Introduction to Electromagnetism

Unit	Utah SEEd Standard / NGSS Performance Expectation	Estimated Lesson Time:
Seventh Grade SEEd Standard 7.1.3: Electricity and Magnetism	Standard 7.1.3 - **Construct a model** using observational evidence to describe the nature of fields existing between objects that exert forces on each other even though the objects are not in contact. Emphasize the cause-and-effect relationship between properties of objects (such as magnets or electrically charged objects) and the forces they exert. (PS2.B)	50 minutes

Access to all material for this lesson:

Lesson Overview

Learning Objective(s)

Students will be able to draw a model that shows electric and magnetic fields and two factors that affect the strength of the attraction.

Anchor Phenomenon

Wireless charging ports: https://www.youtube.com/watch?v=tCutL2ap8i8?start=10&end=14

Driving Question(s)

From *Framework for K-12 Science Education (PS2-B, p. 117)*

What factors affect the strength of electric or magnetic attraction?

Lesson Level Performance Expectations

Students will develop a model to show what factors affect magnetic and electric fields and their attractive or repulsive forces.

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Lesson Snapshot

Lesson Summary:			
	Estimated Time	**Section Overview**	**How are students answering the driving question or meeting the learning objectives?** (Highlight **SEPs**, **DCIs**, and **CCCs**)
Experience the Phenomenon		Show a short video showing a wireless charger (linked below) OR demonstrate an actual wireless charger in the classroom. Wireless Charging Video Have students draw/label their initial ideas about the system.	Students will begin to develop their model of the magnetic and electrical forces and the factors that affect the process between a cell phone and a wireless charger by labeling and drawing on a provided picture.
Investigate the Phenomenon		Students rotate through four stations, investigating how the number of coils affects the rotation speed of an electric motor, how distance affects electrical attraction, the size and shape of the magnetic field, and how close magnets need to be to attract or repel.	***Electric motor station*** – students will use wires with different numbers of coils in an electric motor to investigate how the number of coils affects the speed of rotation and will answer questions on the lab sheet. ***Aluminum can station*** – students will charge a PVC pipe and attract an aluminum can. They will then answer questions on the lab sheet. ***Iron shavings station*** – students will use magnets and iron shavings to observe the magnetic field and will answer questions on the lab sheet. ***Bumper cars station*** – students will measure the distance of attraction and repulsion of magnets and answer questions on the lab sheet.
Model the Phenomenon		Revise the original model to show a new understanding.	Students will revise their model, using the same picture, explaining their new understanding of the magnetic and electrical forces between a cell phone and a wireless charger.

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Disciplinary Core Ideas	Science & Engineering Practices	Crosscutting Concepts
[NGSS Appendix E](#) PS2.B Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object. Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. These forces can be used to describe the relationship between electrical and magnetic fields.	[NGSS Appendix F](#) Developing and Using Models– Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. ● Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed. ● Use and/or develop a model of simple systems with uncertain and less predictable factors. ● Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. ● Develop and/or use a model to predict and/or describe phenomena. ● Develop a model to describe unobservable mechanisms.	[NGSS Appendix G](#) Cause and Effect Students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Materials

Student Materials	Teacher Materials	Lab Materials/Other Resources	
Student Worksheet 7.1.3	7.1.3 Electromagnetism Teacher Slides 7.1.3. Station Instructions 7.1.3 Rubric for Teachers 7.1.3 Lab Materials List	**Electric Motor**: D battery (extras, just in case!) Round magnet Battery holder (Optional) Paper Clips Enamel coated or insulated copper wire – 22 gauge Electrical tape **Bumper Cars**: Ruler 2 bar magnets (same size)	**Pop Can Magic**: PVC pipe – ¾" 1.5-3' Cloth (Microfiber or wool) Empty pop can **Iron Shavings**: Iron Shavings Bar magnet Paper plate Zip-lock bag

Lesson Preparation

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PRIOR TO THE DAY OF THE LESSON:

- Use the instructions at https://miniscience.com/make-a-simple-electric-motor/ to build an electric motor.
- Make three copper wire coils: one with 5 wraps, one with 10 wraps, and one with 15 wraps.
- Cut an 18" length of ¾" PVC pipe.

DAY OF THE LESSON:

Set up learning stations as follows:

Electric Motor Station: Label 3 small plates (or other containers) "A", "B", and "C". Place one cooper coil in each. Put a fresh battery in the electric motor. Place the electric motor, labeled plates and coils, and the "Electric Motor Station Instructions" sheet at a table or area in your classroom for this station.

Pop Can Magic Station: Place the PVC pipe, an empty soda can, a microfiber cloth, and the "Pop Can Magic Station Instructions" sheet at a table or area in your classroom for this station.

Iron Filing Station: Sprinkle a thin coat of iron filings onto the paper plate. Place this bag into a gallon size zipper baggie (to contain the filings if they are spilled). Place the iron filings plate, 2 different strength bar magnets, and the "Iron Filing Station Instructions" sheet at a table or area in your classroom for this station.

Bumper Cars Station: Place two identical bar magnets, a meter stick, and the "Bumper Cars Station Instructions" sheet at a table or area in your classroom for this station.

REQUIRED PREVIOUS KNOWLEDGE:

This lesson builds on students' prior understanding of the following DCIs developed in previous units:

PS2.A/B Grades K-2 - Pushes and pulls can have different strengths and directions, and can change the speed or direction of its motion or start or stop it.

PS2.A/B Grades 3-5 - The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

SUPPORTS STUDENTS WILL NEED/ADAPTATIONS:

Extra support for students struggling to meet the targeted expectations: Include pictures in the station instructions. Encourage student teams to discuss their observations and discoveries with each other at each station.

Extensions for students with high interest or who have already met the performance expectations: provide additional materials to extend their investigations at each station.

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Electric Motor Station: different sizes of batteries

Pop Can Magic Station: cylinders made of different materials, such as a tin can and empty plastic water bottle

Iron Filing Station: round magnets and horseshoe magnets

Bumper Cars Station: sets of bar magnets of various strength

VOCABULARY DEFINITIONS:

Attract - to pull objects toward one another

Coil - a length of something wound or arranged in a spiral or sequence of rings

Magnetic field - the space around a magnet in which magnetic forces can act on objects

Magnetic poles - a line that connects opposite magnetic poles and represents the strength and direction of the magnetic field

Repel - to push objects away from each other

EXPERIENCE THE PHENOMENON/PROBLEM

What Students Are Doing	Teacher Tips
Students will witness a wireless charger for a phone or watch and are given a picture of an advertisement for the charger. Students will draw a diagram of how they think a wireless charger works.	You can use the slideshow to show the phenomenon.
What Teachers Are Doing	**Teacher Tips**
Demonstrate or show a video of a wireless phone charger. Ask students to draw a diagram of what is happening in the charger and to label as much as they can	Don't give too much information about the components of the charger and phone at this point.

INVESTIGATE THE PHENOMENON

What Students Are Doing	Teacher Tips

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Students will be put into groups to rotate through 4 stations. Students will use the worksheets and the instructions at each station to answer the questions and investigate each station. **Station 1: Electric Motor** Students will observe three different coils of wire and how fast they spin. They should try to explain why they spin at different speeds in relation to the electromagnetic field. Students will answer two questions on the worksheet based on their observations. After that, students will discuss how adding more coils affects the system with their group. **Station 2: Magic Pop Can** Students will use a cloth and a PVC pipe to move an aluminum can (without touching it). Students will attempt to determine what force is moving the can. Students will answer the questions on their worksheet. They will discuss with their group: What force(s) is/are moving the can? **Station 3: Iron Shavings** Students will use a paper plate with a thin layer of iron shavings to observe the shape and pattern of a magnetic field around two different-sized magnets and record what they observe on the worksheet. Students discuss: What do the iron shavings allow you to see? **Station 4: Bumper Cars** Students will predict and observe the distance at which Magnets A and B affect each other as they answer questions on their worksheets. Discussion question: If both magnets were stronger, how would that affect the distance of attraction and repulsion?	If you have a larger class, you can put more than one set of materials for each lab or even have multiple stations. Make sure to ask guiding questions pertaining to Cause and Effect at each station as needed. "Are there ways to change it?" "Can you make it go faster or slower?" Etc.
What Teachers Are Doing	**Teacher Tips**
Some stations will require guidance and support from the teacher to ensure that they run correctly and that students get proper results. Some stations may take longer to complete, so the teacher may want to provide extra materials or tasks at some stations. For example, for Station 1, you could provide stronger magnets or different batteries; for Station 2, provide a wool cloth or a balloon or offer different types and sizes of cans; for Station 3, provide a round magnet instead of a bar magnet; and for Station 4, give different sizes or strengths of magnets. After student groups have completed all the stations, the teacher should gather students back as a class and go over the discussion questions individually: 1. What role does the battery/ magnet/ coil have? 2. What role did distance play between the pipe and the can? 3. What do the iron shavings allow you to see? 4. If both magnets were stronger, how would that affect the distance of attraction/repulsion?	The teacher should walk around the room, observing and supporting when necessary. We found that the electric motor station needed the most support. The batteries tend to die quickly, so make sure you have some extras to throw on the motor, just in case!

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Following the discussion, the teacher should clarify what an electromagnetic field is and how students observed them in the stations.	

Model the Phenomenon

What Students Are Doing	Teacher Tips
Students will be given a diagram of the wireless charger components and be asked to label as much of the diagram as possible. Next, students will answer the question: How would misaligning the phone and charger affect the charging process? Students should be able to reason that the electromagnetic fields must be sufficiently close to each other and have the correct orientation to work correctly.	Printing the worksheet in color is helpful for the diagram for students to distinguish between each part (or project the diagram in color on the board, if possible)
What Teachers Are Doing	**Teacher Tips**
Prompt students and guide them to the answer by helping them piece together all the stations they saw—electromagnetic fields, attraction/repulsion, and the distance between them.	Help students see that when the phone and charger are separated, there are two fields, and when they connect the fields, they combine them to make one field!

Possible extensions/Alternative Adaptations

Supports students will need/adaptations:
Extra support for students struggling to meet the targeted expectations: Include pictures in the station instructions. Encourage student teams to discuss their observations and discoveries with each other at each station.

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Extensions for students with high interest or who have already met the performance expectations: provide additional materials to extend their investigations at each station.

- Electric Motor Station: different-sized batteries (AA, AAA, D)
- Pop Can Magic Station: cylinders made of different materials, such as a tin can and empty plastic water bottle
- Iron Filing Station: round magnets and horseshoe magnets
- Bumper Cars Station: sets of bar magnets of various strength

This lesson was created by Denver Smith, Brindy Grange, Parker Peterson, and Megan Sitterud.

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https://www.computerworld.com/article/1714118/wireless-charging-explained-what-is-it-and-how-does-it-work.html

https://www.snexplores.org/article/electricity-cutting-cords

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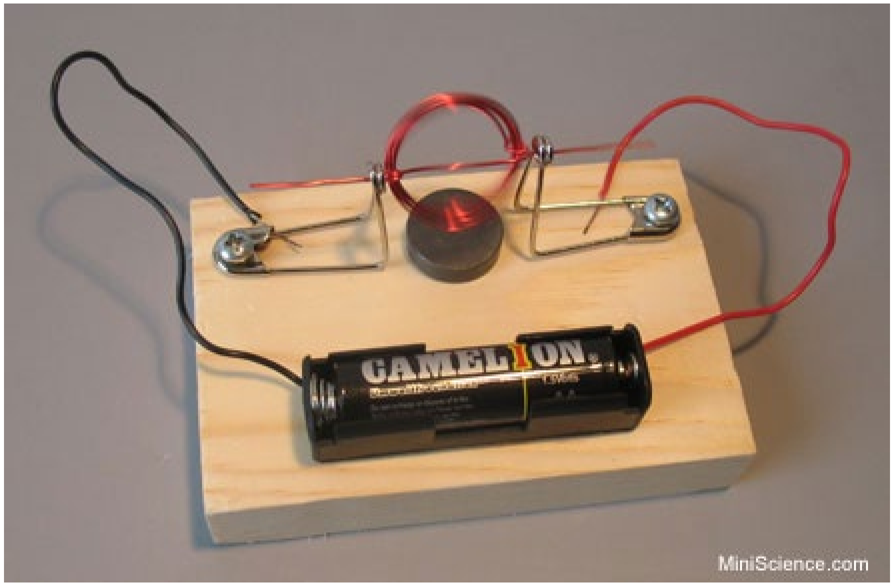

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