Core Knowledge® SCIENCE

Science Literacy

Forces at a Distance:

How can a magnet move another object without touching it?

Science Literacy Student Reader

Magnets and speakers

Magnetic fields

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Forces at a Distance

Science Literacy Student Reader

ISBN: 978-1-68380-747-6

Forces at a Distance

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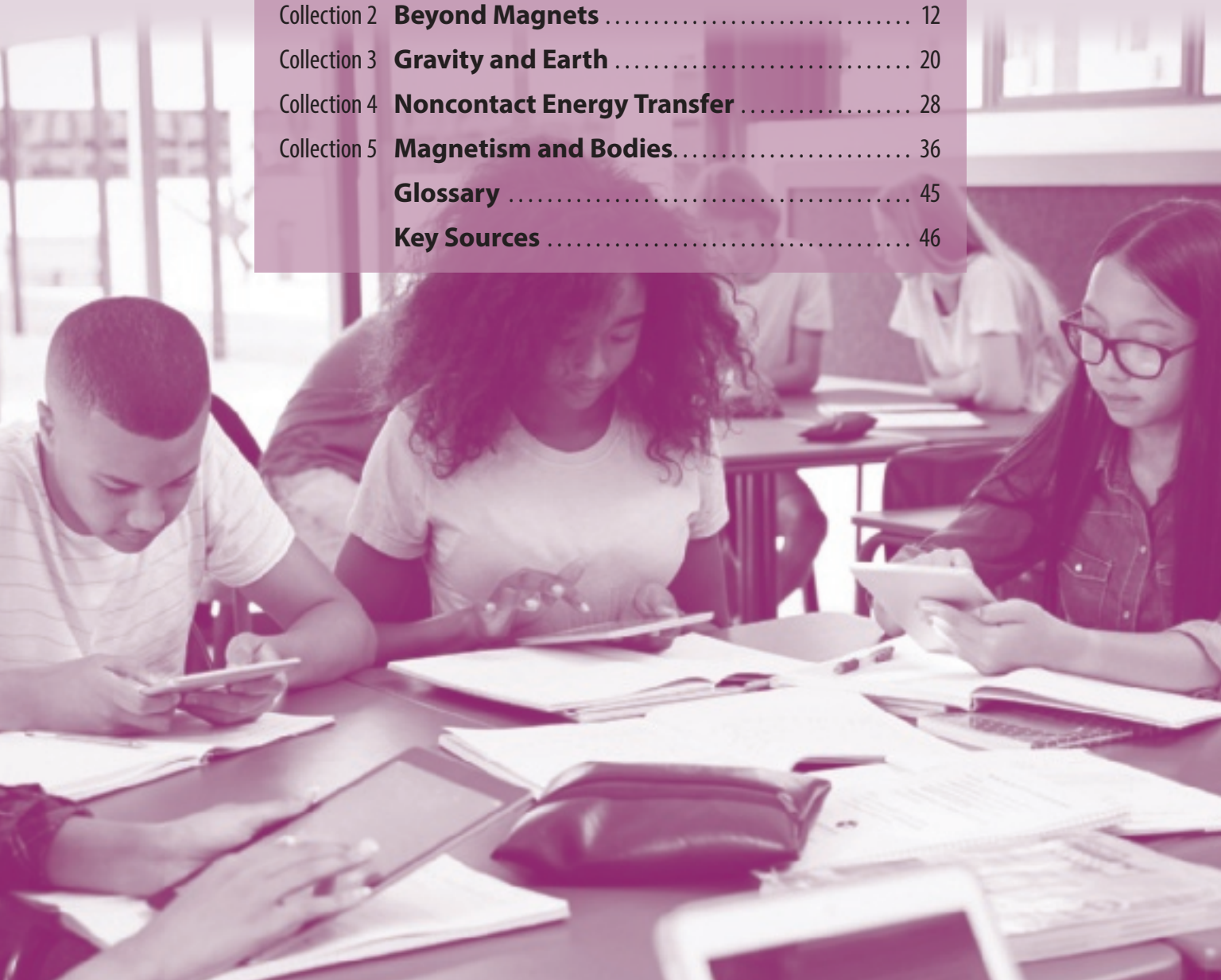


Put Yourself in This Scene

Imagine you are reading a science fiction comic. The story opens with a group of students in the school cafeteria during lunchtime. Suddenly, everyone begins to notice that all sorts of things stop working.

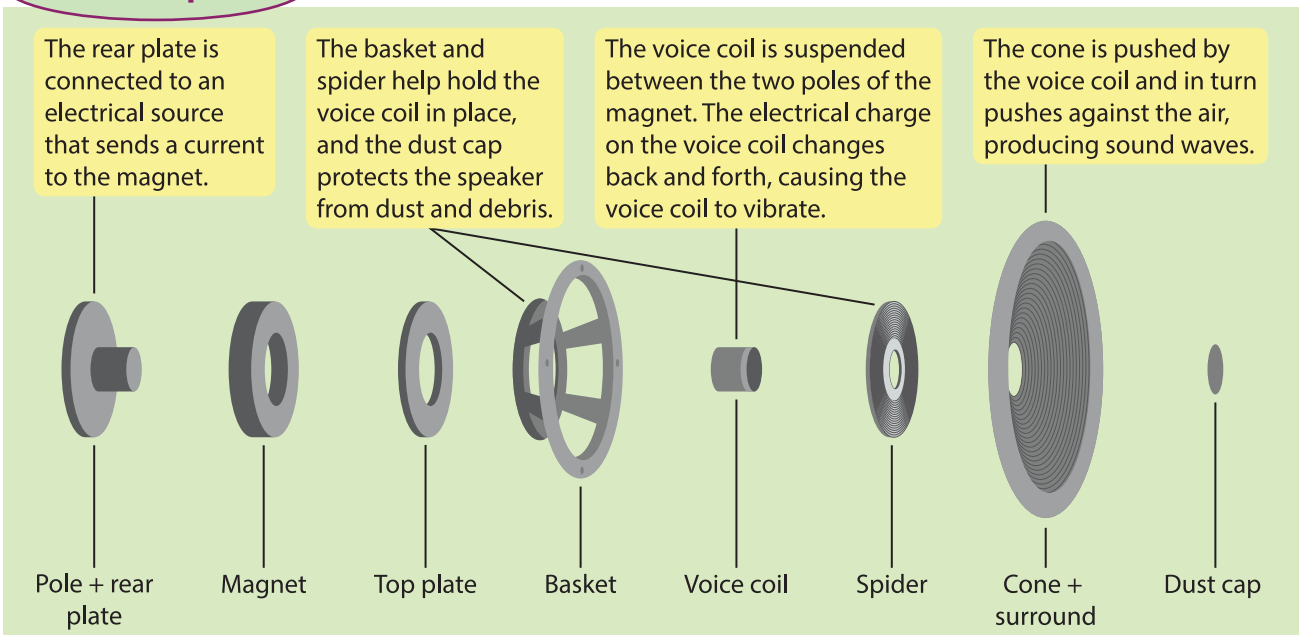
No one's cell phone works—they won't even turn on. It's time for class, but the bell doesn't ring. Someone's watch has stopped. The electronic doors to the school swing sadly on their hinges.

As you read this comic, you stop to wonder what life on Earth *would* be like without magnets. That's what this book is about—science literacy, which means knowing how to think about science topics that you read or hear about. Our world has 24–7 news, social media, and too may websites to count. The amount of information we must sort through is overwhelming, and all the information is not reliable. In the internet age, sources of information are often obscure or not trustworthy. It is good to process information with a healthy degree of skepticism.

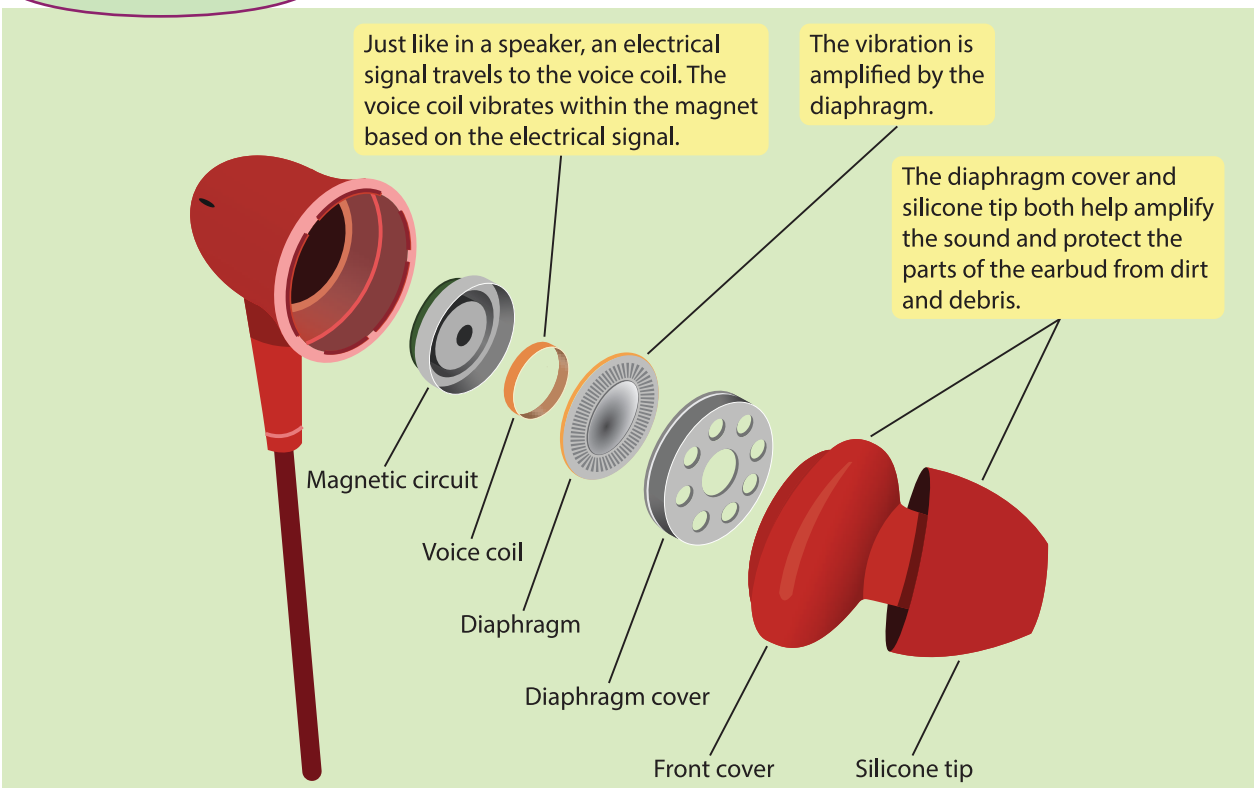
We will make our way back to the topic of how magnets are essential to life on Earth by the end of the book. Along the way, the series of reading selections and the writing exercises that go with them will help you flex your mental muscles and sharpen your science literacy skills. The ability to read about science, understand the information, and tell truth from fallacy or misrepresentation is important. Science literacy helps you as an individual and as a consumer, and it shapes the ways you affect the community in which you live.

Anatomy of Speakers

Parts of a Speaker



Parts of an Earbud



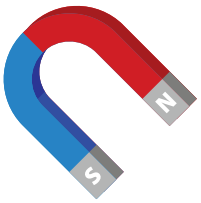
To Be, or Not to Be . . . Magnetic

Materials on Earth can be classified according to their magnetic characteristics. Some materials are natural magnets, others are human-made, and others are not magnetic at all.

Natural Magnets

Some materials are naturally magnetic. Lodestone, first known to the ancient Greeks, occurs naturally on Earth.

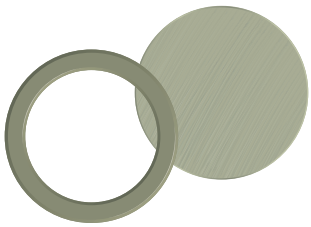
Earth itself is also a magnet. Earth's core is made mostly of iron and nickel, two magnetic metals. The core creates a huge magnetic field that surrounds the planet.



A permanent magnet is one that does not easily lose its magnetic properties over time.

Human-Made Magnets

Ferromagnetic materials are metals that are not magnetic themselves but react to magnets. Iron, nickel and cobalt are the three main ferromagnetic metals.



Rare-earth magnets are made of special metals that produce extremely strong magnetic fields.

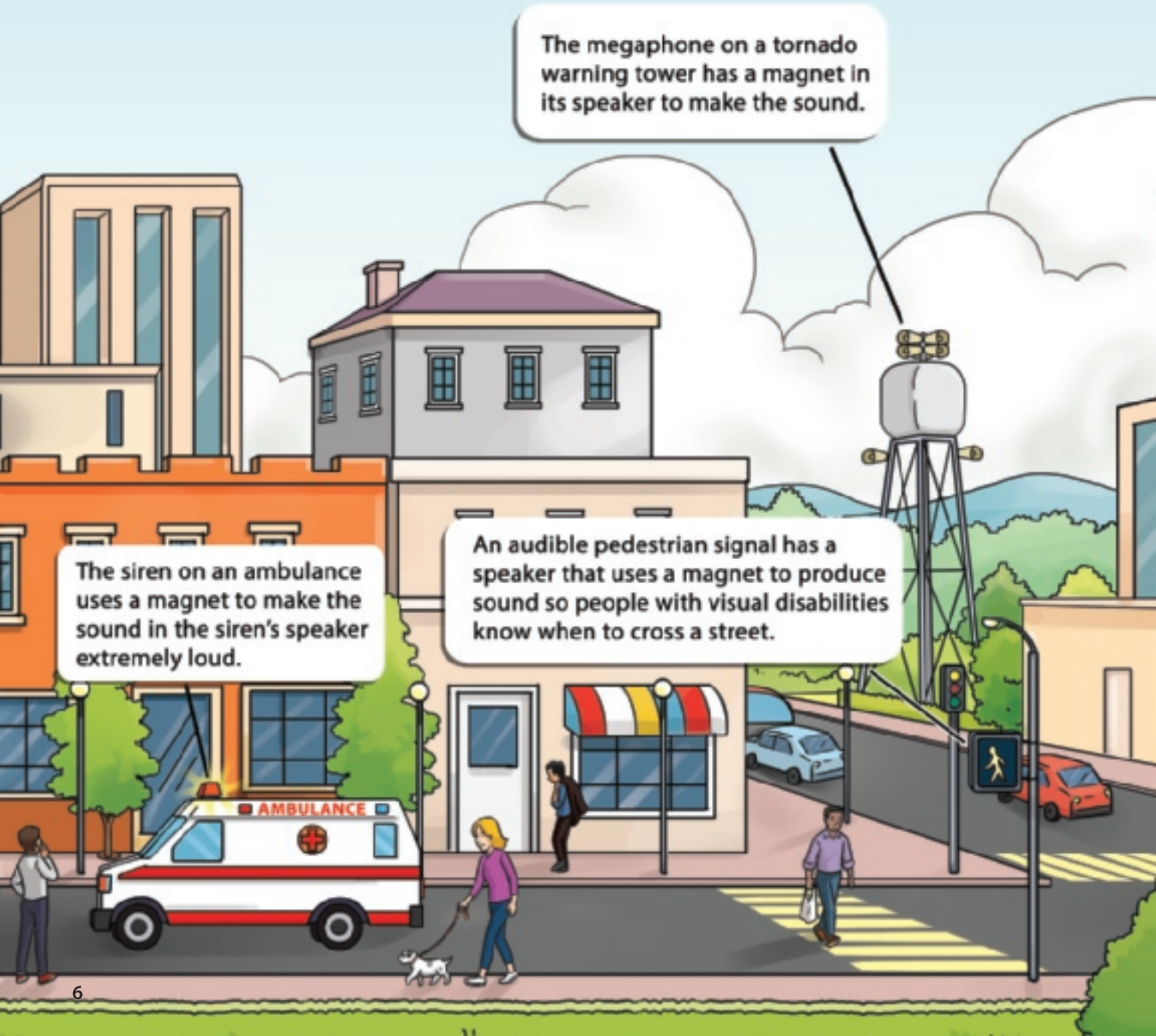
Nonmagnetic Materials

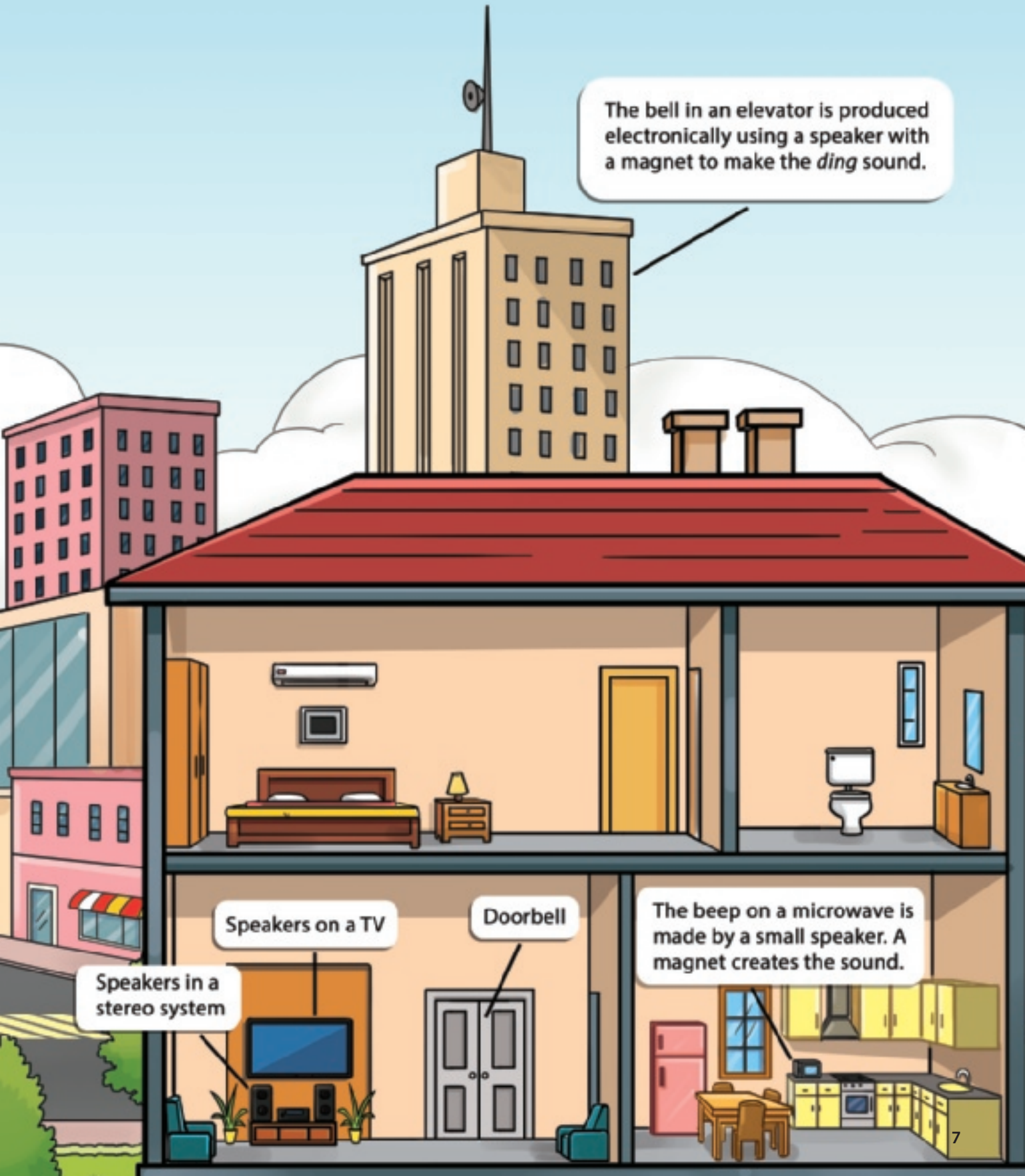
Nonmagnetic materials are those that do not react to magnets at all.

This includes all nonmetals but most metals as well. Aluminum, lead, gold, and silver are just some nonmagnetic metals.

Buzzers and Bells

We think about speakers for music and TV audio and so on, but we encounter simpler noisemakers for sound notifications in a lot of places. Your microwave popcorn is done; it's time to change classes at school; an elevator reaches its stop; a police car speeds by with sirens on; the city tests its tornado sirens; a delivery driver rings your doorbell. What's going on in all the places where we hear these noises? All these sounds are produced by speakers that use magnets to make the sound.




The bell in an elevator is produced electronically using a speaker with a magnet to make the *ding* sound.
Speakers on a TV
Doorbell
Speakers in a stereo system
The beep on a microwave is made by a small speaker. A magnet creates the sound.

Debate: Outlaw Magnets

While the specific situations presented here are fictitious, there was indeed a debate about the danger of "buckyball" magnets, which have been the subject of controversy and bans over their possible harm to children.

First Proposition

We are here today to debate whether the magnets, commonly known as buckyballs, should be banned. This matter will be voted on by Congress in the next month. I am here to represent the group supporting this ban. These magnets pose an unacceptable risk to babies and toddlers, who are likely to put them in their mouths and swallow them. Buckyballs are made of strong magnets and thus have serious consequences if they are accidentally ingested. The magnets will attract each other and can cause obstructions in the digestive tract. They can also pinch portions of the digestive tract together and even cause punctures and ruptures. It is entirely likely and even probable that small children will swallow these magnets, since they are very small and some are even coated with a brightly colored paint that makes them look like candy.

First Opposition

Thank you to my colleague for her opening remarks. While I and other manufacturers of buckyballs appreciate her concern, I would like to assure our legislature that buckyballs do not pose a significant risk to children. This is because, quite simply, they are not toys for children. Buckyballs are a product manufactured and sold to adults. All of our advertising targets adults. The magnets are intended to help with engineering solutions, since they can be stacked and arranged in various shapes and configurations. They are intended to help adults solve problems and relieve stress. They are not made for children, and children should not be playing with them.

Second Proposition

Whether buckyballs are made for children or advertised to children is immaterial. The simple fact is that children, especially small children, will want to play with them if they see them. The brightly colored coatings make them especially appealing to small children. This is not even a hypothetical situation. Children already have swallowed and been harmed by these magnets. In Ohio, a four-year-old boy swallowed 15 of the magnets because he thought they were candy. The magnets stuck together, forming a ring that pinched his small intestine closed. He required surgery. In Mississippi, a two-year-old child died after swallowing only four of the magnets. The magnets pierced her stomach, leading to blood poisoning. In California, a three-year-old girl swallowed 20 magnets, which formed a mass that blocked the entrance to her small intestine. The magnets were surgically removed.

Second Opposition

There is no doubt that objects of all kinds can pose dangers to children if swallowed. Yet razor blades are still sold, rat poison is still sold, and you can even buy explosive fireworks from roadside shops. Manufacturers, including my own company, are more than happy to provide package warnings stating that buckyballs are not toys for children and should not be handled by anyone under age 14. In fact, many manufacturers already provide these labels on our products. But that doesn't mean the manufacture and sale of buckyballs should be outlawed. We allow the sale of other products that could be dangerous to children. Why should buckyballs be held to different standards?

Proposition: Final Words

I strongly urge Congress to ban the manufacture and sale of buckyballs. Whether they are marketed to children or not, children find them in the home all too easily. All it takes is for a parent to leave a stack of buckyballs on their desk and turn their back for a minute. Unlike razors and poison, which are well known to be dangerous and usually kept away and out of sight, buckyballs are brightly colored and meant to be displayed. People think of them as toys and don't understand just how much of a danger they can be.

As my opponent stated, many manufacturers already do label their product packaging with warnings, and it hasn't been enough to prevent children from coming to harm. The only reasonable action to take is to prevent these toys from reaching children in the first place.

Opposition: Final Words

No one understands better than the manufacturers of buckyballs how dangerous our products are. After all, we handle them every day. This is why we have voluntarily added warning labels to our packaging to ensure our customers know that our products can cause harm if used incorrectly. Of course, so can many other products, yet those products are still available for purchase. It is not the job of the government to protect every child from every possible danger. That is the job of parents. Government has a responsibility not just to parents but to its law-abiding citizens to allow free enterprise and trade. Banning the manufacture and sale of buckyballs, which have caused harm only rarely and only when used against manufacturer recommendations, is not a reasonable action. This is especially true when many other dangerous products remain on the shelves. The reasonable action is to trust that consumers can and do know how to protect themselves and their families.

Words to Know

An *obstruction* is a blockage, which may allow some material to get through or may stop all material from passing through.

Hypothetical means something that hasn't actually happened but might happen.

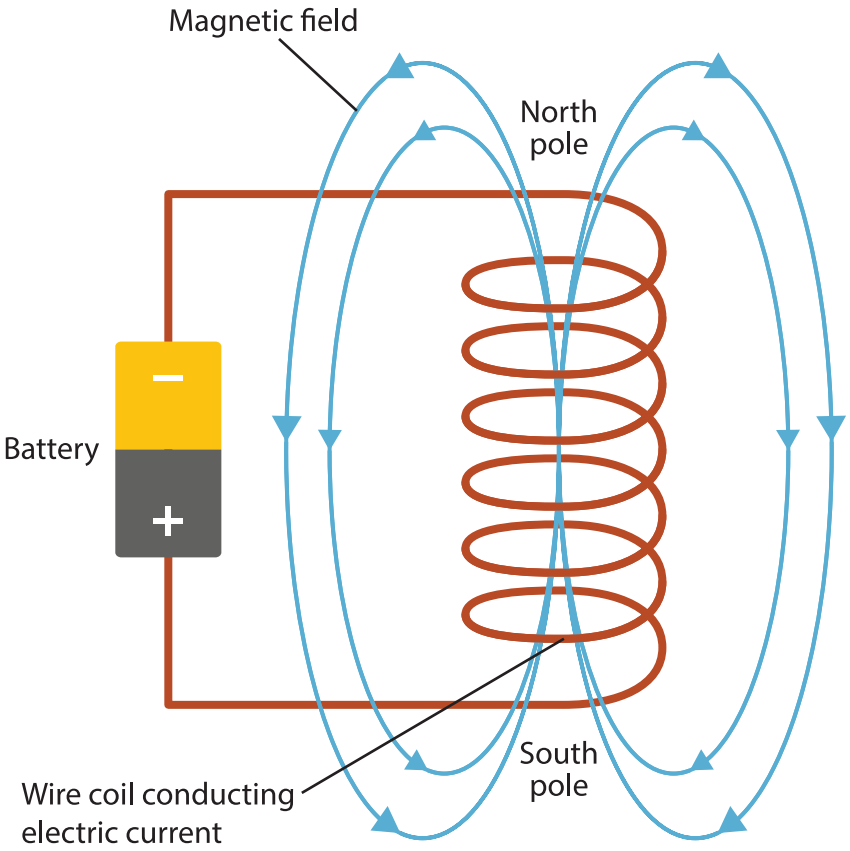
Dig into Data

The proposition's statement uses examples of child-related incidents to strengthen their argument. The opposition's statement does not provide any data or examples. What kind of data could have been included to strengthen the opposition's argument?

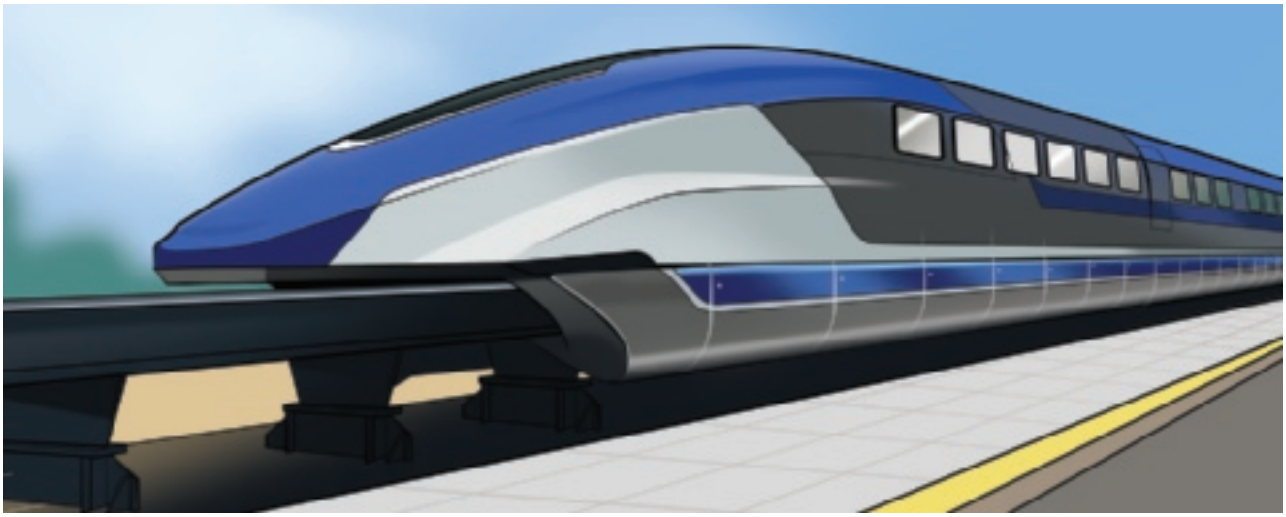
Consider the Sources

The news and social media are filled with controversial issues that provoke debates. When reading articles and scrolling through people's arguments, remember to consider the sources. In this article, the people opposing the ban of buckyballs are the product manufacturers. They have a vested interest in making sure that their product is not pulled off of shelves and banned from sale. The party who is proposing the ban of buckyballs does not have a vested interest in the product but is still trying to win an argument. From what you've read so far, do you think buckyballs should be banned?

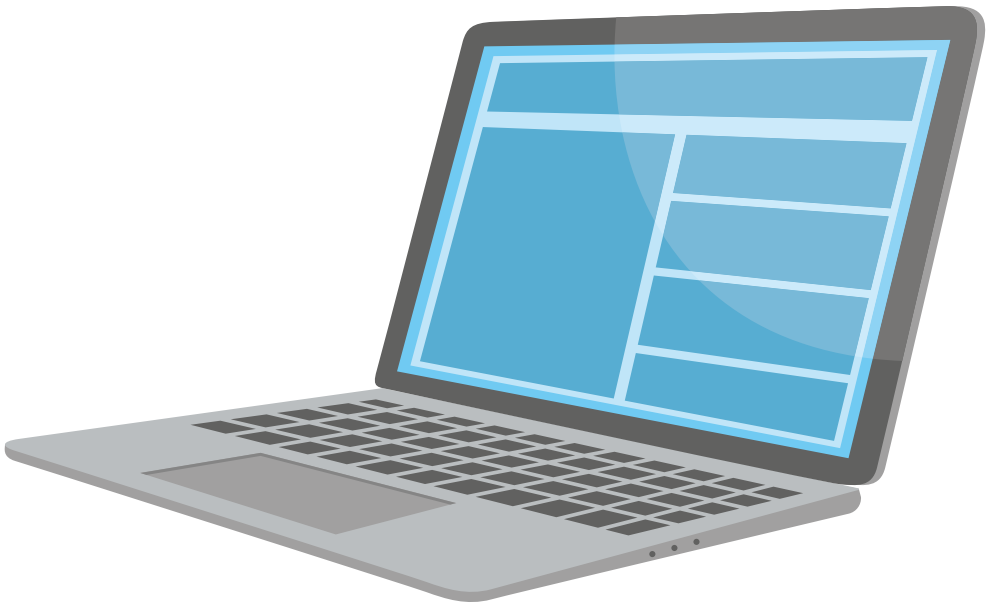
Flip of a Switch, Turn of a Dial



Electromagnets are simple devices, but they perform a range of amazing jobs. The ability of an electromagnet to be switched on and off—or strengthened by an electric current—makes it ideal for many uses.



Maglev trains use electromagnets to move the train. The *mag* in *maglev* is for "magnet," and the *lev* is for "levitation." The trains hover (or levitate) above their tracks. They can reach speeds of 430 km/h (270 mph)! Electromagnet controls are used to slow them down or speed them up.



The hard drive in your computer uses an electromagnet to write and read data. The hard drive disk itself is made of material that can be magnetized. An electromagnetic read/write head magnetizes the disk one way for 1 and the other way for 0. It can then read the direction of the magnet to retrieve data.

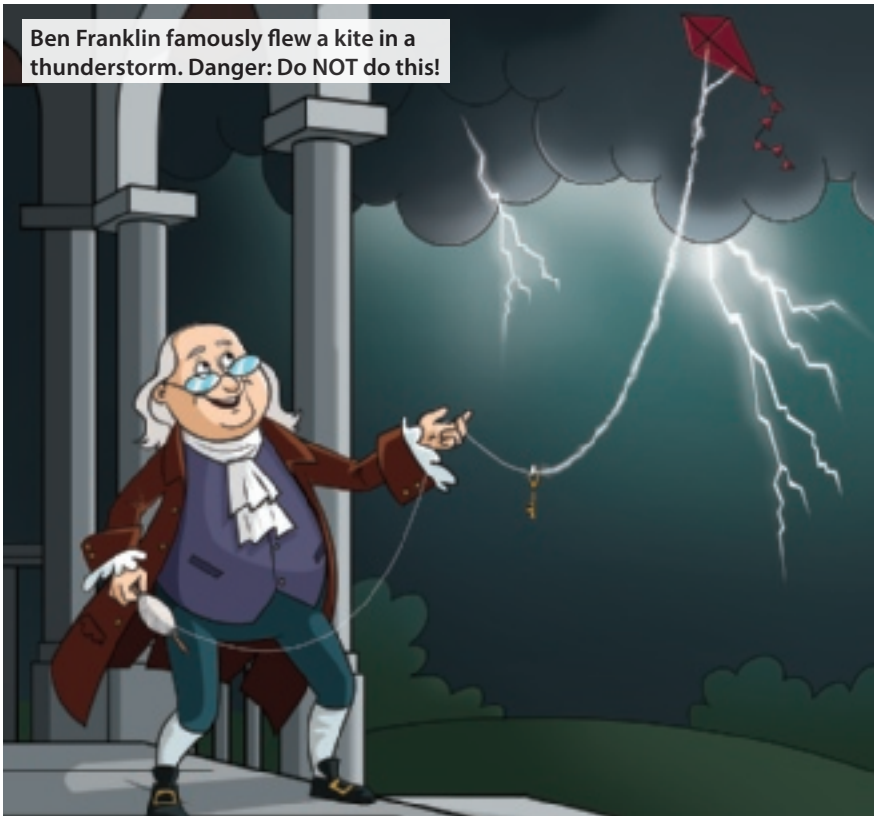
With the flip of a switch, induction stoves use electromagnets to heat pans. Those coils transfer electromagnetic energy to your pans that are made of those metals that can be magnetized, like iron. The electromagnet generates an oscillating magnetic field, which causes the molecules in the pan to move back and forth, increasing their temperature. Induction heating is used not just in cooking but also in plastics molding, welding, and metal casting.

Ben Franklin's Kite

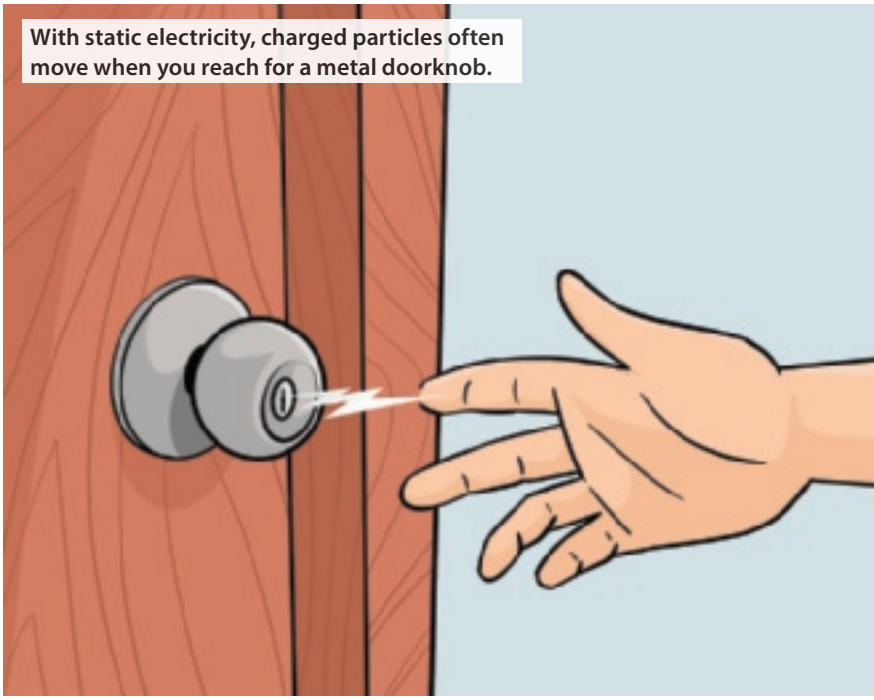
You might be familiar with the story of Benjamin Franklin flying a kite in a thunderstorm. But have you thought about why he did?

A common misconception is that Franklin discovered electricity with his kite experiment. In fact, electricity was well known in Franklin's time, especially static electricity. Static electricity is an electric charge on the surface of an object. It is called "static" because, unlike electric current that exists in a wire, static electricity remains on a surface. But it is often discharged with a snapping sound and a spark when two surfaces come into contact. You might have noticed this if you've ever walked across carpet and then touched a doorknob.

In Franklin's time, people knew about static electricity. Lightning, however, was a bit of a mystery. Franklin hypothesized that lightning was a form of static electricity as well. He suggested that electrical charges accumulated on the surfaces of clouds. To test his hypothesis, he designed an experiment.



Ben Franklin famously flew a kite in a thunderstorm. Danger: Do NOT do this!

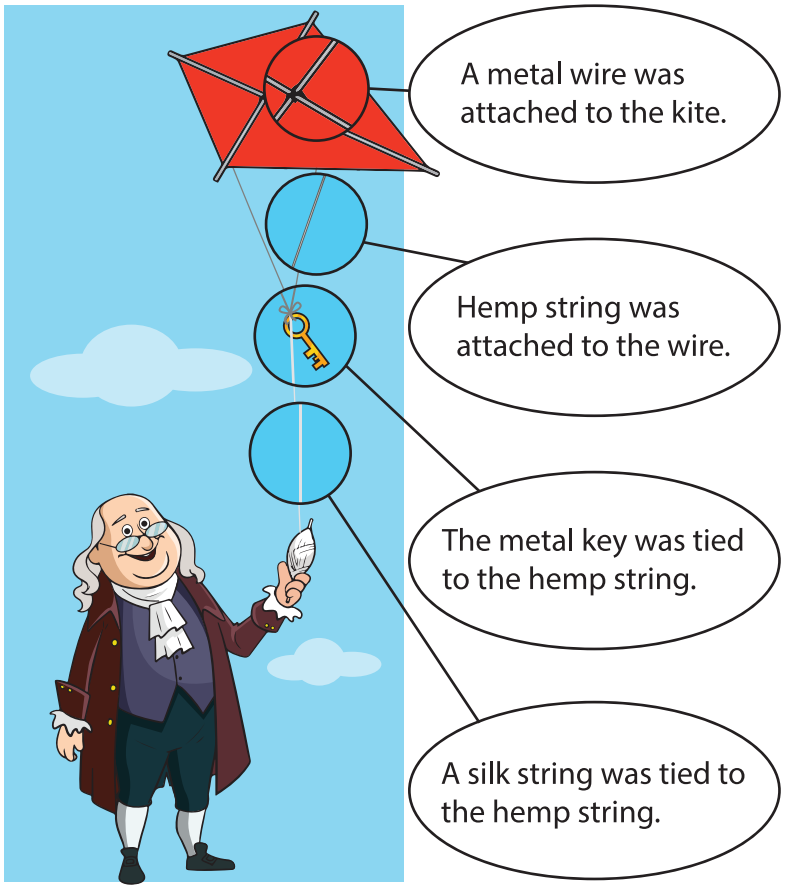


With static electricity, charged particles often move when you reach for a metal doorknob.

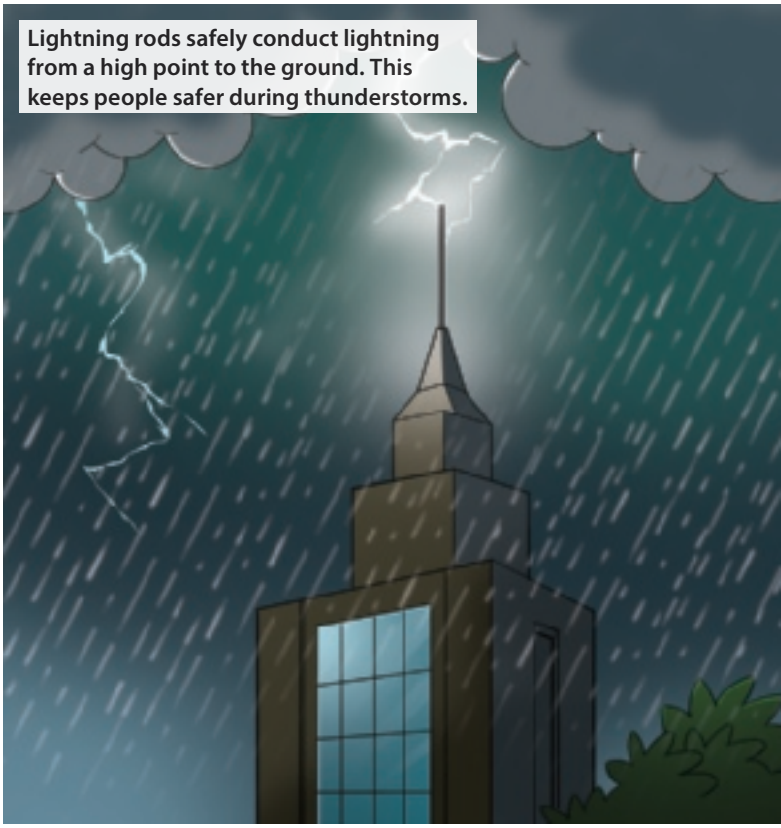
Franklin's original idea was to use a church spire to capture the electric charge. However, he realized he could achieve the same means using a kite with a metal key attached.

Why did Franklin include two types of string? The hemp, wet with rain, would conduct the electricity from the kite to the key, while the silk string remained dry in Franklin's hand.

Franklin's experiments led him to develop the lightning rod.



Myth-buster alert! Contrary to popular belief, Franklin's kite was most likely not struck by lightning. Lightning strikes are very dangerous and can kill people. Instead, Franklin's kite likely became charged in the air. Franklin then moved his hand close to the key, and a spark jumped from the key to his finger. This showed that the electricity in a thunderstorm could be static electricity, the same type that causes sparks to jump between a person's hand and a doorknob.



Lightning rods safely conduct lightning from a high point to the ground. This keeps people safer during thunderstorms.

Engineering Blog

Electrostatics and Cleaner Air

It's another lovely morning here in Bangalore, India. If you've been following my blog, you know that I've recently landed in the "Silicon Valley of India," where the exportation of information technology products is booming. The purpose for my journey is to meet up with fellow environmental engineers and learn about how India is addressing concerns related to global warming.

I've just finished my second plate of dosas from the ever-popular Brahmin's Coffee Bar—my new go-to breakfast spot—where I had the pleasure of meeting with Pavan Singh, an electrical engineer who helps design some really cool stuff: electrostatic precipitators (ESPs). Simply put, electrostatic precipitators are air filtration machines. They use electrostatic forces to clean particles found in the air as a means of reducing pollution. Mr. Singh and I had a lengthy discussion about the use of ESPs in both residential and industrial settings. In order to understand how ESPs work, it's important to know a little about electrostatics.

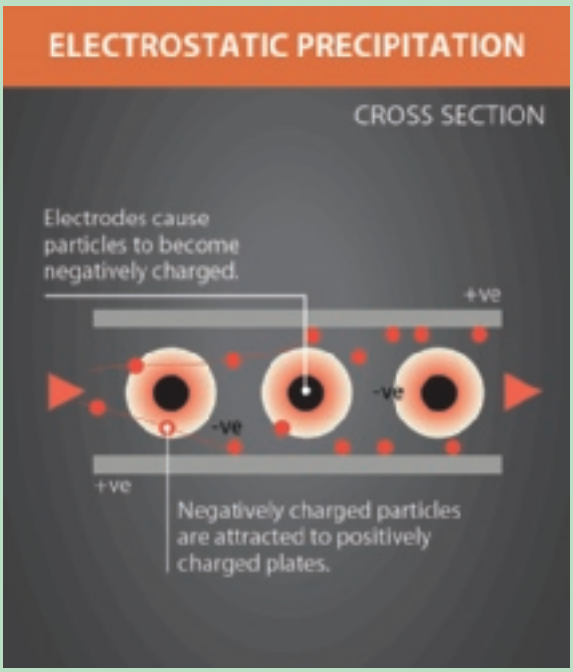
This is an industrial-size electrostatic precipitator. Residential ESPs are often marketed as "air purifiers."

Mr. Singh beams with pride when he shares that there are over 2,000 ESPs successfully working in India and globally: a glimmer of hope, perhaps, in the global warming crisis. These machines work by collecting unwanted particles (like smoke) from streams of air, but in order to do so, the particles first undergo some changes. Scientists and engineers came up with a way to use electrostatic forces to negatively charge the unwanted particles. Those negatively charged particles are then attracted to positively charged plates built into the precipitators. The plates pull the unwanted particles out of the air, and cleaner air is released into the atmosphere.

With the continued use of big industries, manufacturers, and power plants and the ever-increasing population, pollution will not go away anytime soon. And although electrostatic precipitators may not be a complete solution to the pollution problem, they're a step in the right direction.
The people who work on ESPs are my environmental heroes. Mr. Singh extended an invitation for me to tour one of the ESP manufacturing plants in India, an offer I was excited to accept. You might say I was ecstatic! ;)

Electrostatic Forces

Electrostatic forces are noncontact, invisible forces based on polarity, or the attraction or repulsion between particles according to their electric charge. Electrostatic forces engage in push-pull behavior. Opposite charges attract each other, and like charges repel each other.



Plates with positive charges attract negatively charged, unwanted particles to remove them from the air.

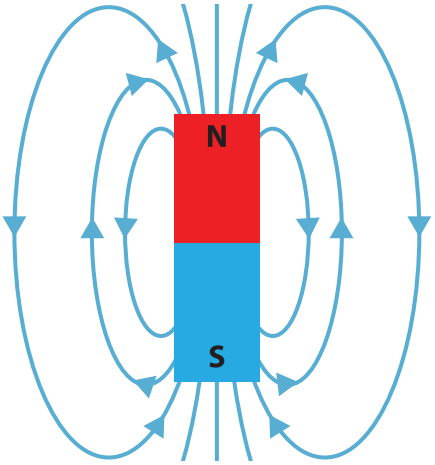
Pushing and Pulling Without Touching

Magnetism isn't the only **noncontact force**. Three phenomena—**magnetism**, **gravity**, and **electrostatic force**—affect our lives every day.

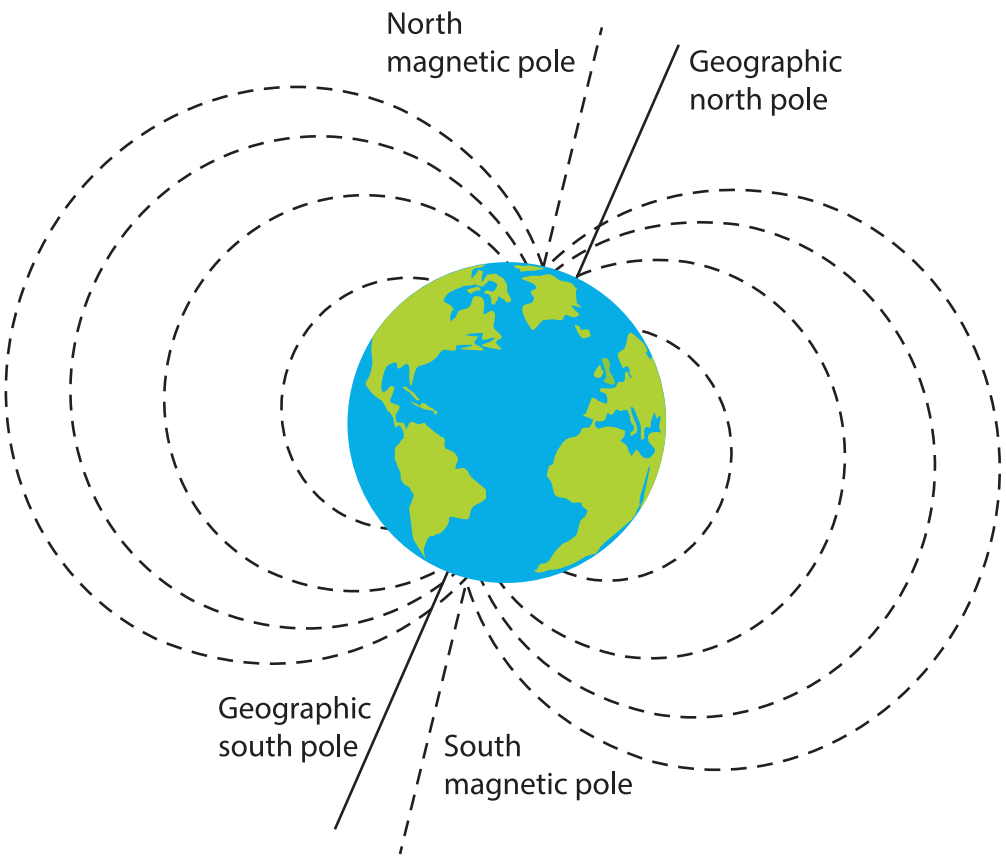
Magnetism	Electricity	Gravity
Strength Magnetism is a relatively strong force. The strength of the magnet depends on the material and manner in which it was made.	**Strength** Static electricity is a relatively strong force. The strength of an electrical field depends on how much the charge builds up on a surface.	**Strength** The strength of a gravitational field is related to the mass of an object. Every mass results in a gravitational field.
Generates a field Magnets generate magnetic fields. These fields can be visualized through simple means, such as scattering iron filings around a magnet. The filings line up along the magnetic field lines.	**Can take the form of a field** A field of static electricity, called an electrical field, can be generated by electric charges or magnets. If you've ever seen a person touch an electrostatic ball and had their hair stand on end, you've witnessed the effects of an electrostatic field.	**Generates a field** Distance plays a role in the effect of gravity that two objects exert on one another. This is why Earth is greatly affected by gravity from the sun, but much less affected by gravity from Vega, which has more than double the mass of the sun but lies over 25 light years away from Earth.
Uses Magnets are used in many everyday items, ranging from the speaker in your phone to the seal on your refrigerator. Magnets are also used to write digital data, including both the hard drive on a laptop and the drives in computer servers. Nearly all digital information exists because of magnets!	**Uses** Electrical fields have many uses. Laser printers use them to place ink on paper. Some air filters use electrostatic fields to draw contaminants out of the air. These fields are even used in nuclear physics research.	**Uses** Gravity keeps everything on Earth grounded on Earth, as well as keeps Earth and the other planets in orbit around the sun. But many objects use gravity to do work. Satellites in orbit around Earth rely on Earth's gravity to avoid shooting out into space. Earth's tides, which people rely on for fishing, recreation, and many other things, exist because of the interaction of Earth's gravity and the moon's gravity. Many water systems use gravity to generate water pressure—this is why water is stored in towers.

Earth Is a Magnet

Earth generates a magnetic field. Earth's core is made of nickel and iron, and Earth's spin causes motion in the core metals that creates a magnet. The magnetic field around Earth helps protect Earth's surface from solar winds that would otherwise blow away Earth's atmosphere. Earth's magnetic poles are not perfectly aligned with Earth's axis. This means that compasses, which help humans navigate, do not point to true north. The place compasses point to is known as "magnetic north."



A simple bar magnet generates a magnetic field. By convention, the ends of a magnet are designated north (N) and south (S). The magnetic field extends around the magnet.



Connection

Did you know humans are not the only ones who use Earth's magnetic field to navigate? Scientists believe that migratory animals, such as birds, use magnetism to find their way. Some birds have a region in their beaks that contains iron, while others have magnetic-sensing receptors in their eyes. Exactly how migratory animals sense Earth's magnetic fields is not fully understood yet, and research is ongoing to learn more.

No Touching

The Science Art Gallery welcomes you to our newest exhibit: No Touching. No doubt you are used to being asked to not touch the art in museum galleries, but in this exhibit, the art itself was made *with no touching!* Until you can visit the gallery in person, let this brochure be your guide to the fun collection of noncontact work by our science artists.

Magnet Paintings

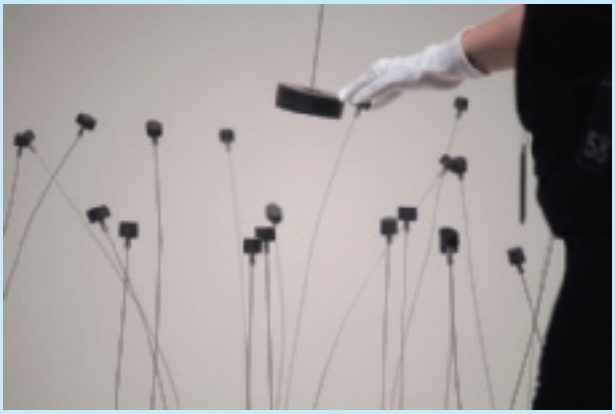
Several beautiful paintings were made using magnets, metal objects, and acrylic paints. The metal objects were dipped in the paint, then placed on the canvas. A magnet was then moved around on the back of the canvas. The metal object covered in paint was attracted to the magnet and moved along with it. You can try this painting method at home!

Magnetic Fluid Sculpture

This moving sculpture is made of a liquid that contains a suspension of magnetic nanoparticles. The liquid is known as a ferrofluid, named for iron, one of the metals used to make the nanoparticles. The nanoparticles are coated in a material that keeps them from sticking together, so the fluid never forms clumps.

When no magnet is present, the fluid acts like any other liquid. But when a magnet is introduced, the nanoparticles react, forming spectacular three-dimensional shapes. These shapes are influenced by the magnetic field and most often take the form of spikes. The arrangement of the spikes depends on the strength, shape, and placement of the magnet.

Kinetic Sculpture



Kinetic sculpture, as the name implies, is any sculpture that moves. Not all kinetic sculptures employ noncontact forces. Many are powered by wind, electric motors, or even human touch. However, this interactive kinetic sculpture is powered by magnets. The hanging magnet is moved into various positions near the magnets on stems. This creates either a magnetic attraction or a repulsion, causing the sculpture to move.

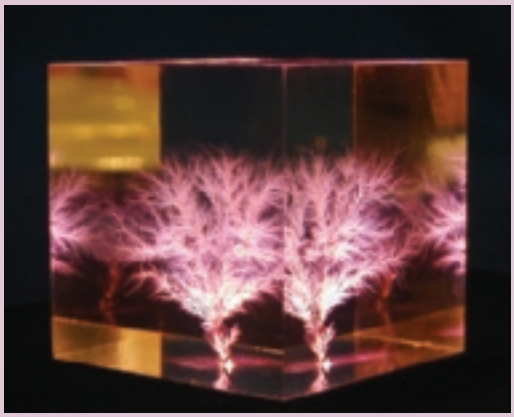
Of course, this sculpture does eventually stop moving. A first push is required to set it in motion. The motion can last for hours afterward. And even when the sculpture stops moving, the shapes it makes are still beautiful and interesting to see.

Pendulum Painting

Our pendulum painting harnesses the force at a distance, gravity, to make art. The mechanism is simple, yet the results are astonishing. A reservoir is filled with paint, with a small opening at the bottom the paint pours through. This is suspended on a rope from a support. Beneath is the paper or canvas. A push sets the pendulum in motion, and gravity does the rest!

You can see many paintings made using a pendulum and observe the intricate designs made using only paint and gravity, and you can watch the pendulum in action. New paintings are being made all the time.

Lichtenburg Figures



Lichtenberg figure is the name given to the afterimages created by static electricity. The installation here in our gallery was created by sending a controlled jolt of static electricity into a piece of acrylic plastic. The acrylic is lit from one side to make the image more visible.

The Lichtenberg figures on display in our gallery were artificially created, but they occur naturally as well. When lightning strikes certain materials, a Lichtenberg figure can be left behind. They have been observed in sand, wood, and soil. Lichtenberg figures have even been left as scars on the skin of people who survived being struck by lightning, although this is not a common occurrence.

The Moon Matters

Have you ever thought about what the moon means for life on Earth? The moon is more than just a pretty figure in the night sky. The moon affects every living thing every day.

The moon is over 220,000 miles (360,000 km) from Earth. It orbits Earth, just as Earth orbits the sun. The moon and Earth interact, with each exerting a gravitational effect on the other. Earth's gravitational effect is greater than that of the moon since Earth is so much more massive. Earth's gravitational field is so strong that it causes the moon to be tidally locked to Earth. This means that the same side of the moon always faces Earth. The other side of the moon faces away from Earth. Some people refer to this side as the "dark side" of the moon. They are referencing the side of the moon not visible from Earth. That side of the moon still gets light from the sun, but humans on Earth can't see it because it faces away from us.

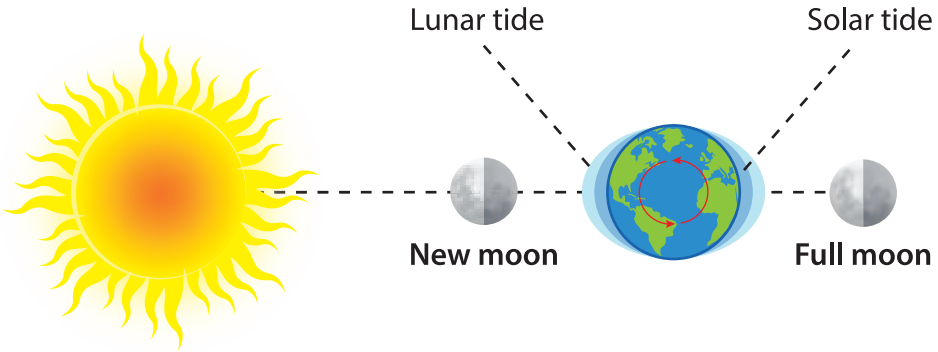
Humans use the moon's phases to keep track of the passage of time. A new moon refers to the moon phase when the moon appears dark in the sky. During a new moon, the side of the moon receiving light from the sun faces away from Earth. As the part of the moon that appears bright in the sky grows larger, the moon is said to be waxing. A waxing crescent moon refers to a thin strip of lit moon. A waxing quarter moon is when half of the moon facing Earth is lit. A waxing gibbous moon is lit on more than half the side facing Earth. A full moon occurs when the entire side of the moon facing Earth is lit. As the part of the moon that appears bright in the sky grows smaller, the moon is said to be waning. The moon goes through waning gibbous, waning quarter, and waning crescent phases before finally returning to the new moon phase. Then the cycle begins again. This cycle occurs once every 28 days, which is just under the length of a month. In fact, the word *month* comes from the word *moon*!

The moon's gravity plays an important role for Earth as well. The moon's gravitational pull causes tides. This means that water on Earth's surface rises and falls based on the pull of gravity from the moon. Tides happen on a regular, predictable basis.

Tides aren't just useful for boats. Tides are the reason life on land is possible. Long ago, life existed only in Earth's oceans. The land was bare rock. Tides created pools in the rock and sometimes stranded living things in those pools. Over time, these living things developed the ability to live outside the water. Life moved onto the land, spreading over the continents. Without the moon to give Earth its tides, none of that would have been possible.

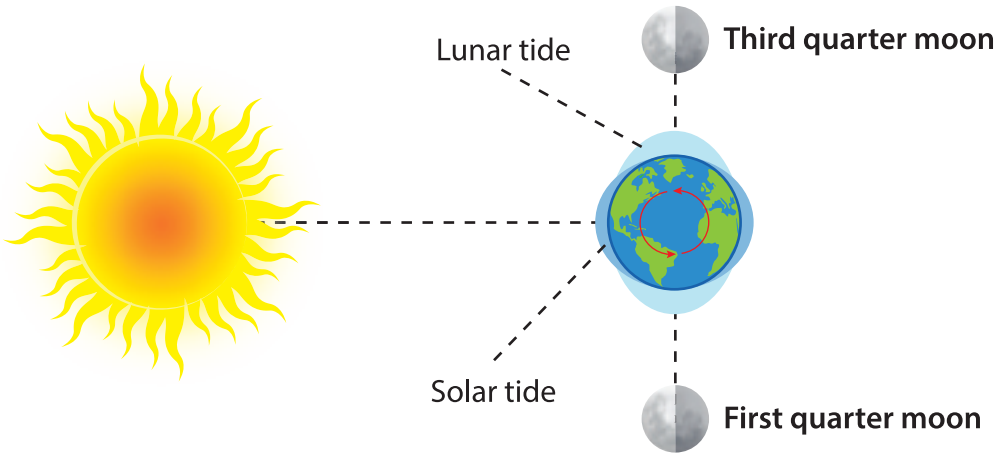
Spring tides occur during new moons and full moons. Spring tides are the most extreme tides, with high tides at their highest and low tides at their lowest.

Spring tide



Neap tides also occur twice a month, during the quarter moon phases. These are the most moderate tides, with the lowest high tides and the highest low tides.

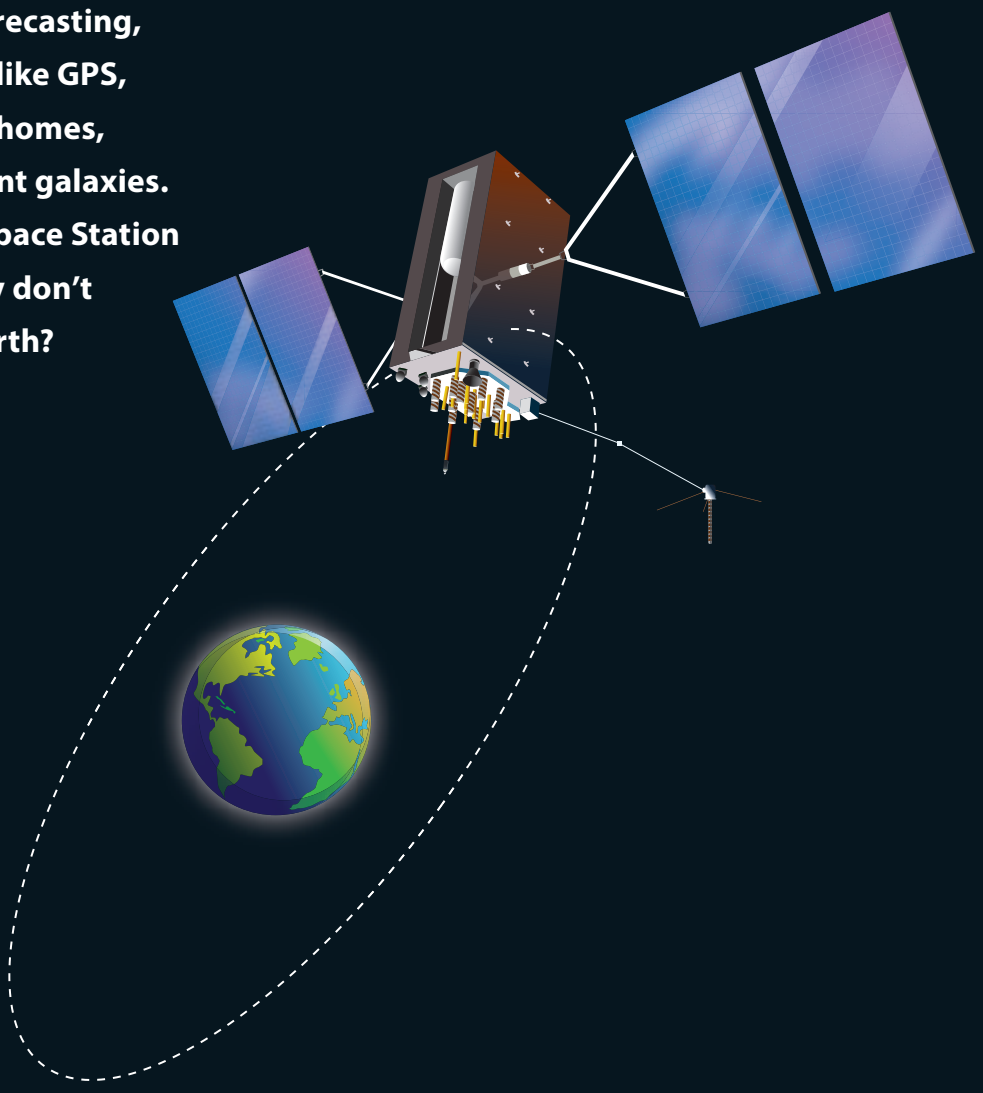
Neap tide



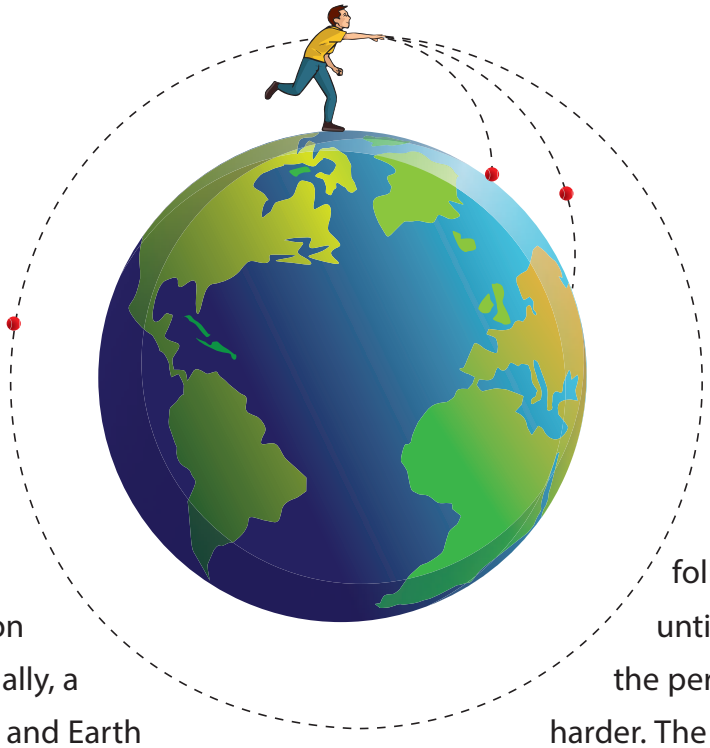
Phases of the Moon

Why Don't Satellites Fall?

There are thousands of satellites zooming around Earth. They help with weather tracking and forecasting, provide navigation aids like GPS, send television feeds to homes, and take photos of distant galaxies. Even the International Space Station (ISS) is a satellite. So why don't satellites plummet to Earth?



Satellites orbit Earth, the same way the moon orbits Earth. This is how you can be certain they are subject to gravity, since orbits only exist because of gravity. Unlike the moon, many artificial satellites can have their orbits changed or corrected if they start to drift. Onboard thrusters can shift the position of the satellite as needed.



Satellites have a gravitational interaction with Earth. Gravitationally, a satellite attracts Earth, and Earth attracts the satellite. However, the effect of Earth's gravity is enormously greater because its mass is enormously greater. Shouldn't that mean the satellite should always and immediately crash into Earth's surface? Well, not exactly, because the satellite also moves at a right angle to Earth's gravitational force.

Think of it like this: If a person stands at one point on Earth and throws a ball, the ball follows a curved path until it lands. Suppose the person throws the ball harder. The curved path of the ball lengthens, and the ball lands farther away. If a person could somehow throw a ball so hard that the curved path along which it fell followed the curve of Earth's surface, the ball would continue its motion and also be subjected to the force of Earth's gravity. This is essentially what happens with satellites. They are always falling, but they are moving fast along a path that follows the curve of Earth, so they never fall *down*.

Connection

Satellites are complex products to design and make. Aerospace engineers design satellites that must withstand a variety of conditions in space. Some engineers specialize in radiation and making sure that satellites are built out of materials that can tolerate the amount of radiation they are exposed to in orbit around Earth. Other engineers specialize in figuring out how the satellite would hold up from a collision, such as from a meteorite. Electrical engineers design the computerized chips that go into the satellites that essentially instruct the machinery on what to do. All engineering for satellites attempts to minimize their mass because lifting on a rocket and getting them moving fast enough to enter orbit are tremendously challenging.

Gravitational Lensing

Imagine a force of gravity so strong it pulls on light! A gravitational lens can occur when a huge amount of matter, like a cluster of galaxies, creates a gravitational field. This field distorts and magnifies the light from distant galaxies that are behind it. The effect is like looking through a giant magnifying glass in the sky.

Galaxy cluster Abell 370 is located about four billion light years away. It contains an astounding assortment of several hundred galaxies. These galaxies are tied together by gravity. Entangled among the galaxies are mysterious-looking arcs of blue light. These blue lights are distorted images of remote galaxies behind the cluster. The gravity from the cluster acts as a huge lens in space. It magnifies and stretches images of background galaxies like a funhouse mirror, making it possible for scientists to observe them.

Smaller objects, like individual stars, can also act as gravitational lenses. This happens when they pass in front of more distant stars. For a few days or weeks, light from the more distant star temporarily appears brighter because it is magnified by the gravity of the closer object. This effect is known as gravitational microlensing.

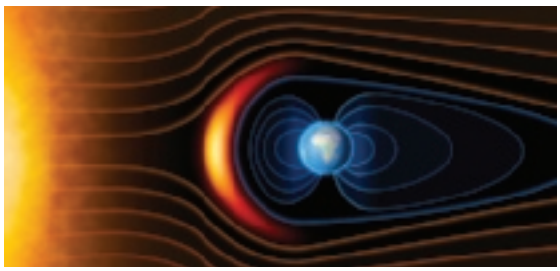
The simplest type of gravitational lensing occurs when there is a single concentration of matter at the center, such as the dense core of a galaxy. The light of a distant galaxy is redirected around this core. It often creates multiple images of the background galaxy. When the lensing approaches perfect symmetry, a complete or almost-complete circle of light is produced.

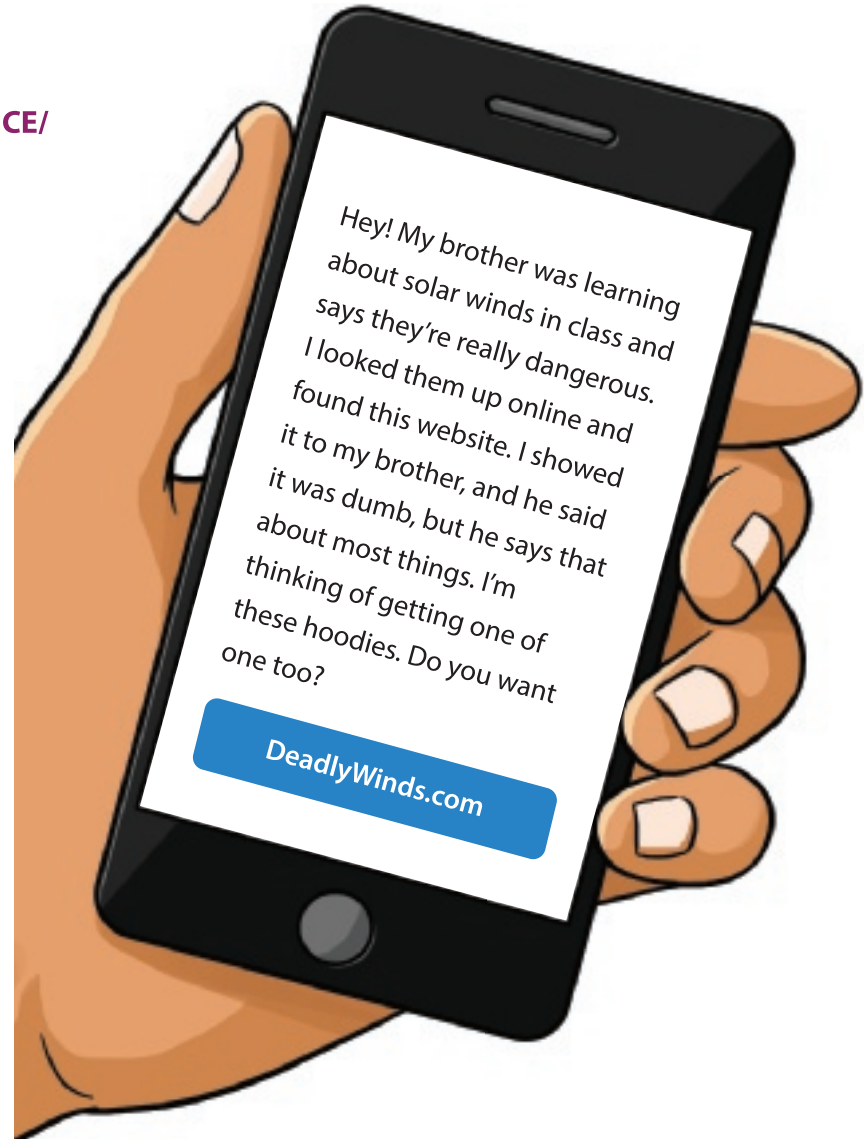
This image shows two different galaxies: one red and one blue. The gravity of a luminous red galaxy (LRG) has distorted the light from a much more distant blue galaxy. Such light bending results in two images of the distant galaxy, but here the lens alignment is so precise that the background galaxy is distorted into a horseshoe—a nearly complete ring.

Solar Winds

Excerpt Summary from NASA Article at https://www.jpl.nasa.gov/nmp/st5/SCIENCE/solarwind.html

The solar wind is an outward expansion of charged particles from the sun's atmosphere. The solar wind carries with it some of the sun's magnetic field. The radiation extends like a bubble reaching far beyond most planets in the solar system. Where the solar wind approaches our planet, it is deflected by Earth's magnetic shield. The "zone" around Earth that encounters and blocks solar wind is called the magnetosphere. Earth's magnetosphere causes most of the solar wind's energetic particles to flow around and beyond the planet. The magnetosphere reacts dynamically to the sun's activity. Interaction between the magnetosphere and the sun's charged particles can be visible as the northern and southern lights (aurora borealis and aurora australis). Solar winds can disrupt and damage satellites and harm unshielded people outside Earth's atmosphere. Intense solar flares can also temporarily disrupt radio communication and navitation systems on Earth.





You click the link in your friend's text and are taken to a website all about the dangers of solar winds. Do you think your friend is correct? Should you buy a hoodie?

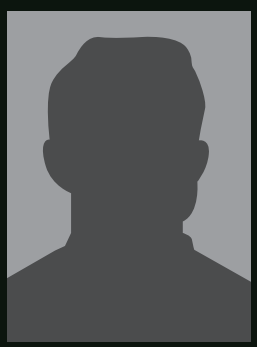
Word to Know

Dynamically means in a constant state of change.

deadlywinds.com

HOME ABOUT US SERVICES CONTACTS

The Danger of Solar Winds



The greatest threat to human life on Earth is not a pandemic or global warming or even war. The greatest threat is solar winds.

What are solar winds?
- Come from the sun
- Contain dangerous radiation
- Very high speed
- Strip away atmosphere
- Damaging to DNA and living things

It is well known that all life on Mars died because solar winds ripped away the atmosphere. The very same thing will happen to Earth if we don't take action soon. The government has created a disinformation campaign about Earth's magnetic field driving away solar winds. But ask yourself: If Earth is a magnet, why doesn't metal stick to it? And since when have magnets ever stopped wind?

Don't fall for the lies! Protect yourself from dangerous solar winds with a Rare Earth Mesh Hooded Jacket (order form below).

Spot the BS

Heads up! There's some **b**ad **s**cience on this page. Can you list all the ways this website distorts facts? How does the writer of the website try to convince you that you need to buy this jacket?

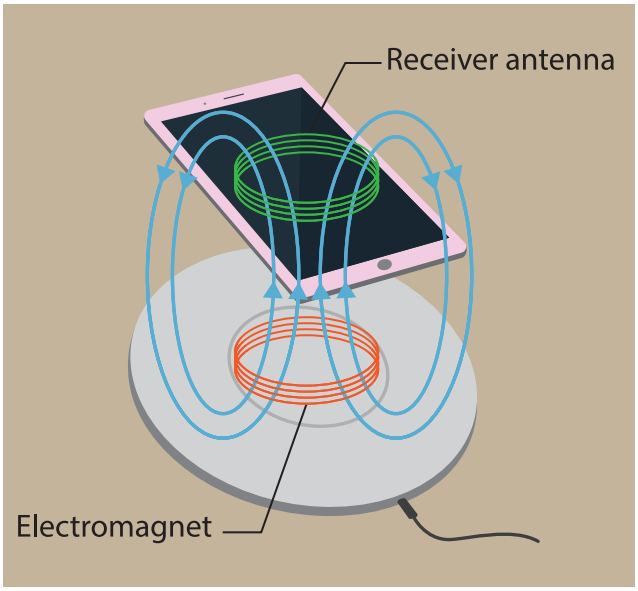
Consider the Source

Does this website lists a researcher? Does it state what they have discovered, or how it relates to the claims on the website?

Unplugged

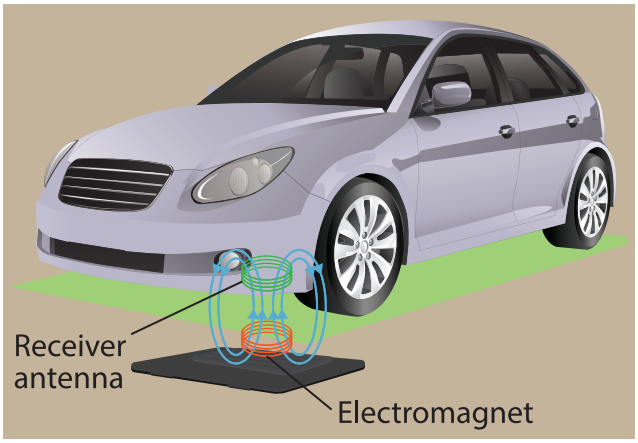
What if you could charge your phone without a cable? That's the idea behind wireless chargers. To use a wireless charger, you simply set your phone on it. There are no wires connecting the phone to the base.

In a wireless charger, an electromagnet made of copper coils generates an oscillating magnetic field. The phone responds to the field by establishing an electric circuit that charges the battery. So the charging device must have a wire coil designed for this purpose, usually called a receiving antenna. Many of the latest phones have wireless charging capabilities built in.



This is the same idea behind wireless electric vehicle (EV) charging pads. Wireless chargers can be incorporated directly into parking spots so EVs don't have to be plugged in to bulky stands when they need to recharge. These chargers are already available for home use and may be incorporated into public use in the future.

Wireless charging is held back by the need for the charger and device to be very near each other. A separation of more than a few inches makes charging impossible. You must leave the phone on the charge pad, or the magnetic field becomes too weak to charge the battery. However, research into increasing the distance between the charger and receiver is ongoing. It's possible that, in the future, you'll never need to plug in your phone!



Touchless Music

Plenty of musical instruments rely on electricity—keyboards, electric guitars, and turntables, just to name a few. But one instrument, the theremin, uses an electrical field and isn't even touched by the musician playing it.

The theremin was invented in 1920 by a Russian physicist named Lev Sergeyevich Termen, whose name in Western countries is Leon Theremin. He was conducting research on proximity sensors when he noticed that he could change the pitch of the sensors by moving closer to or farther away from them. He created the instrument that now bears his name and toured Europe for nearly a decade before moving to the United States and filing a patent for the instrument in 1928.

A theremin has two metal rods that the musician, called a thereminist, uses to vary the pitch and volume of the sound. When the thereminist places their hand inside the theremin's electric field, their hand interferes

with the field. The theremin then translates this difference into either a change in frequency (pitch) or amplitude (volume).

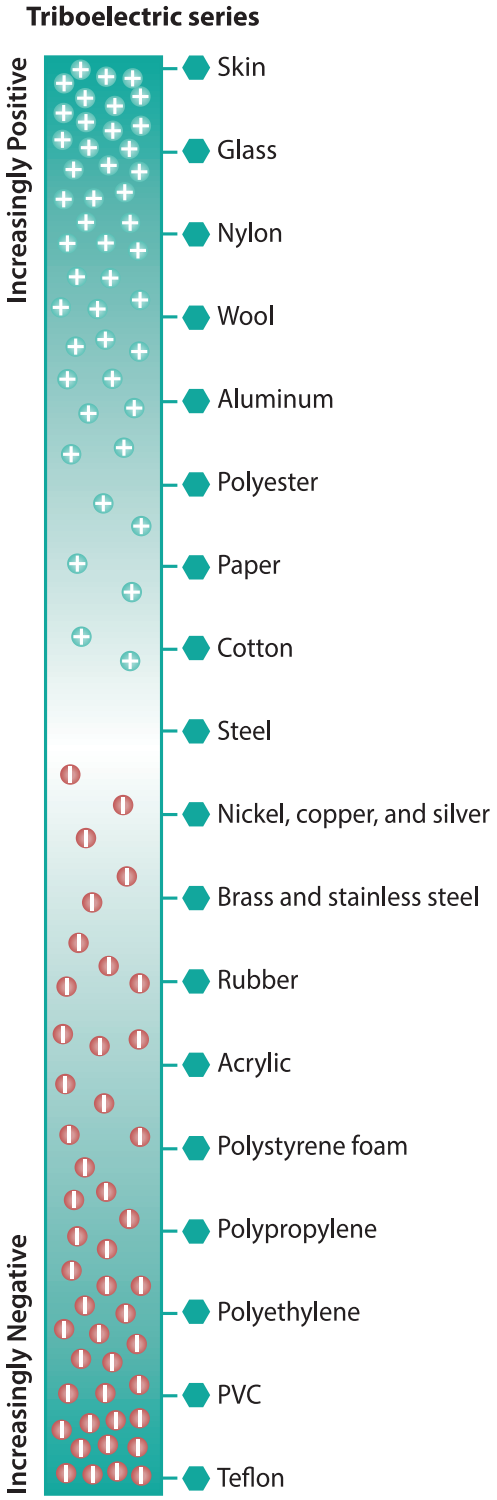
The sound produced by a theremin has an eerie, futuristic quality that composers often incorporate into music to give it a spooky feel. They're not only used to add that spooky vibe, though. A theremin is also featured in "Good Vibrations" by the Beach Boys.

The Triboelectric Effect

The triboelectric effect is the phenomenon that occurs when two surfaces become oppositely charged when they touch. This is common with natural surfaces, such as wool and skin, as well as synthetic surfaces, such as vinyl and polyester. When the two surfaces are pulled apart, electrostatic discharge (ESD—a static shock) may occur.

A triboelectric series is a way of organizing materials that tend to acquire positive or negative charges when they contact each other. The further apart in the series two materials are, the greater the static charge that will build between them. Thus, rubbing wool on glass builds very little charge, but rubbing wool on polystyrene foam builds a lot of charge and might generate a spark.

Electrostatic forces both push and pull. A buildup of charge on surfaces of technological devices could lead them to attract dust. For this reason, many computer components are manufactured in clean rooms that control for ESD.



Dig into Data

Which materials in this diagram would create the largest charge when contacting each other? Which materials would create the smallest charge?

Safety First!

For most workers, rubbing up against something and creating a bit of static charge is no big deal. But for some, a small static spark could ruin a product, contaminate a substance, or even cause an explosion. If you are in the group that has to avoid static, we make just the line of workwear for you. Announcing our new electrostatic discharge (ESD) protective clothing!

Our ESD clothing is made to prevent static buildup. A patented carbon fiber weave insulates the body against external charges and directs electrostatic forces into the ground. Our clothing is ideal for workers in sensitive industries, including:

- **Electronics manufacturing**
- **Research laboratories**
- **Flammable fuels refining**
- **Medical devices manufacturing**
- **And many more!**

Any industry in which dust, dirt, or sparks could harm the products or workers should use ESD clothing to prevent problems. We've got you covered! (Contact our sales department for volume pricing for your whole team.)

SciFi or SciFact?

SciFi or SciFact?

You weigh less at the top of a mountain than you do at the beach.

SciFi or SciFact?

Science Fact! Weight is a measurement of how much an object is pulled by gravity. Gravitational force depends on the masses of two objects and the distance between the centers of the objects. You are farther from the center of Earth on a mountain than at sea level, so the gravitational force you experience is less. But this difference is so small you probably won't notice.

SciFi or SciFact?

Earth's geographic north pole is also its magnetic north pole, and Earth's geographic south pole is also its magnetic south pole.

SciFi or SciFact?

Science Fiction! In fact, Earth's magnetic and geographic poles are reversed. The magnetic south pole is in the Northern Hemisphere, and the magnetic north pole is in the Southern Hemisphere. The magnetic poles also don't perfectly line up with Earth's rotational axis—they're both about a thousand kilometers away and moving all the time. Yes, they are moving! Earth's magnetic poles move constantly, so much that they swap back and forth. It's not known exactly how long this swap takes, but some scientists think it could be as fast as every 1,000 years or so!

SciFi or SciFact?

Scientists used a magnet to make a frog float in midair.

SciFi or SciFact?

Science Fact! A group of researchers from the Netherlands used a very powerful magnet to levitate a very bewildered—and unharmed—frog. It took 16 teslas (a unit used to measure magnetism) to raise the frog off the ground. The researchers hope the technology can be used as a safe and inexpensive way to test the effects of weightlessness before astronauts are sent into space.

SciFi or SciFact?

Science Fact! Canadian astronaut Chris Hadfield noticed that he spoke differently upon returning to Earth after spending five months aboard the International Space Station. He claimed he could feel a difference in where his tongue was positioned in his mouth due to gravity. Scientists subsequently conducted a study using NASA's recordings of the voices of astronauts before, during, and after spaceflight. The study showed that astronauts did, indeed, have an accent when they returned to Earth. This "space accent" disappears over time as the astronauts get used to gravity again.

SciFi or SciFact?

Astronauts develop an accent in the microgravity environment of the International Space Station.

SciFi or SciFact?

Science Fiction! Although scientists still don't understand exactly how magnetic sensation happens, they do know that some animals, such as pigeons, have spaces in their skulls filled with high concentrations of iron-rich blood. And humans seem to share this trait! Although we aren't aware of sensing magnetic fields, scientists have used special chambers to study whether people could sense the direction of magnetic fields. They found that people's brain waves change as the magnetic field around them changes. This ability may help humans navigate by helping us sense which way is north and which way is south.

SciFi or SciFact?

Some animals can sense magnetism, but humans can't.

SciFi or SciFact?

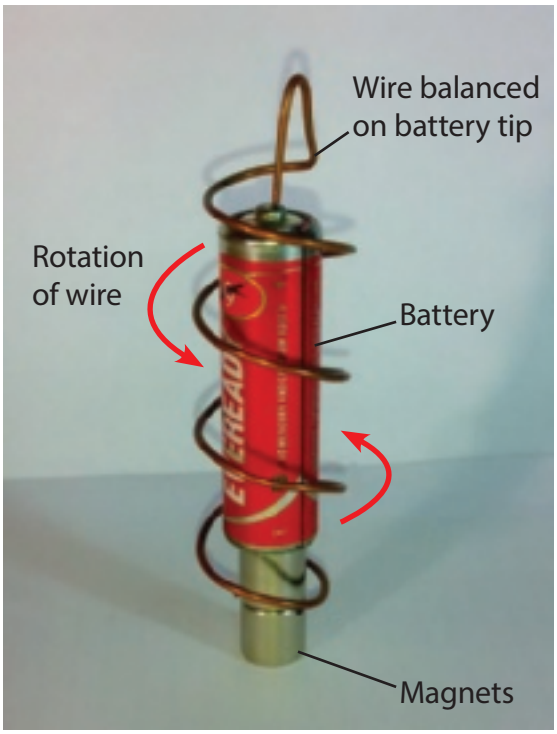
Science Fiction! While lightning strikes are dangerous and can be deadly, about 70% of lightning strike victims survive. On average, about 50 people a year die because of lightning strikes. However, current electricity, like the electricity in a light socket, kills about 200 people a year! The light socket in your home is much more dangerous than a thunderstorm.

SciFi or SciFact?

Lightning is the most deadly form of electricity.

Magnet and Motor

Electric motors use magnets to produce motion—rotation of a rotor. A monopole motor, also called a homopole motor, is a simple motor that uses current electricity and a magnetic field to generate movement. A monopole motor works because a current flows through the wire, which is in a magnetic field. The magnetic field is perpendicular to the current in the wire and repels or pushes the wire, which creates rotational force. This force is called a Lorentz force. A monopole motor is simple to make following these steps:

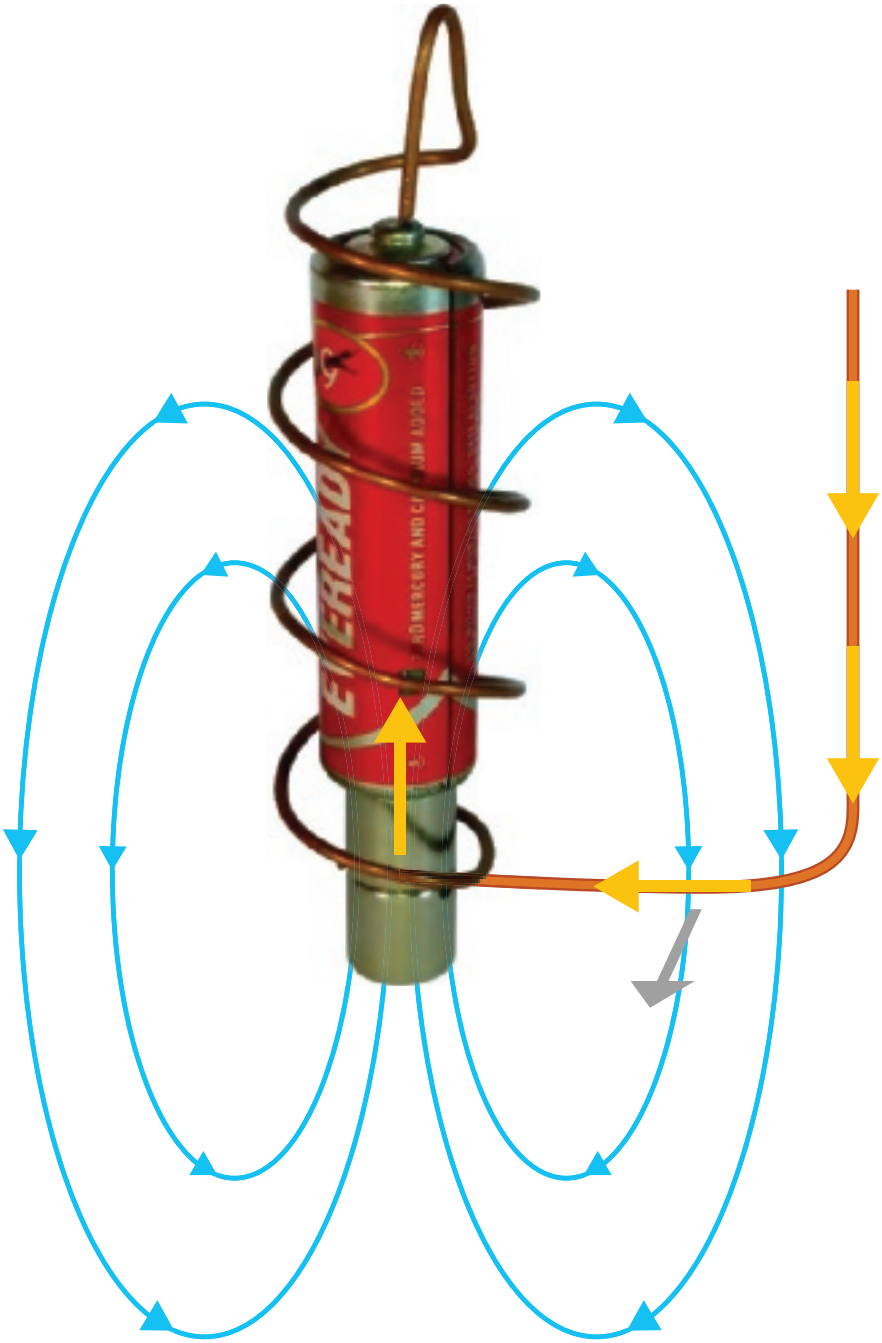


Materials

- AA battery
- thick copper wire
- small magnet (preferably a rare earth magnet, but any magnet will work)
- wire cutters

Steps

1. Cut a length of wire at least 8 cm (3 in.) long.
2. Bend the wire into a shape that goes around the battery, from the top of the positive end to below the negative end. Be creative! Make the wire any shape you like! (Note: smaller shapes, such as coils, will be more stable than larger ones.)
3. Place the magnet on a flat surface.
4. Place the battery on top of the magnet, positive end up.
5. Place one end of the wire on top of the battery, wrapping the other end around the magnet.
6. Watch as your motor moves the wire!



Connection

A motor is basically the opposite of a generator. A motor takes electrical energy and makes something move with it (mechanical energy). On the other hand, a generator takes mechanical energy and turns it into electrical energy. An easy way to remember the difference is that an electrical motor uses electricity, whereas an electrical generator produces (generates!) electricity.

Movie Magnetism

From: Jenny Lyons
To: Taylor Hernandez
Subject: Effects of Neutron Stars on People

Dear Dr. Hernandez,

I am writing a script for a film about a group of astronauts whose spaceship comes too close to a neutron star. I'd like to make the effects of the star on the bodies of the astronauts as realistic as possible. I've read your research on neutron stars, especially magnetars, and I was hoping you could tell me what it might be like if a human being came within the magnetic field of such a star.

Thank you sincerely for your time and consideration. I'll be certain to thank you in the film's credits as well!

Warmest regards,
Jenny Lyons

From: Taylor Hernandez
To: Jenny Lyons
Subject: Re: Effects of Neutron Stars on People

Dear Ms. Lyons,

Thank you for contacting me about neutron stars, specifically magnetars. I'm excited to see the subject of my research shown on the big screen.

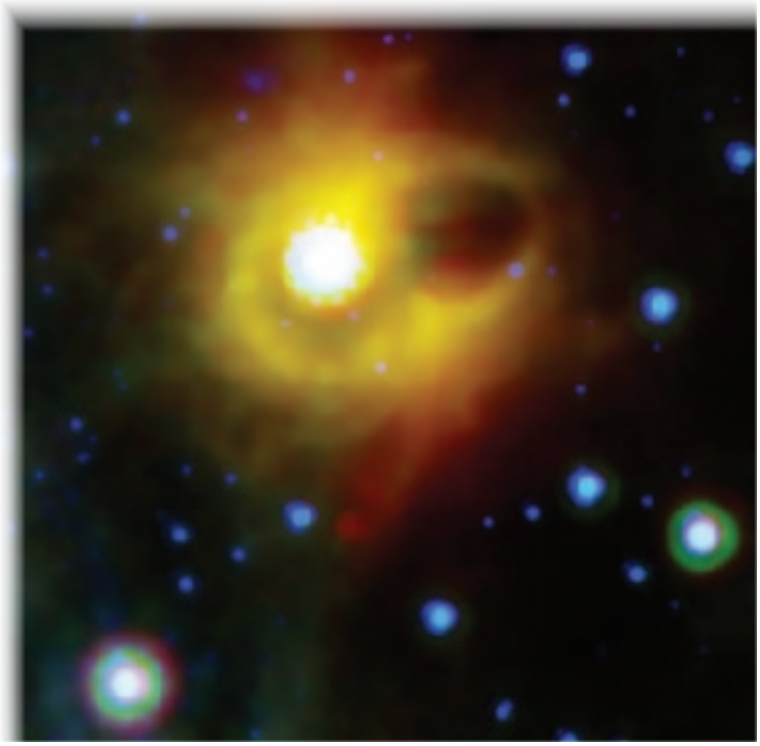
As you may know from my research, magnetars are a special type of neutron star with an extremely powerful magnetic field. Magnetars have magnetic fields of about 10^9 to 10^{10} teslas, which is a trillion or more times the strength of Earth's magnetic field. This is also a thousand times stronger than the magnetic field of pulsars, the other type of neutron star.

Magnetars, like pulsars, form when large stars collapse. Magnetars have a diameter of only about 20 kilometers but have a mass of up to 25 times that of our sun. Their magnetic field is so strong, no person could survive being within 1,000 kilometers of a magnetar. The magnetic field of a magnetar is powerful enough to change the shape of atoms. Positive protons are pulled to one side, while negative electrons are pulled to the other. The atom forms an elliptical shape.

As you might imagine, this would be terrible for the atoms in a human body. A person might notice for a brief instant that their nervous system stopped functioning, only moments before their body came apart entirely. The magnetic field would basically vaporize them.

In fact, the magnetic field of a magnetar is so strong it can do strange things to the photons of light. This is actually how we detect these stars—by observing the unusual bursts of electromagnetic radiation they emit. Thankfully, magnetars are too far away from Earth for us to see them. Instead, we detect them with X-ray telescopes and sometimes with longer-wavelength telescopes that detect radio waves or infrared light. I hope this explanation is enough to give you dramatic results in your script. Please do let me know if I can help in any other way.

Sincerely,
Dr. Taylor Hernandez



This photo of a magnetar was taken using X-rays, then colored to show what the star would look like if its electromagnetic radiation were in the visible spectrum.

Are Humans Magnetic?

Try it yourself! Use any magnet in your home—a fridge magnet, a bar magnet, even a rare earth magnet. No matter how many times you try, you'll never get it to stick to your skin. There just isn't enough iron in your blood for that!

Net Magic Treatments

Are you suffering from a misaligned personal magnetic field? Many people are; they just don't know it. Symptoms of magnetic misalignment include:

- Morning fatigue
- Headaches
- Anxiety
- Depression
- Joint pain
- Back pain
- Flu-like symptoms
- Insomnia

If any of these describe you, then YOU need a magnetic bracelet! Our magnetic bracelet is attractive, lightweight, and durable. It is made of hematite, an iron metal. It has a small magnetic effect, which realigns the magnetic field generated naturally by the body.

Magnetic bracelets are used all over the world as a simple, affordable alternative to invasive medical procedures and dangerous chemical medications. A magnetic bracelet is often used to treat such ailments as:

- Cancer
- Arthritis
- Mumps
- COVID-19
- Diabetes

According to the Association for Mega Magnetics, wearing a magnet bracelet on a daily basis increases circulation, decreases inflammation, and improves mind and body well-being. Our bracelets start at only $74.99 and can be personalized or ornamented to match any wardrobe.

Spot the BS

Heads up! There's some **b**ad **s**cience on this page. Can you spot the wild claims made about this product? Are the sources reliable?

Magnetic Therapy Spa

Are you feeling tired, run-down, or stressed? Do you have joint pain, muscle pain, or back pain?

Visit our healing Magnetic Therapy Spa to rest, rejuvenate, and renew!

Our trained technicians use natural stones to dispel the buildup of magnetic energy in your body. According to the Organization for Anti-Toxins, magnetic energy builds up over time through exposure to electromagnetic radiation, especially cell phone signals and WiFi signals constantly bombarding us.

Magnetic stone therapy has been used for centuries to eliminate toxic magnetic buildup. Our technicians practice natural, holistic magnetic stone therapy passed down through generations of natural healers.

Spa packages start at $150.00. Ask about our bundle discounts for regular visits.

Spot the BS

Heads up! There's some **b**ad **s**cience on this page. Can you spot the buzzwords that don't fit with what you know about magnetism? Are the sources reliable?

Magnetic Medicine

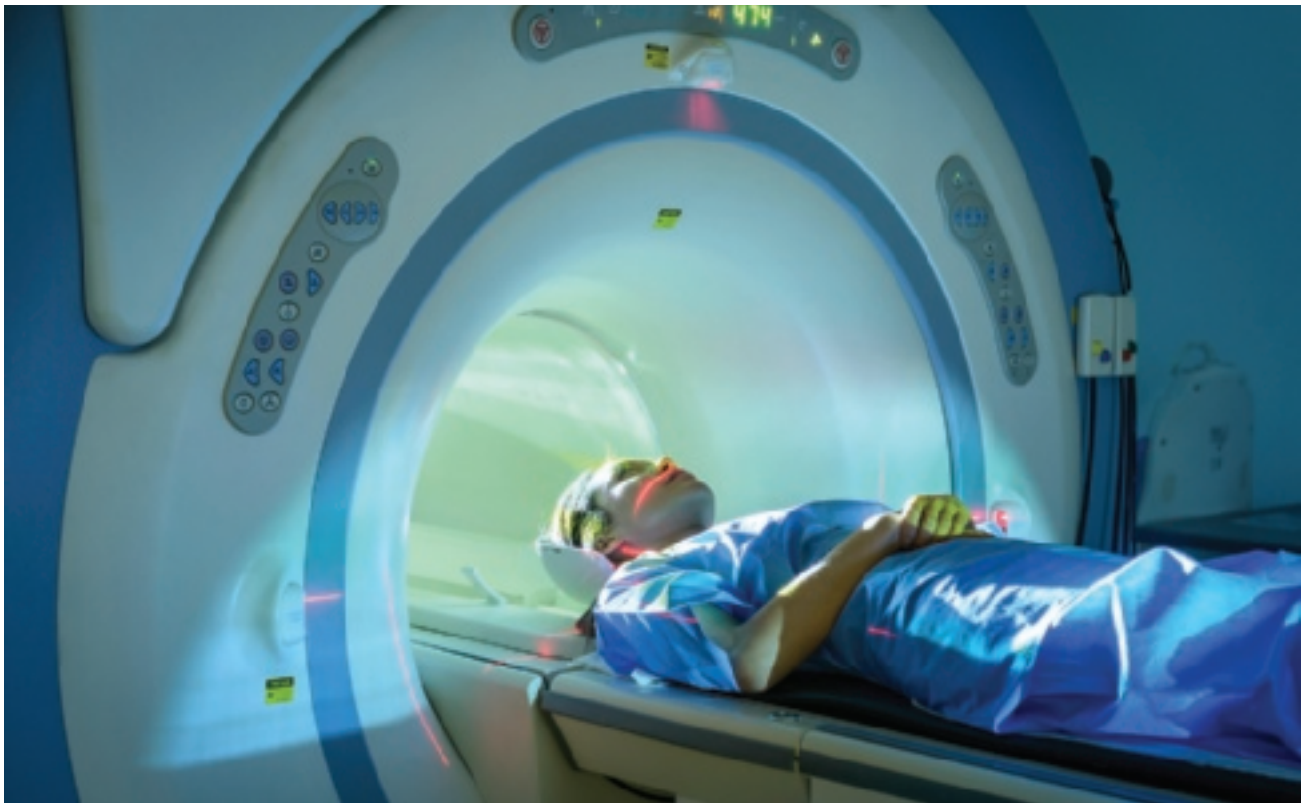
Magnetic Resonance Imaging

While it's true that humans aren't magnetic, magnets really do help doctors and researchers to diagnose and treat illness and to study the structures and functions of parts of the body.

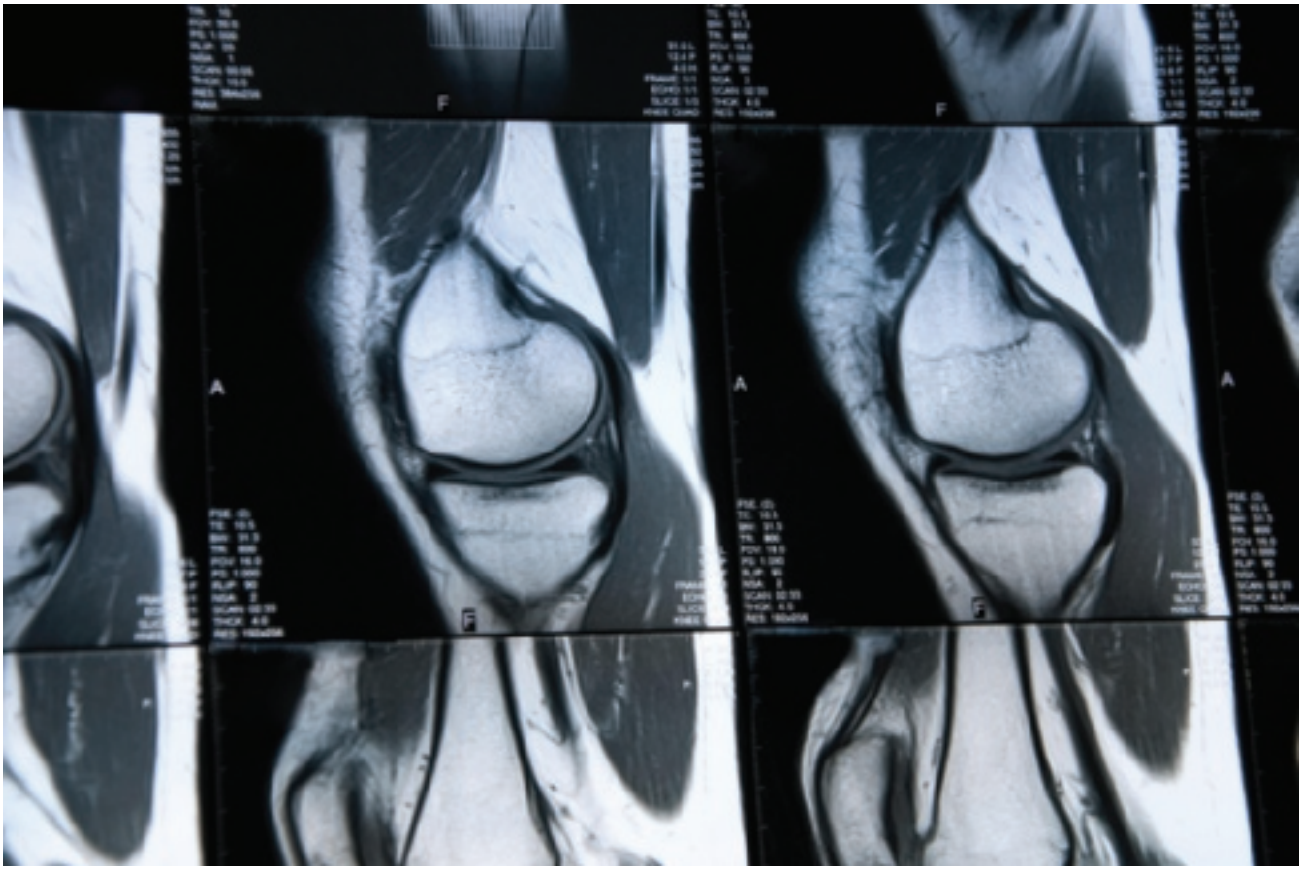
Magnetic resonance imaging (MRI) is a technique that uses strong magnets to generate images of body structures. An MRI machine uses magnets that are incredibly strong. The magnetic field generated by the magnets is so strong that it forces the protons in the body to align to it. Radio waves are then used to disrupt the alignment of the protons, which give off a slight amount of energy as they then realign to the magnetic field. Sensors in the MRI machine detect this small amount of energy and generate an image.

MRI is used to diagnose a wide range of disorders, from soft tissue injuries to cancers. MRIs offer a great advantage over X-rays, which can only image hard tissues such as bones. Additionally, MRIs do not use damaging radiation, as is used in computer tomography (CT).

One specialized type of MRI is the functional MRI, or fMRI. An fMRI measures changes in blood flow in the brain. These types of MRIs are more commonly used in research than in medicine. Using fMRIs, researchers can detect which parts of the brain are involved in certain tasks. For example, fMRI has been used to determine which parts of the brain are used in speech, as well as in recognizing emotion in other people's faces. Studies using fMRI have also shown which parts of the brain are affected by certain diseases and disorders.



An MRI machine can be used for medicine or research.

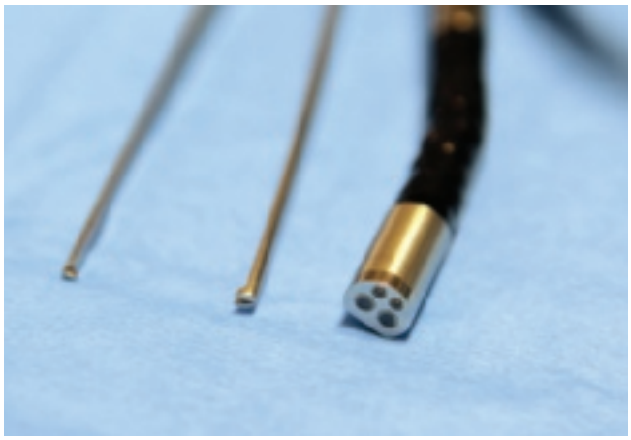


An MRI shows a progressive sections of a knee joint, with both hard tissues (bones) and soft tissues (fat, muscles, and cartilage) visible.

Magnetic Medical Devices

Some medical devices rely on magnets to function. For example, some insulin pumps use magnets rather than a battery. Batteries lose charge over time, eventually requiring replacement, which means that the patient needs periodic surgeries to replace the battery in the pump. Using magnets to power the pump eliminates this need.

Devices used in surgery can also employ magnets. Endoscopes, which are cameras on thin tubes used to record images of the inside of the body, can be articulated by magnets. That is, magnets in the tube allow medical personnel to move the end of the tube to point the camera in different directions. Similarly, magnets may be used to open and close medical clamps used during surgeries.



Endoscopes vary in size depending on their purpose. The camera lens is visible in both endoscopes shown on the right.

Medical researchers are also interested in the possibilities of using magnets in medical microbots and nanobots. These are tiny, even microscopic, robots that can be directed to serve a particular function. It may be possible to use magnetic fields to direct ferrous microbots or nanobots to specific areas of the body. For example, magnetic microbots have been used in ophthalmology to deliver medications to the retina to treat macular degeneration, a condition in which the retina becomes damaged over time. This is an exciting field of medical research, with new inventions happening often.

Glossary

attract, v. to draw toward; the opposite of *repel*

collision, n. an event in which bodies come into sudden contact

contact force, n. pushes and pulls between objects that are touching

dynamic, adj. subject to ongoing change

electric current, n. electrical charges in motion through a conductive material

electromagnet, n. a device consisting of a core through which electric current is passed to produce a magnetic field

electrostatic force, n. a noncontact push or pull that results from the electrical charges of particles in a material

force, n. a push or pull that can change the motion of an object

force pair, n. the action force and reaction force of two bodies in interaction with one another

gravity, n. the universal, noncontact force that attracts all masses of matter to all other masses; experienced on Earth as the downward pull of weight

hypothesis, n. a starting point for further investigation

hypothetical, adj. referring to something that might or could happen but has not occurred as a confirmed event

interaction, n. the way in which matter and fields affect one another

magnet, n. an object that generates a magnetic field

magnetic field, n. the region around a magnetic material where magnetism is able to exert force

magnetism, n. the force applied by magnetic materials that attract or repel one another based on the alignment of charges in the particles of which they are made

noncontact force, n. a force that acts on an object without touching it

obstruction, n. a blockage in a passageway that may allow some material to get through or may stop all material from passing through

orbit, v. to revolve in a curved path around a central object

orientation, n. the relative direction of something

oscillation, n. the act of moving regularly and repeatedly from one position to another and back

repel, v. to push away; the opposite of *attract*

science fiction, n. a genre of storytelling based on imagined science and technology

science literacy, n. the ability to read, hear, and comprehend information about scientific topics and demonstrate understanding in discussion and through writing

social media, n. websites and applications that allow users to participate in sharing content on the internet

tesla, n. the SI unit for measuring magnetism

vibration, n. movement of an object or material back and forth past its starting position

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