The Strength of an Electromagnet

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Experimental Procedure

Making Your Electromagnets

1. Make four different electromagnets—with 50, 100, 150, and 200 turns of wire, respectively—by tightly winding the magnet wire around the iron bolts (Figure 2). Here are some tips for making the magnets, but you can also refer to our How to Make an Electromagnet (https://www.youtube.com/watch?v=Wm9_DqQKmd0&feature=youtu.be) video for more details. If you have trouble, see the FAQ (#help) for more information.
    a. Use a paper towel holder to hold the magnet wire spool while winding your magnets, or make an improvised one using a pencil and a cardboard box (Figure 3). This will help you keep your coils neat and prevent knots in the wire.
    b. Leave a tail of wire—at least 6 cm long—at each end of the coil. You will use these wire tails to connect the coil to the battery.
    c. Use small pieces of masking tape to attach each end of the coil to the bolt, to prevent it from unraveling.
    d. Rotate the iron bolt to unwind the magnet wire from the spool. Do *not* pull the wire off the spool and wrap it around the bolt while still holding the bolt; this will cause the wire to get tangled. Use your fingers to keep the wire tight against the bolt, and wrap each successive turn tightly against the previous one. If these instructions are not clear, watch the video (https://www.youtube.com/watch?v=Wm9_DqQKmd0&feature=youtu.be) to see how to wind the magnet.
    e. Your 50- and 100-turn coils should fit entirely on the smooth part of the bolt. The 150- and 200-turn coils will go onto the threaded part. This will make it more difficult to keep the turns neat and tightly packed against each other, because they will tend to go into the threads of the bolt, but this is okay.
    f. Keep track of how many turns you make. This is easier if you use a piece of tape or a mark on the bolt so you can easily count one full rotation. It also helps to recruit a helper to make tally marks for you.
    g. Use masking tape and a pen or fine-point marker to label each magnet with the total number of turns.
    h. Use the 220-grit sandpaper to sand off 1 cm of the enamel insulation from both ends of each coil. To do this, cut a small piece of sandpaper, fold it in half, then pinch it around the wire and gently pull on the wire several times to remove the insulation. Watch this video (https://youtu.be/Pd5Q-XDmvys) for a more detailed explanation of how to strip the wires.

Figure 2. Four electromagnets with 50, 100, 150, and 200 turns of wire, respectively.

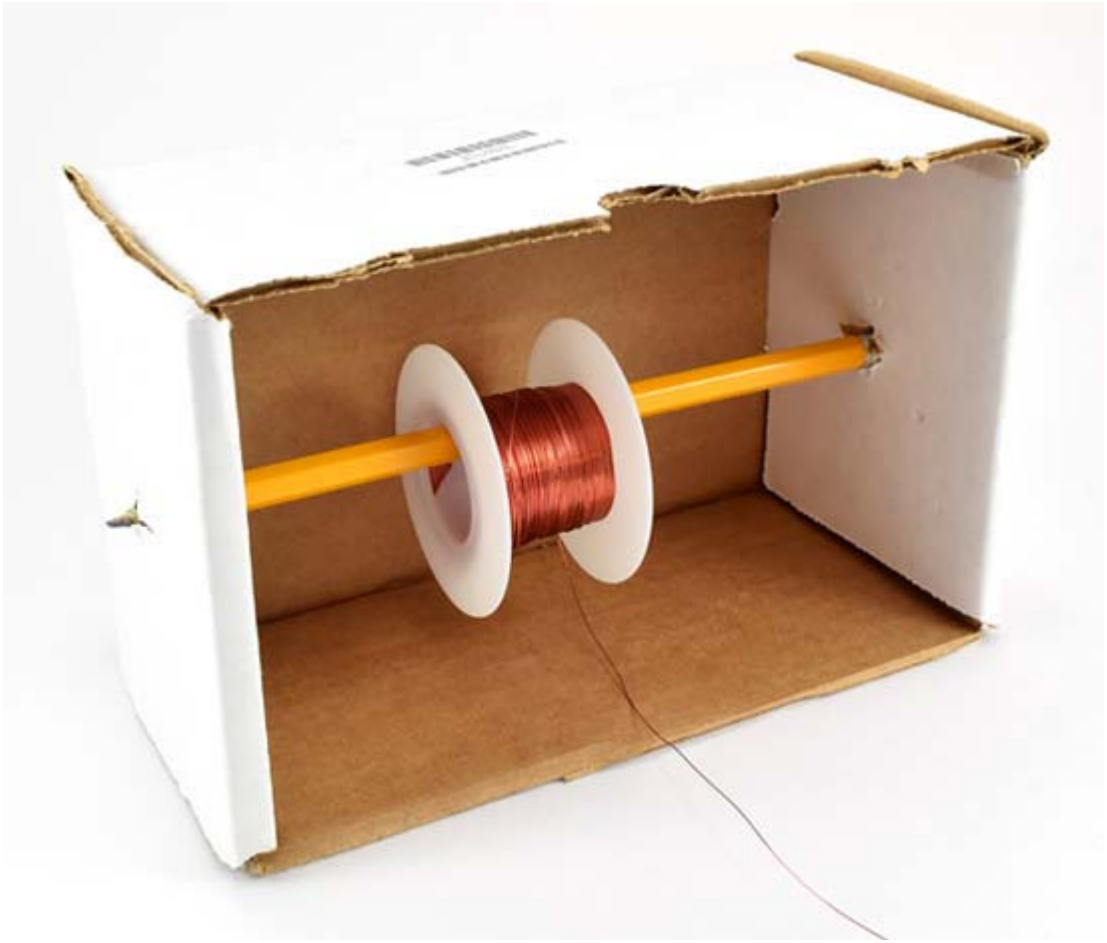

Figure 3. An improvised wire spool holder made from a pencil and cardboard box. This makes it much easier to wind the magnets.

Testing Your Electromagnets

1. Make a data table, like Table 1, in your lab notebook.

Number of Turns	Number of Paper Clips Picked Up					
	1	2	3	4	5	Average
50						
100						
150						
200						

Table 1. Example data table.

2. Place the paper clips in a small, shallow container. If you do not have a shallow container, put the paperclips in a pile on a flat surface.
3. Starting with the 50-turn coil, use the electromagnets to pick up paper clips from the shallow container.
    a. **Important:** Your electromagnets will get hot if you leave them connected to the battery in between tests. Always disconnect one alligator clip when your electromagnets are not in use.
    b. Connect one end of the red alligator clip to the "+" terminal of the battery, and the other end to one end of the wire coil. Make sure you connect to the part where you sanded off the insulation. *Note*: In electronics, it is standard convention to use red for positive and black for negative. Your electromagnet will still work regardless of which color alligator clip you use, but it is a good habit to practice!
    c. Connect one end of the black alligator clip to the "-" terminal of the battery, and the other end to the free end of the wire coil. As soon as you do this, your electromagnet will turn on and begin to heat up, so it is important to work quickly.
    d. Touch the head of the bolt to the pile of paper clips, and then pull the coil away from the tray (Figure 4). There should be some paper clips attached to the bolt. If it does not lift *any* paper clips at all, then your electromagnet is not working. See the FAQ (#help) for help.
    e. Move the bolt away from the tray, and then disconnect *one* alligator clip (it does not matter which one, and you do not need to disconnect all four alligator clips). This should turn your electromagnet off and the paper clips should fall away from the bolt.
    f. Count the number of paper clips that the magnet picked up, and record this value in your data table.
    g. Return all of the paper clips to the container.


EVERGREEN


EVERGREEN

Figure 4. Lifting paper clips with the electromagnet.

4. Repeat step 3 four more times, for a total of five trials.
5. Repeat steps 3–4 for the 100, 150, and 200-turn coils. Always remember to disconnect your electromagnets from the battery when not in use.
6. Analyze your data.
    a. Calculate the average number of paper clips picked up for each number of turns in the coil.
    b. Make a graph of the results. Plot the number of paper clips picked up (y-axis) versus the number of turns in the coil (x-axis). If you need help making a graph, try using the Create a Graph (http://nces.ed.gov/nceskids/createagraph) website.
    c. Does the number of paper clips picked up increase or decrease as you increase the number of turns in the electromagnet?

Frequently Asked Questions (FAQ)

FAQ for this Project Idea available online at https://www.sciencebuddies.org/science-fair-projects/project-ideas/Elec_p035/electricity-electronics/strength-of-an-electromagnet#help (http://www.sciencebuddies.org/science-fair-projects/project-ideas/Elec_p035/electricity-electronics/strength-of-an-electromagnet#help).