Wizards of Wright

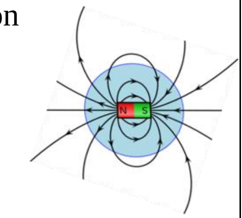
Lesson: Electromagnetism

Use WOW! Lesson Intro to begin.

Background Info for Wizards:	This lesson is used to review what students may have already learned about circuitry, electricity, and magnetism. This will offer them the opportunity of 3 very distinct hands-on activities to see these topics in action.
Materials:	Activity 1 - SOLENOIDS - Student groups/pairs will receive one of the blue boxes. Included: 1 battery pack, 1 solenoid with 3 wires already attached, 1 baggie of washers, and 1 donut magnet Activity 2 – ST. LOUIS MOTOR - Student groups/pairs will receive 1 St. Louis motor, 1 red double-ended alligator clip, and 1 black double-ended battery clip. They will already have a battery pack. Activity 3 – HAND CRANKS - Student groups/pairs will receive one hand crank generator, one light bulb mechanism, and one bell mechanism.
Lesson Time: 60-70 minutes	Introduction: 5 minutes Guided Lesson #1: 10 minutes Student Activity #1: 10-15 minutes Guided Lesson #2: 5 minutes Student Activity #2: 10 minutes Guided Lesson #3: 2 minutes Student Activity #3: 10-15 minutes Conclusion: 5 minutes
Learning Targets:	Students will learn about the transfer of energy. Students will experiment with force and magnetic fields. Students will experience the use of an electromagnet.

Introduction for Students: 5 minutes	An electromagnet is a magnet that uses electricity. Electromagnets are used to power microphones, speakers, headphones, some telephones, doorbells, computer hard drives and some household appliances. Magnets called permanent magnets aren't turned off. These magnets do not need electricity to work. As we will see today, the strength of an electromagnet can be changed by changing the amount of electricity that it is connected to. There are many forms of energy like wind energy, solar energy, and sound energy. Today we will be using mechanical energy and electric energy. Mechanical energy is said to be "the ability to do work". Mechanical energy is the moving energy or kinetic energy of an object plus that object's stored energy or potential energy. Think of mechanical energy as movement. Walking people and rolling bikes are examples of mechanical energy. Running cars and moving gears in machines are examples of mechanical energy. Electrical energy is a form of energy caused by the flow of electrons, or electricity. Electrical energy runs our computers and TVs, and turns our lights on. We normally find electrical energy in a wall outlet, or in a battery. ******* *Discuss with students the difference between a generator and a motor, and discuss how they relate to each other*. - A motor is a machine that makes power. It is an electric device which converts electrical energy into mechanical energy. The generator works in reverse. It generator converts mechanical energy into electrical energy. Let's take it one more step and talk about force and a magnetic field. - The space around a magnet is where the force of the magnet is, this is called its magnetic field. A magnetic field can be seen when we draw the magnetic lines of force that begin on the north pole of a magnet and end on the south pole of the magnet.
Guided Lesson #1: 10 minutes	Let's take it one more step and talk about **force** and a **magnetic field**.

The space around a magnet is where the force of the magnet is, this is called its magnetic field. A magnetic field can be seen when we draw the magnetic lines of force. The direction of a magnetic line of force is the direction of force on a North Pole, they always begin on the N-pole of a magnet and end on the S-pole of the magnet. (**show graphic**)

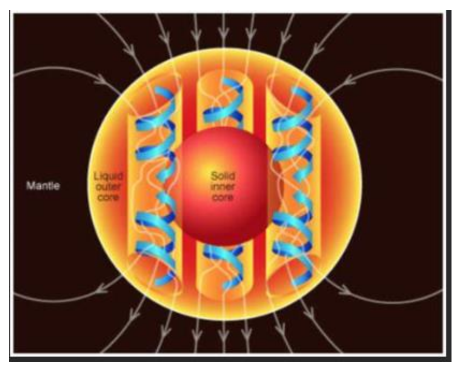


Discuss with students the difference between a permanent magnet and an **<u>electromagnet</u>**.

Most of the magnets you are familiar with are permanent magnets, meaning the material displays magnetic properties all the time. Did you know that a magnet can also be created using electricity?? These type of magnets are called **electromagnets**. Electromagnets create a magnetic field through the application of moving electrons, or an electric current. With this, we can generate an electric current.

The earth is a giant electromagnet. We already know that:

- the Earth's core is made from iron
- the Earth has a North Pole
- the Earth has a South Pole



These aren't just places on a map, or a part of the Earth's geography, they are actually opposing magnetic forces.

The movement of liquid iron in the core, creates an electrical current (this is called the dynamo effect). The current then creates a magnetic charge. The Earth having its own magnetic charge is what makes a compass work! (**show graphic**)

When using an electromagnet a current is introduced, either from a battery or another source of electricity, and it flows through a wire.

- The magnetic field is formed around the wire, magnetizing it.
- It creates a magnet.
- The magnetic field only exists when electric current is flowing through the coil, and disappears when the current is turned off.
- Therefore, you can turn the magnet on and off by completing or interrupting the circuit.
- It's like on-demand magnetism.

	The electromagnet that we will experiment with today is called a **solenoid**. The wire is wrapped around a rod. **(Show students a solenoid from inside one of the blue boxes that will be used for Activity 1).** The atoms in the metal are arranged randomly, not pointing in any particular direction. When the current is introduced, the magnetic field will realign the atoms. The solenoid is electrified/magnetized. When the current is turned on and the atoms are all moving, now in the same direction, the magnetic field gets bigger. The alignment of the atoms increases and decreases with the level of current. Therefore, by controlling the flow of electricity, you can control the strength of the magnet. There comes a point when all of the atoms are aligned and it has reached its maximum magnetism, adding more current won't make it any more magnetic. When the current is turned off, the atoms lose their alignment, and go back to sitting randomly. Fairly quickly, it loses its magnetism. In our example, the strength of the magnet is directly related to the number of times the wire coils around the rod. If we wrap the wire tightly, we get a stronger magnetic field because there are more loops for the current to travel through.
Student Activity #1: 10-15 minutes	SOLENOIDS - Student groups/pairs will receive one of the blue boxes. Included: 1 battery pack, 1 solenoid with 3 wires already attached, 1 baggie of washers, and 1 donut magnet The students will hook up the electromagnet to the battery pack: The red terminal is positive and the black is negative. Electric current flows from positive to negative. *The battery pack contains three batteries in series, using the last plug makes the electromagnet strongest.* **See student sheet for specific directions**.
Wizard Information for Activity #1:	What will the students be doing? The students will **experiment** by lifting the washers - pressing and holding the power button and then dropping them by removing power/finger. Ask the students to compare number of washers they picked up against the number of batteries used.
Guided Lesson #2: 5 minutes	Let's take what we know about electromagnets further. Explain to students that they will take what they learned about the attraction and

repulsion of the donut (permanent) magnet and the electromagnet and discuss how a motor works.

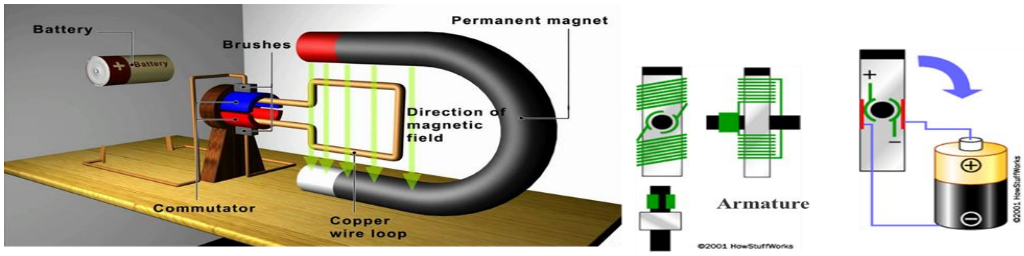
They will use a **St. Louis Motor** (an Induction Motor). It uses the moving magnets and coiled wire to create an electrical current. It converts electrical energy to mechanical energy (from the battery to the motor). A St. Louis Motor can also work in reverse.

Electromagnets are an essential part of motors. A key principle of the motor is to cause continuous motion and change the field at the right time, otherwise the magnet would rotate once and get "stuck."

Wizard Information: *Only share if you feel that it is necessary and will be understood by the students in the group you have.*

Motors use a changing electric current to produce a changing magnetic field, which spins a rotor by attracting and repelling it. The armature is similar to the electromagnet you just used. It is made by coiling thin wire around two or more poles of a metal core. The armature has an axle, as the armature passes through the horizontal position, the poles of the electromagnet flip. Because of the flip, the North pole of the electromagnet is always above the axle so it can repel the field magnet's North Pole and attract the field magnet's South Pole. The "flipping the electric field" part of an electric motor is accomplished by two parts: the commutator and the brushes. The commutator and brushes work together to let current flow to the electromagnet, and to flip the direction that the electrons are flowing at just the right moment. The contacts of the commutator are attached to the axle of the electromagnet, so they spin with the magnet. The brushes are just two pieces of springy metal or carbon that make contact with the contacts of the commutator. When you put all of these parts together you have a complete electric motor.

Information credited to: https://studyres.com/doc/3241665/period-17-activity-solutions--induction-motors-and-transf..., https://electronics.howstuffworks.com/motor5.htm, and https://electronics.howstuffworks.com/motor6.htm

	
Student Activity #2: 10 minutes	ST. LOUIS MOTOR - Student groups/pairs will receive 1 St. Louis motor, 1 red double-ended alligator clip, and 1 black double-ended battery clip. They will already have a battery pack. **See student sheet for specific directions**.
Wizard Information for Activity #2:	What will the students be doing? The students will use the alligator clips and battery packs to run the St. Louis motor.
IMPORTANT!	**COLLECT ALL MATERIALS BEFORE DISTRIBUTING HAND CRANKS FOR ACTIVITY 3.** **If students don't follow directions, and the hand cranks are connected to the battery packs or St. Louis motors, they will break.**
Guided Lesson #3: 2 minutes	Both motors and generators use changing magnetic fields. **Motors convert electrical energy into mechanical movement (kinetic energy), while generators do the reverse, they change mechanical movement into electric energy.** When a generator spins a coil of wire near a magnet it uses kinetic energy to create a changing magnetic field, and create a an electrical current.
Student Activity #3: 10-15 minutes	HAND CRANKS - Student groups/pairs will receive one hand crank generator, one light bulb mechanism, and one bell mechanism. **Caution**: **Please ask students to be gentle with these cranks.** When using the hand generators, it is natural for students to want to go as fast as possible. However, this can break it. Turn the handle at a reasonable rate, fast enough to observe what you are testing, but not excessively.

	Have students discuss how the generator is similar to the motor they just used. How is it different? **See student sheet for specific directions**.
Wizard Information for Activity #3:	<u>What will the students be doing?</u> 1. The students will connect the leads on the hand crank to the leads of another generator (2 groups will need to work together for this part). - While only one person turns the generator handle, watch the handle of the other generator. Does it turn? Does it turn in the same or the opposite direction from the first generator? - Students will crank in the opposite direction. Does the second handle respond? - Tell students not to crank the first generator but to crank the second one. Does the first handle respond? - Reverse the leads where you have the two generators connected together. Now turn one generator, does the second generator handle turn in the same direction as before, or in the opposite direction? Does the second generator make as many turns as you turn the first generator? 2. The hand-cranked DC generator demonstrates the conversion of mechanical energy to electrical energy. Turning the crank produces an electric current that causes the light bulb to glow. The faster the crank is turned, the brighter the bulb will shine. **Always have the circuit closed with the light bulb screwed in or the leads touching.** 3. Ask students, When would an electromagnet be better than a permanent magnet? Doorbell! The doorbell is a good example of how electromagnets can be used in applications where permanent magnets just wouldn't make any sense. When a guest pushes the button on your front door, the electronic circuitry inside the doorbell closes an electrical loop, meaning the circuit is completed and "turned on." The closed circuit allows electricity to flow, creating a magnetic field and causing the clapper to become magnetized. The hardware of most doorbells consist of a metal bell and metal clapper that, when the magnetic charges causes them to clang together, you hear the chime inside and you can answer the door. The bell rings, the guest releases the button, the circuit opens and the doorbell stops its infernal ringing. This on-demand magnetism is what makes the

	electromagnet so useful.
Conclusion: 5 minutes	Review what was learned by using the solenoids, St. Louis motors, and hand cranks. Review with students what they already know about magnetism and how it relates to electricity. Review key terms: generator and motor, mechanical energy and electrical energy, magnetism and electromagnet

Information credited to: https://studylib.net/doc/18064325/hand-crank-generator-activities; https://studylib.net/doc/18064324/hand-crank-generator; https://science.howstuffworks.com/electromagnet.htm

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