Unit 3: Cause and Effect Relationships in Electric and Magnetic Forces

Standard(s):

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)

7.1.4 Collect and analyze data to determine the factors that affect the strength of electric and magnetic forces. Examples could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or of increasing the number or strength of magnets on the speed of an electric motor. (PS2.B)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Students analyze various types of data in order to create valid interpretations or to assess claims/conclusions.	**PS2.B Types of Interactions**	**Cause and Effect** Students investigate and explain causal relationships in order to make tests and predictions.

Big Ideas:

- Any two objects in contact also exert forces on each other that are electromagnetic in origin.
- Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact. These forces are explained by force fields that contain energy and can transfer energy through space. These fields can be mapped by their effect on a test object (mass, charge, or magnet, respectively).
- Electric forces and magnetic forces are different aspects of a single electromagnetic interaction. Such forces can be attractive or repulsive, depending on the relative sign of the electric charges involved, the direction of current flow, and the orientation of magnets. The forces' magnitudes depend on the magnitudes of the charges, currents, and magnetic strengths as well as on the distances between the interacting objects. All objects with electrical charge or magnetization are sources of electric or magnetic fields and can be affected by the electric or magnetic fields of other such objects.

Preceding Grade Bands:	Target Grade Bands:	Following Grade Bands:
● When objects touch or collide, they push on one another and can change motion or shape. ● Electric, magnetic, and gravitational forces between a pair of objects do not require	● Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths	● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.

that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	involved and on the distances between the interacting objects. ● Forces that act at a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively).	● Forces at a distance are explained by fields permeating space that can transfer energy through space. Magnets or changing electric fields cause magnetic fields; electric charges or changing magnetic fields cause electric fields. ● Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Proficiency Scale:

4 **Advanced**	3 **Proficient**	2 **Approaching Proficiency**	1 **Beginning Proficiency**
I can: **Analyze and interpret data** to support claims about what causes electric and magnetic fields to exist and the factors that affect the strength of electric and magnetic fields. AND **Use data** to predict how a change to one part of the system would affect the strength of the field.	**I can:** **Analyze and interpret data** to support claims about what causes electric and magnetic fields to exist and the factors that affect the strength of electric and magnetic fields.	**I can:** **Use data** to support claims about what causes electric and magnetic fields to exist and/or the factors that affect the strength of electric and magnetic fields.	**I can:** **Use data** to recognize that electric or magnetic fields can cause objects to move.

Anchoring Phenomenon:

Junkyard Electromagnet

Essential Question:

How do electric and magnetic fields exert forces on objects?

Learning Goals:

Students will be able to:

- Construct a model that shows how the properties of magnetic or electrically charged objects can affect objects they are not in contact with.
- Analyze data from an investigation to determine what affects the strength of electric and magnetic fields.

	Learning Opportunities	Formative Assessments

Engage

 	
	• Watch the junkyard video
	  ○ What things are attracted to the electromagnet?
	  ○ Why do the objects fall off the electromagnet when they were attracted to it at the beginning?
		Suggested for this activity
		
		Options:
		• Student questions
		• Student discussions

Learning Goal 3A: Construct a model that shows how the properties of magnetic or electrically charged objects can affect objects they are not in contact with. (Proficiency Scale)		
Explore	Floating paper clip (1st page of the Magnet stations packet) • Student Copy of the Magnet Stations packet (make a paper copy of this for each student). The first page of this packet is what the students will need for this activity. • Teacher Copy--this presentation contains the supply list and the teacher instructions for all of the Magnet Stations. The slides you need for this activity are slides 1-5. The materials in this learning goal were originally created by Dr. Lauren Barth-Cohen, Dr. Sarah Braden, Tamara Young, and Sara Gailey at the University of Utah and Utah State University in 2019.Additional edits were implemented by Celeste Butler, a teacher in Jordan School District, in 2022.	**Suggested for this activity** These are additional resources you can use as needed. • Coulomb's Law Phet simulation • Charges and Fields Phet simulation phet simulation • What picked up the metal pieces in the video? Magnetic field visual demo Making magnetic fields visual **Options:** • Exit ticket

Explain	Magnet Stations
	• Student Copy of the Magnet Stations packet (this is the same packet that was used in the Explore activity. Have a paper copy for each student.)
	• Teacher Copy
	  ○ Station instruction sheets--print these pages out and place them at each station for the students to follow.
	  ○ Supply list and teacher instructions
	
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		Suggested for this activity
		
		Options:
		• Exit ticket
		• Fields Quiz
		  ○ Fields Quiz Answer Key

Learning Goal 3B: Analyze data from an investigation to determine what affects the strength of electric and magnetic fields. (Proficiency Scale)		
Explore  	Different batteries with different voltages. ● Strength of Fields Phenomenon ● Can you change the strength of a field?--the activities I did with my students are starred, other ideas that could work are listed. ○ *Try to stick a balloon to the wall, rub it once on your head or clothes and try again, rub another time or two and try again, keep repeating until the balloon sticks well. ○ *Bend water stream from the faucet. (Can be tricky once the balloon or comb gets wet.) ○ Styrofoam plates--change the amount of charge on the plates to repel each other ○ Rice Krispies in a petri dish and rub with a cloth ○ Other activities from the strength of fields phenomenon ● What makes the force grow stronger? ● What makes the force grow stronger? New Butler version ● Coulomb's Law Phet simulation--we don't have to explain Coulomb's Law, but we can use it to show that positives and negatives attract/repel, how the magnitude of the charge affects the force, and how the distance affects the force. ● Faraday's Law Phet simulation--to show how a generator works[	**Suggested for this activity** Optional Resources to use: **Options:** ● Exit ticket
Explain  	● Electromagnets, motors, and generators--Oh my! ● We would love to do this differently, maybe use some of the simulations above like Faraday's Law or any ideas you have about making electromagnets or here are a few other simulations ○ simple electric motor (here is some info that might help teachers) ○ simple generator (here is some info that might help the teacher) ○ Electromagnets	**Suggested for this activity** **Options:** ● Exit ticket ● Strength of Fields Quiz ○ Strength of Fields Quiz Answer Key

Elaborate	● Electromagnetic Simulation ○ https://www.fossweb.com/delegate/ssi-wdf-ucm-webContent/Contribution%20Folders/FOSS/multimedia_2E/MagElec_MM_2E/activities/electromagnet_html5/index.html ● Build an electromagnet	
Evaluate		