick or more paper clips)?

2. What happened when you increased the number of coils in the insulated aluminum wire? Did it increase the strength of the magnet (pick or more paper clips)?

3. Why do you think increasing or decreasing the number of coils affected the strength of the magnet?

4. Which wire performed better (insulated copper wire, or insulated aluminum wire)? Why do you think it performed better?

5. List 5 applications in engineering that may use electromagnets. Why is it important to be able to control the strength of the magnet?

All engineers use the Engineering Design Process to plan, build, test and reflect on their designs and when coming up with solutions to a problem. The steps for the Engineering Design Process are listed below. Use the Engineering Design Process to test and improve your design.

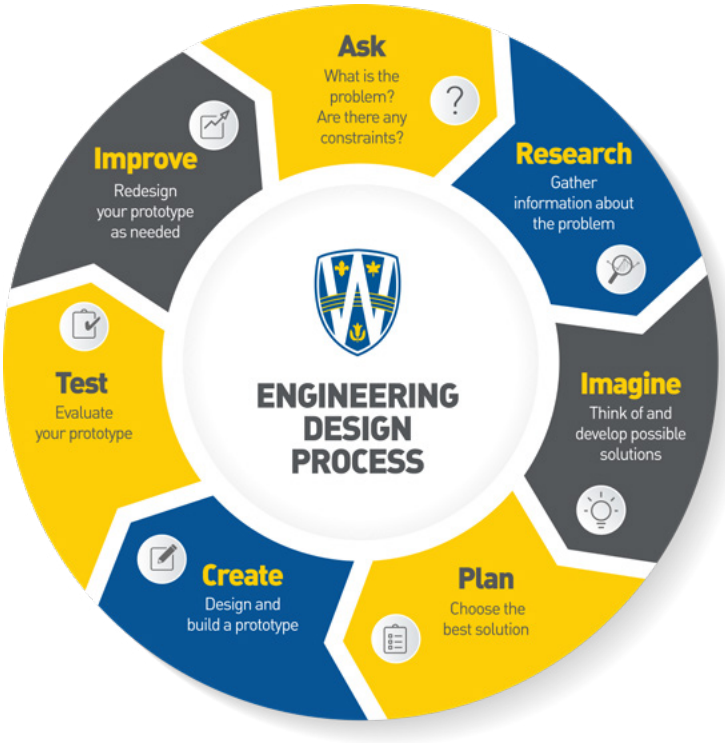
ENGINEERING DESIGN PROCESS

First, think of the problem.

How can you fix it? Think of as many ideas as you can that you think will solve this problem.

It might be helpful to first sketch out your ideas on a piece of paper. Make as many different designs as you can!

Test and compare all of your solutions. Which one solves the problem and works the best?



CURRICULUM UNIT CONNECTIONS

Grades 3 to 5 - Understanding Matter and Energy – Forces Causing Movement; Understanding Structures and Mechanisms – Forces Acting On Structures and Mechanisms

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