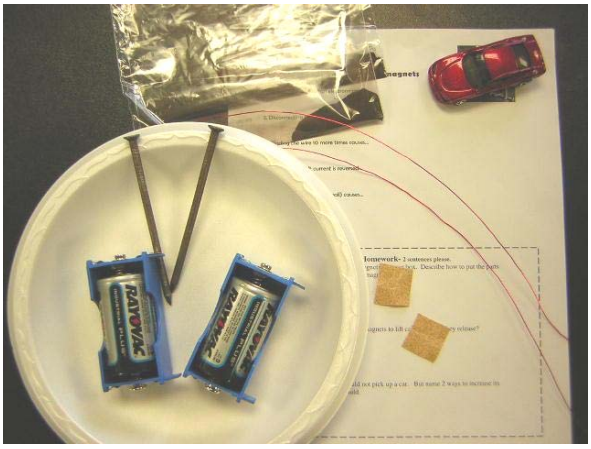
# Teacher Notes- "Electromagnets-6 Mini Investigations"

In this lesson students will discover 6 amazing properties of electromagnets with their own hands and eyes. They will assemble, disassemble, and make changes to a working electromagnet, and will learn about them without even needing any prior knowledge. That makes this a great introduction to electromagnetism.

At first, the lesson may look huge and overwhelming. But its format is simple- you and your students will be lead through 6 timed challenges by a PowerPoint. The other nice thing about this lesson is its flexibility. You can compress it into a short 25 minute activity, or stretch it out to 45 minutes by including readings from your textbook, more dialogue, longer play time, and time to answer the homework questions.

**Materials per group of 4 students:**



2-nails (size 16 D or larger)
2- 50cm long pieces of enameled (magnetic) wire- 22 gauge or similar (item #WW63641M22 at sciencekit.com). You could use insulated wires with "gator clips" on the end instead (item #WW47889M00 at sciencekit.com), but they don't work as well.
2-D cell batteries (fresh batteries wok best)
2-battery holders- optional (item #WW46481M00 at sciencekit.com)
2-small squares of sandpaper (1" by 1")- 100 to180 grit
2-baggies with iron filings (item #WW94154M06 at sciencekit.com)- ~15 grams
2-styrofoam plates-dinner plate size
4-student handouts (see p. 6)
1-toy car (optional)

This lesson was designed for students to do the first 5 investigations in pairs, and in the last one they'll combine their materials and work in 4's.

**Additionally:**

PowerPoint-"Electromagnet Investigations" (see p. 6)

**Beforehand:**

1. Cut enough pieces of wire so that you can change it at least every 2 classes. (New wire every class is not a bad idea). Enameled wire is the shiny red wire commonly found inside speakers and motors.

2. If you don't have iron filings or would rather not use them because of the mess they can make, substitute in small paper clips or bb's. Iron filings are preferred because of their small size, which makes them a more accurate indicator of strength throughout the electromagnet.

3. Choose which PowerPoint you want to use. One is a smaller file that prompts the tasks and notes, but is without a timer, so you'd have to keep time yourself. The other includes a timer with each task that counts down by seconds.

4. Find the section in your book on electromagnets. If you want to connect with your book today, insert those page and paragraph numbers in the PowerPoint on the slides that students take notes from. Look for the bright blue lettering. If you're using the PowerPoint with the timer included, book page numbers go on slides 1, 126 (*following task 1*), and 188 (*task 2*). The other places you could insert a page number prompt is on slides 250 (*task 3*), 312 (*task 4*), 374 (*task 5*), and 436 *(task 6*).

5. Set out all your materials *the day before*. Leave yourself time to realize you're missing something, research something or even make a change. In the morning read through the notes one last time. Relax and have fun along with your students. Remember- you're only as effective as your plan.

6. *A word to you!* Even when this lesson goes well, there will be a lot of excitement in the room. If things begin to head towards chaos, be ready with some firm leadership. Consider a rule like- "no touching materials unless the timer is counting down", so that it is abundantly clear when it's ok to play, and when its not. And if they do touch materials when they're not supposed to, take their nail during the next task. (This rule gets their attention!) Harsh? Yes, but you need order today if any learning will take place.

**Procedure:**

1. When class first begins there are a few preliminaries that need to be taken care of:
    a. Go through the materials aloud with students so they're aware of what's there, and to find out if anything is missing.

    b. Have students pour their bag of iron filings onto the Styrofoam plate.*[1]

    c. Then have them test their nail to see if there's any residual charge in it. Drag the nail in the filings to see if any cling. If so, have them throw the nail on a hard floor or hit it with a hammer, which will deaden it by scattering the domains inside (see Interactive Notes-Magnetism, demo #2).

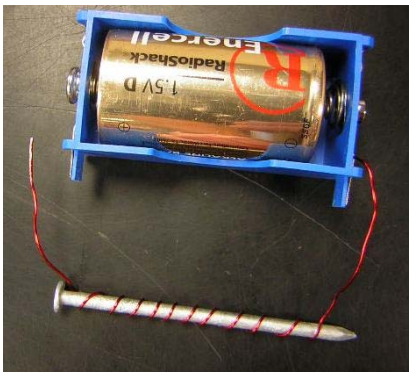
    d. Students also need to sand the ends of the enameled wire to remove the paint, so it will conduct current. Make sure students protect your tables from scuffs by putting something like a folder beneath the wire.

    e. Make sure students understand that the wires today will heat up when connected to the battery, and the longer they're connected the hotter the wires will get! Tell them to connect for only **5 seconds at a time**, and then give it time to cool. If it becomes too hot to touch, use a pencil to unhook the wire.

2. It's time to begin investigating electromagnets! Since most students have never built an electromagnet, that's where we need to start:

> "Using the materials we've just gone over, you first task today is to build a working electromagnet. Without any hints, clues, or help, you'll have just 1 minute to figure out how to build an electromagnet. You'll know it's working if it picks up iron filings. When I advance the slide on the screen, a timer will keep track of the time. You may begin!"

3. Advance the slide (if you're using the timed PowerPoint) and enjoy watching students frantically do some of the strangest things you've ever seen done with a nail and wire. After 30 seconds if there's not enough tension in the room, announce that those who don't successfully build an electromagnet will be ejected through the window by their seat.




4. At the end of the minute make sure everyone understands how to build an electromagnet (*by winding wire around the nail, then running current through the wire by touching it to both ends of the battery*). Advance the PowerPoint to the next slide to shows this.

5. Give those students who didn't get theirs working initially an extra minute to do so.

6. As indicated on the slide, have students spread their coils so they're spread the length of the nail. If they're bunched in the middle, task #1 won't work as well.

7. This is also a good time to tell students to go ahead and attach one end of the wire permanently to one side of the battery holder so it's always contacting (shown as the right wire in the picture above). The other end can then be touched to the other end of the battery only when current is needed, and then released to stop the current (and the heat). If you don't have battery holders, students can masking tape one of the sanded wires to one end of the battery while they hold the other wire to the other side of the battery with their fingers. *Caution: Don't leave wires hooked up longer than 5 seconds at a time due to overheating!*

8. Now the stage is set. The next 6 Mini Investigations will run rapid-fire. Students are anxious to get going, so move right into the first investigation (the strongest part of an electromagnet). Announce the task and then advance the PowerPoint slide to begin the timer. If they get a quick answer, they can go ahead and finish the statement on their handout since they know the answer.

9. When the timer gets down to zero it will advance after 4 seconds on its own to the next slide which has on it the completion of the first statement ("The strongest part of an electromagnet is at the ends, just like on a bar magnet.).

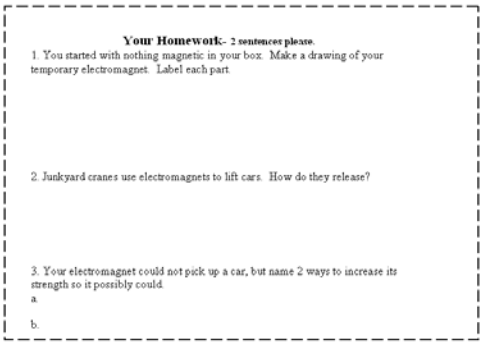
10. That will begin to settle things down a bit, and so will doing a reading from your textbook. And after the reading you'll have a moment or two when all students are tuned in, and you can apply what just happened even further.

11. Use the following table to help you move through the 6 tasks:

| | Task | Results | Comments |
|---|---|---|---|
| #1 | See which part- the ends or the middle- is **strongest**. | The ends are the strongest since they hold the most iron filings. | Beforehand, the wire should be wound evenly from top to bottom on the nail. If it's bunched in the middle, then only the middle will attract. |
| #2 | Load the electromagnet up with iron filings, **disconnect** the wire, and watch what happens | Disconnecting the current causes most filings to drop because the current stops the magnetism. | The filings that don't drop are a result of residual/leftover charge. |
| #3 | Wind the wire **10 more times**, or as many as possible, while still leaving enough wire on the ends to touch to the battery. | The electromagnet picks up exponentially more iron filings with increased winds. | Electromagnets that don't do this have a weak(er) battery. Keep fresh batteries ready to remedy this.<br>Leave the wire wound like this for the remaining tasks. |
| #4 | **Reverse the current**. Have students hook up one way and observe how many filings stick and where. Then hook the wires up in reverse (touching to opposite ends of the battery) and see what, if any, difference there is. | When the current is reversed, nothing noticeable occurs. | But the poles do reverse. |
| #5 | Slip the nail out from the coils while leaving them intact, and **run current through the coils "dry"**. | A "dry" coil will hold a few filings. There is a small bit of magnetism around the live wire. | A few iron filings will still stick to the "dry" coil because wherever there is electricity, there is magnetism.<br>Try inserting a pen/pencil through coils to see if they pick up any filings. |
| #6 | **Double the current** to 3 volts by combining 2 batteries, but still using 1 nail and wire. If your D cells are in battery holders, just snap the ends together and run current from the ends. If you're not using holders, lay the batteries end to end (the "+" end of one touching the "-" end of the other), | Increased current means increased strength, and more filings are picked up. | Will disappoint most students because the electromagnet may not double in strength. Thicker wire and a larger nail would allow stronger magnetism.<br><br>Don't leave them |

| | | | |
|---|---|---|---|
| | and run a wire from both ends by holding on (briefly!). | | hooked up long-it can melt the battery holder! |

12. At the conclusion of the 6 mini investigations look at the homework questions together. Number 1 is a straightforward warm-up (*draw an electromagnet*). For number 2 (*how do junkyard cranes release?*), ask for someone in class to give the easy answer to this question (*disconnect the current*). Call on someone who rarely raises his/her hand. For question number 3 (*two ways to increase strength*) ask if their electromagnet is strong enough to pick up the toy car in their box. Let them actually try and fail. What could they do to increase strength so that it could? (***answer**: increasing the current, winds of wire, thickness of wire, size of the iron core*).


**Your Homework**- 2 sentences please.

1. You started with nothing magnetic in your box. Make a drawing of your temporary electromagnet. Label each part.

2. Junkyard cranes use electromagnets to lift cars. How do they release?

3. Your electromagnet could not pick up a car, but name 2 ways to increase its strength so it possibly could.
a.

b.

13. As shown on the last slide, prepare for the next class by having students
    a. throw nails on floor to kill the residual charge in it, or tap with a hammer
    b. straighten the wire so it's not as obvious to the next class what to do at the beginning; it wouldn't be a bad idea to put out new wire every class; (not necessary if you're using new wire next class)
    c. put out new handouts with the materials for the next class

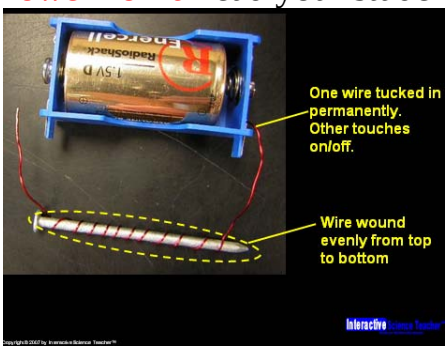
14. Either tomorrow or later in the week, review this or test them using the true/false quiz.

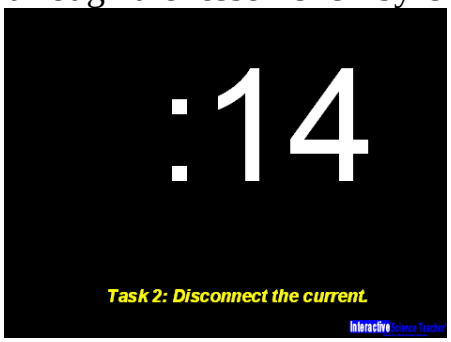
**Accessories:** Other sub-topics you can add for more length and depth.

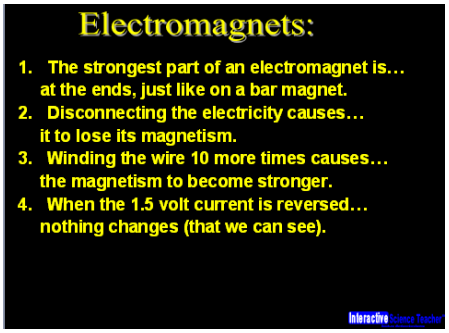
- *[1] Ask students if they can name some vitamins and minerals found in their breakfast cereal. Eventually you'll hear "iron". Stop there and have them look at the iron filings on their plate. They're both the same thing! (Obviously, their cereal doesn't have as much as what they see on the plate.) Iron helps our red blood cells to carry oxygen. People who don't have enough iron have a condition called "anemia".

Come back and visit InteractiveScienceTeacher.com to upgrade this lesson with:

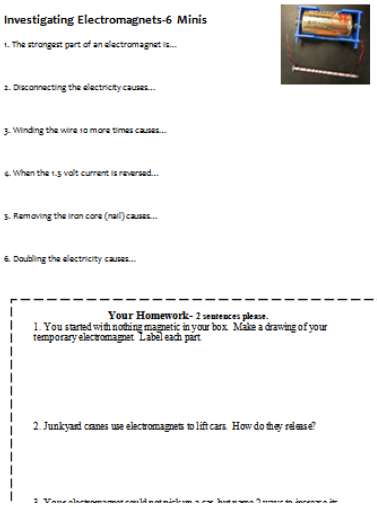
**PowerPoint-** lead your students through the lesson click-by-click




## Student Handout



Investigating Electromagnets-6 Minis

1. The strongest part of an electromagnet is…

2. Disconnecting the electricity causes…

3. Winding the wire 10 more times causes…

4. When the 1.5 volt current is reversed…

5. Removing the iron core (nail) causes…

6. Doubling the electricity causes…

**Your Homework- 2 sentences please.**

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3. Your electromagnet could not pick up a car, but name 2 ways to increase its

## *Quick*Notes

Teacher *Quick* Notes- "Electromagnets-6 Mini Investigations"

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2- 50cm long pieces of enameled (magnetic) wire- 22 gauge or similar
2-D cell batteries
2-battery holders (optional)
2-small squares of sandpaper- 100 to 180 grit
2-baggies with iron filings
2-styrofoam plates
4-student handouts
1-toy car (optional)

Ideally, students are seated in groups of 4's and can work in pairs until the last mini investigation, where they will join batteries and double the current.

**Additionally:**
PowerPoint-"Electromagnet Investigations" –located in the Resources folder (optional)

**Procedure:**
1. Before getting started:
   a. Have student pour the iron filings onto the plate.
   b. Sand the enamel paint off both ends of the wire.
   c. Warn students about wires heating up (after 5 seconds of being hooked up).
   d. Start the PowerPoint, if you're using it.
2. Tell students they have 1 minute to construct a working electromagnet, without any further help or clues from you. Start timing.
3. Announce the first task (strongest part) and advance the PowerPoint slide to begin the timer.
4. Do a paragraph reading from the book if you want to connect with anything in it.
5. Do the same for the next 5 investigations as students…
   #2- load up the electromagnet with iron filings and then disconnect the wire.
   #3- wind the wire 10 more times, or as many as possible while still leaving enough wire on the ends to touch to the battery.