GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.

LESSON PLAN

ELECTRIC AND MAGNETIC FIELDS
GRADES 6-8

SUMMARY

Students will plan and carry out an investigation to determine how changing different parts of an electromagnet affects the magnetic strength. Students will use their data to design an electromagnet that can pick up 15 paper clips.

NEXT GENERATION SCIENCE STANDARDS CORRELATION

MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Science & Engineering Practices	Connections to Classroom Activity
Asking Questions and Defining Problems **Planning and Carrying Out Investigations**	• After viewing a video clip of an electromagnet in use at a junkyard, students will generate questions that lead to an investigation during which they build and then manipulate the components of an electromagnet to determine how to make the electromagnet stronger.

Disciplinary Core Ideas	Connections to Classroom Activity
PS2.B: Types of Interactions Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.	• Students will use ideas from the Generation Genius video about magnetic and electric fields to explain how an electromagnet operates and how an electromagnet would be expected to interact with a permanent magnet.

Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).	
Cross Cutting Concepts	**Connections to Classroom Activity**
Cause and Effect	• Students will use ideas from the Generation Genius video to explain how changes in the components of an electromagnet lead to changes in the strength of the electromagnet.

DURATION

90 min.

MATERIALS

- D-cell batteries (at least 2 per group)
- Battery holders (1 per battery)
- Alligator clip leads (2 per group)
- Insulated copper wire (at least 1 foot per group with ends sanded to reveal bare wire)
- Nail or metal rod, 3 inches or longer and made of zinc, iron, or steel (1 per group)
- Small metal paper clips (20 per group)
- Optional: Additional nails or rods of larger sizes for student exploration
- Optional: Small compasses (1 per group)

ENGAGE

Tell students you have an interesting phenomenon you want to share with them. Ask students to create a t-chart and then write *Notice* on one heading and *Wonder* on the other heading. Tell them to record observations in the notice column and questions in the wonder column. Play the video clip of the junkyard crane in action. Students may wonder things such as the following: How can the crane pick up metal without hooks or claws? How can the crane "let go" of the metal? or What kinds of objects or materials can the crane pick up? After students watch the video clip, ask them to share their observations with a partner.

Next, ask students to share observations and questions with the class. Record them for the class. Some students likely will identify the device in the video as an electromagnet, but they will wonder how the electromagnet works. Have students share with a partner about any previous experiences with electromagnets.

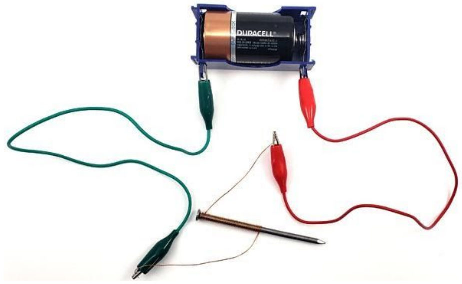
Tell students you are going to give them the materials to build an electromagnet that can pick up pieces of metal like the crane in the video, but on a smaller scale.

EXPLORE

Give small groups of students the materials needed to build an electromagnet, and ask them to follow these steps:

1. Before you begin, check to see if the nail is magnetic. Does it attract the paper clips?
2. Wrap the wire tightly around the nail in a single direction, leaving enough wire at each end to easily connect to the alligator clip leads.

3. Attach one alligator clip lead to each end of the wire.
4. Attach the other end of each alligator clip lead to each terminal on the battery holder.
5. Place a battery into the battery holder. The complete setup should resemble this image.



6. Check again to see if the nail is magnetic. Does it attract the paper clips? Record how many paperclips you can pick up with your electromagnet.

Have groups show their electromagnets and share how many paper clips they picked up. Tell the class they will investigate to figure out how to make the electromagnet stronger. Ask students to think about the components of the electromagnet and how they could change any of the components to make the electromagnet stronger. Lead the class in brainstorming a list of components and how they might change them. Ideas might include adding more batteries (do not exceed three), adding more wire turns, using a larger or different nail or rod, and so on. Assign a variable to each group and have them conduct a simple investigation to determine how changing that variable affects the strength of their electromagnet. Ask students to change the variable incrementally. For example, when investigating the effect of the number of turns of wire on the strength of the electromagnet, they might test 10 turns, 15 turns, and 20 turns to look for a pattern in the data.

Have groups make a poster-sized data table and share their data with the class. As each group shares, challenge the class to use any familiar science ideas to explain how the change caused the observed effect. Remind students to refer to their data and provide evidence to support their ideas.

Next, task student groups to design an electromagnet that can pick up double the number of paper clips as before. Constraints could include time allotted and the number of batteries used (i.e., two batteries). Consider asking students to draw their plan before receiving materials so that they are relying on class data to design their electromagnet and not manipulating materials until they “get it right” (trial and error).

If time permits, have students engineer a switch that allows them to turn their electromagnet on and off. You could also challenge students who meet the criteria quickly to next build an electromagnet that picks up the same number of paper clips using only one battery.

End of Day 1

EXPLAIN

WATCH THE GENERATION GENIUS ELECTRIC AND MAGNETIC FIELDS VIDEO AS A GROUP

Revisit the crane phenomenon and have students use science ideas from the investigation and Generation Genius video to explain how it works. Use the following prompts to scaffold students’ explanations:

- What happened? I observed that …
- Why did it happen? Even though I can’t observe _________, we learned in the video that … So, I think it is happening because ...

ELABORATE

Have students respond to the following prompt:

Two students construct an electromagnet similar to the one you built in our investigation. The students place the north pole of a bar magnet next to the bottom of their working electromagnet and observe what happens. They then place the south pole of the bar magnet next to the bottom of their electromagnet and observe what happens.

Describe what the students most likely observed.

EVALUATE

There are multiple ways to assess your students' understanding of this topic. The exit ticket is an opportunity for students to use the science ideas they built in the lesson in a new context. Alternatively, you can use the Kahoot! quiz (which provides downloadable scores at the end of the game) and/or the paper quiz. All these resources are located right below the video in the assessment section.

EXTENSION

Have students use the small compasses to map the extent of the magnetic field around the electromagnet. If time permits, have students manipulate the same variables as above and determine how these changes affect the magnetic field.

