FOCUS: How can we describe electromagnetism?

1. WATCH THE VIDEO “MAGLEV TRAIN”.
2. READ THE FOLLOWING.
3. EXPLAIN TO CLASS.
4. Write a paragraph.

Magnets and Electromagnets

Magnets are materials that attract pieces of iron or steel. In ancient times, people first discovered magnetism when they found some naturally **magnetic** rock in the earth. They called these rocks lodestone. Loadstones have a lot of iron in them, but we now know that other materials can be magnetized as well. Nickel, cobalt, certain types of ceramics and certain blends of metals can also make good magnets. If you could look at a magnet at the atomic level, you would notice that the magnet was divided into a number of smaller regions called domains. All of the **atoms** in a domain point in the same direction and, since each atom acts like a little **magnet**, all of their little magnetic fields add together to make a larger, **stronger**field. A magnet can be weakened if some of its atoms are thrown out of alignment. Hitting or heating a magnet is usually enough to scramble some of its atoms.

Magnets have north and south poles. The north pole of one magnet will repel, or push away, the north pole of another magnet, and the south pole of one magnet will repel the south pole of another magnet. But, if you put the north pole of one magnet near the south pole of another magnet, you'll feel an attractive force. You may have heard the saying "opposites **attract.**" This is just one of the rules of nature that scientists have discovered. Everyone knows that magnets stick to refrigerators, but did you know that magnets are used in all sorts of things? Most of the magnets we are used to seeing are made from metals rich in **iron**. Magnets that hold our school work to the refrigerator are called permanent magnets. They are magnets today and they'll be magnets tomorrow. They just hang there and continue to be magnets without us doing anything to them. Can you think of anywhere else you might find permanent magnets in your house? Did you know there's a magnet in the seal on the inside of your refrigerator door? You don't use that one to hold your school work, but it does hold the door closed when you're not looking for a snack or a cold drink. Some cabinet doors have magnetic latches too. Can you think of any other places where magnets have practical uses?

Permanent magnets are one kind of magnet, but there's another kind of magnet called an electromagnet. **Electromagnets**are made from metal and electricity! When the **electricity**is on, you have a magnet, but turn the power off, and you just have a hunk of metal and some wire. Unlike permanent magnets, the strength of an electromagnet is easy to change. One way to do this is to change the amount of current used. Another way is to change the amount of wire you have wrapped around the metal core. You see, when you wind wire in coils around a piece of metal that has a lot of iron in it, and then you run electricity through the wire, it creates a magnetic field. More coils of wire or more electric current creates a stronger magnetic field. This magnetic field causes the atoms in the core to align, giving the metal **magnetic**properties.

Electromagnets are used in many devices. Think of things that use power and have moving parts. Chances are, an electromagnet is causing the motion! Power windows in a car, automatic doors at the grocery store, and the little motor in a CD player that makes the CD spin so you can listen to your favorite music all contain electromagnets! Electromagnets really make our lives **easier**, and more fun, too!

Magnetism and electricity are closely related phenomena. Electric charge is a fundamental property of matter. Matter is made up of electrons, neutrons, and protons. Electrons have a negative electric charge, while protons have a positive electric charge; neutrons have no electric charge. These tiny particles are the building blocks of atoms. An atom has a net positive electric charge when it loses one of its electrons, and a net negative electric charge when it gains an extra electron. On the other hand, magnetic charges do not exist - Magnetic fields are generated solely by moving electric charges.

An example of the relationship between electricity and magnetism is the motor. In a motor, a voltage is applied across the terminals of a coil of wire. The voltage causes the electrons in the wire to move, which in turn generates a current. This current results in a magnetic field, which interacts with permanent magnets attached to the core of the motor, causing it to move.

Perhaps the most significant relationship between electricity and magnetism is light, which is known to physicists as an electromagnetic wave. Light waves are oscillating patterns of electric and magnetic fields, propagating through space at the speed of light (3x108 meters/second).

Electric and Magnetic phenomena are intricately described by a collection of physical laws, known as Maxwell's equations. Fully understanding these complex equations require a thorough knowledge of calculus and differential equations.

If you have been to an airport lately, you have probably noticed that air travel is becoming busier and busier. Even though there are often delays, airplanes still provide the fastest way to travel. Air travel changed the transportation business in the last century. It allows people to travel great distances in a matter of hours instead of days or weeks.

Cars, buses, boats, and conventional trains are other options for travel. These travel choices seem to be just too slow for today's fast-paced society. However, there is a new form of transportation that could revolutionize travel for the 21st century the way airplanes did in the 20th century.

A few countries are using powerful electromagnets to develop high-speed trains, called maglev trains. Maglev is short for magnetic levitation, which means that these trains float over a track not sit on it. Magnets are used to replace the old steel wheel and track trains. If you have ever played with magnets, you know that opposite poles attract and like poles repel each other. This is the basic idea behind electromagnetic propulsion.

The big difference between a maglev train and a conventional train is that maglev trains do not have an engine - at least not the kind of engine used to pull typical train cars along steel tracks. The engine for a maglev train is rather unnoticeable. The magnetic field created by the electrified coils in the walls and the track combine to propel the train forward. There is no need for fuel! These trains use electricity.

The magnetized coil running along the track is called a guideway. The guideway repels the large magnets on the bottom of the train. This allows the train to levitate (rise) between 0.39 and 3.93 inches (1 to 10 cm) above the guideway.

Once the train is lifted, power is supplied to the coils within the guideway walls. This creates a unique system of magnetic fields that pull and push the train along the guideway. The electric current running to the coils in the guideway walls constantly changes. This changes the pull of the magnetized coils. This change in polarity causes the magnetic field in front of the train to pull the train forward. The magnetic field behind the train adds more forward thrust. These trains move passengers and freight at faster speeds and at a lower cost because they use less energy. Maglev trains float on a cushion of air; there's no friction. This lack of friction and the trains' design allow them to reach speeds of more than 310 miles per hour! That is twice as fast as Amtrak's fastest commuter train. In comparison, a Boeing-777 airplane can reach a top speed of about 562 mph.

Developers say that maglev trains will be able to connect cities that are up to 1,000 miles apart. At 310 mph, you could travel from Paris to Rome in just over two hours!

**21ST CENTURY TECHNOLOGY**

STATE-OF-THE-ART TECHNOLOGY MAKES SCMAGLEV THE MOST ADVANCED HIGH-SPEED TRAIN SYSTEM IN THE WORLD

The Superconducting Maglev (SCMAGLEV) is the world’s fastest train. This revolutionary system utilizes the concept of superconducting magnetic levitation, originally conceived by American physicists. This concept influenced the creation of the SCMAGLEV system in Japan, which has been gone through more than 50 years of research and development. The SCMAGLEV utilizes magnetic forces to smoothly and rapidly accelerate trains to speeds of more than 300 miles per hour while levitating inches off of the ground. Some properties of the SCMAGLEV are:



LINEAR MOTOR: The SCMAGLEV utilizes a linear motor, which resembles a conventional electric motor rolled out. In this example, the rotors inside a conventional motor correspond to the Superconducting Magnets on-board the vehicle, and the external stators correspond to the Propulsion Coils in the guideway. In a linear motor, though, the magnetic forces cause the magnets to move forward in a line, rather than rotating.



GUIDEWAY Instead of riding directly on rails like conventional trains, the SCMAGLEV levitates in a U-shaped concrete guideway. This guideway envelops the vehicles, preventing derailments. Installed into the sidewalls of the guideway are metal coils, which are key to the SCMAGLEV’s propulsion, levitation and guidance.



PROPULSION SYSTEM: By passing an alternating electrical current through the Propulsion Coils installed on either side of the guideway, magnetic forces with alternating north and south poles are produced. The SCMAGLEV train is propelled by both the simultaneous attractive and repulsive magnetic forces created between the Propulsion Coils and the on-board Superconducting Magnets.

(ADDITIONAL INFORMATION ABOUT MAGLEV TRAINS visit http://northeastmaglev.com/)

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| NAME:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ANSWER THE FOLLOWING QUESTIONS:1. What is an atom made up of? |  |
| 2. What is a magnetic field? |  |
| 3. In most cases, does electricity create magnets or do magnets create electricity? Explain. |  |
|  |  |

WRITE A PARAGRAPH. Justify your answer, use the rubric below.

4. What advantages do magnetically levitated trains have over conventional trains?

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RUBRIC FOR WRITING:

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| 0 | 1 | 2 | 3 |
| A response gets no credit if it provides no evidence of the benefits of maglev trains. | Gives limited evidence of the ability to describe the benefits of maglev trains•Includes identification of details but they are not explicit or make only vague references to the text•Supports the explanation with at least one detail but the relevance of that detail to the text must be inferred | Gives some evidence of the benefits of maglev trains•Includes some specific identification of details that make reference to the text•Adequately supports the explanation with relevant information from the text | Gives sufficient evidence of the ability to describe the benefits of maglev trains•Includes specific identification of details that make clear references to the text• Fully supports the explanation with clearly relevant information from the text |