

FAST LANE

Level of Difficulty: 2

Grade Range: 9-12

Activity Time: 45-60 min

Business Category: Manufacturing

Topic: Transportation

OVERVIEW

Many countries around the world are looking to meet their transportation demands for the future with sustainable and environmentally friendly systems. Magnetic levitation (Maglev) trains are a transportation technology that makes use of electromagnetic suspension (EMS). It relies on high-powered electromagnets that produce magnetic fields that force the train above its track and propel it forward without friction. In this activity, students will investigate how electricity and magnetism are closely related by building and testing their own electromagnets.

STEM LESSON FOCUS

STEM incorporates Science, Technology, Engineering, and Mathematics to focus on real-world issues and problems guided by the engineering design process. This type of instruction supports students in developing critical thinking, collaboration, reasoning, and creative skills to be competitive in the 21st-century workforce.

Each Siemens STEM Day classroom activity highlights one or more components of the engineering design cycle and an essential 21st-century skill.

Engineering Design Cycle <ul style="list-style-type: none">• Creating or Prototyping	21st Century Skills <ul style="list-style-type: none">• Critical Thinking (Analysis, Synthesis, Flexibility, Evaluation)
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OBJECTIVES

Students will be able to:

- discover the close relationship between electricity and magnetism
- build and test their own electromagnets

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MATERIALS

Piece of iron (such as a large nail or bolt), insulated wire, wire strippers or scissors, D/6V Lantern/AAA Batteries, holders, and alligator clips, magnetic items (like paper clips, staples, etc.), bare copper wire (for optional extension activity), small Neodymium disc magnets (for optional extension activity)

HAVE YOU EVER WONDERED...

What do door bells, loudspeakers, electric motors, and super-fast levitating trains have in common?

Can you **make** an electromagnet using ordinary household materials?

MAKE CONNECTIONS!

How does this connect to students?	How does this connect to careers?	How does this connect to our world?
<p>Example 1: Engineers use the basic properties of electromagnetism to engineer roller coasters that reach incredible speeds and brake in a fail-safe manner.</p> <p>Example 2: You may have seen in movies or on T.V., or experienced firsthand, Maglev train technology. Making use of electromagnetic suspension (EMS), Japan and Germany have already tested and implemented magnetic levitation (Maglev) trains. In addition, several cities in the U.S., including Pittsburg and Las Vegas, have proposed Maglev initiatives.</p>	<ul style="list-style-type: none"> • Auto mechanics use an understanding of electromagnets to recognize and diagnose problems in a vehicle, such as issues with electric/hybrid engines and power lock doors. • Robotics engineers use electromagnets to make monitors spin and cause robots to move. • Magnetic Resonance Imaging (MRI) Technicians use machines with electromagnets to look inside a patient's body and generate pictures of the tissues, which can be examined by doctors. 	<p>It is important to understand electromagnetism concepts and their applications since they have the potential to enhance the aerospace, transportation, computer, and nuclear industries.</p>

If you want students to further explore career opportunities connected to this topic, please allow for more classroom time.

BLUEPRINT FOR DISCOVERY

1. Prior to starting the activity, lead a class discussion about how moving magnets through a magnetic field source induces a small, but measureable, current. In addition, looping a current-carrying conductor (in this case, the nail wrapped with wire) energizes and strengthens the magnetic field. As the number of wire loops and the amount of electric current increases, the strength of the electromagnet increases. Therefore, electricity and magnetism are inextricably connected.
2. Instruct students to begin building electromagnets by following the steps below, individually or in small groups.
3. Invite students to gather the materials they will be using to build the electromagnet.
4. Wrap insulating wire in a tight coil around the length of a large iron nail or bolt so that there are at least several layers. Leave a few inches of loose wire on either end and strip the insulation off of the loose ends using wire strippers or scissors.
5. Using alligator clips, attach the ends of the wires to separate terminals (positive and negative) of a 6-Volt lantern battery. Alternatively, you can use several type D batteries connected in series with battery holders but make sure they are aligned in the same direction in the circuit.
6. Use your electromagnet to pick up as many magnetic items as possible. Experiment with various battery configurations to make the electromagnet stronger. Make sure to disconnect the electromagnet from the battery when not in use so it does not overheat or drain the battery. *Note: the ends of the electromagnet work best since the magnetic field is strongest at these points.*
7. Unhook one of the wires and then use the electromagnet to pick up magnetic materials such as paper clips. Does it work? Ask students: “What has to flow through the wire to make the iron core function like a magnet?”
8. Now, remove the iron nail from the wire coil and try using the nail to pick up paper clips. Does it work? How many paper clips can it pick up? Also, try dropping the nail/bolt on the floor several times. What effect does this have on the number of magnetic items the electromagnet can pick up?
9. Engage students in a discussion of the experimental factors that affect the strength of the electromagnet.
10. If time permits, invite students to start working on the extension activities.

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TAKE ACTION!

As an extension, invite students to build a simple electromagnetic train that can move efficiently along a track using a AAA battery, bare copper coil, and small Neodymium disc magnets.

After building the electromagnetic train, students can make a circular loop and determine the centripetal acceleration of the train. This procedure requires the following steps:

- Time how long it takes the train to make one revolution
- Measure the radius (R) of the circular loop and determine the circumference ($2\pi R$).
- Calculate the velocity (v) and plug into the centripetal acceleration (a_c) equation:

$$v = 2\pi R/T$$

$$a_c = v$$

NATIONAL STANDARDS

National Technology Standards	18: Students will develop an understanding of and be able to select and use transportation technologies.
Next Generation Science Standards	<p>PS2.B: Types of Interactions Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.</p> <p>PS3.A: Definitions of Energy Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.</p>

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