Electromagnetism

Electricity is closely related to an invisible force called magnetism. In fact, electricity and magnetism are two aspects of the same force, which modern science views as one of the four fundamental forces in the universe- electromagnetism.

When electricity flows through a conductor, like an insulated wire, it produces an invisible magnetic field around the wire. This is known as the electromagnetic effect. Magnets made in this way, by flowing electricity, are called electromagnets.

Here are the activities we'll do as we investigate electromagnets:

Activity #1: Make an electromagnet that will attract a metal object.
Activity #2: Compare the properties of magnets and electromagnets.
Activity #3: How can you increase the strength of an electromagnet?
Activity #4: Electromagnets have lines of force.

The experiment kit contains:

- 20 inch strip of insulated copper wire, 1/2 exposed on each end
- 40 inch strip of insulated copper wire, 1/2 exposed on each end
- 2 size "AA" batteries
- 2 iron nails, 4" long
- a bunch of paper clips
- small compass
- 1 roll of electrical tape
- 1 bar magnet

Make an electromagnet that will attract a metal object

A typical electromagnet is made from a coil of plastic-covered wire wrapped around an iron bar, called a core. A coil of wire, or solenoid, produces a stronger magnetic field than a straight length of wire. The wire is connected to a source of electricity like a battery. As soon as the electrical circuit is completed, the iron bar becomes a magnet. When the electricity is switched off, the magnetism disappears. Let's make an electromagnet from an ordinary nail, some wire, and batteries.

What you need:
20 inch strip of insulated copper wire, 1/2 exposed on each end
1 "AA" battery
iron nail, 4" long
a bunch of paper clips
electrical tape
scissors to cut the electrical tape

What to do:

1. Using only the nail, try to pick up as many paper clips as possible. How many did you get?
2. Now wrap the copper wire around the nail about ten times leaving 5-6 inches of wire free on each end of the nail.
3. Attach one end of the wire to the negative pole of the battery using the electrical tape
4. Touch the other end of the wire to the positive pole of the battery. Use electrical tape to hold it in place.
5. Now use the nail to pick up paper clips.
6. How many nails did you pick up?

Compare the properties of magnets and electromagnets.

Electromagnets have poles which can be **reversed** when the path of electricity is reversed. **This is not a characteristic of regular magnets.**

What you need:

- 20 inch strips of insulated copper wire, 1/2 exposed on each end
- 1 "AA" battery
- compass
- iron nail
- Electrical tape
- scissors

What to do:

1. Wrap the wire around the nail about ten times leaving 5-6 inches of wire free on each end of the nail.
2. Attach one end of the wire to the **negative** pole (the flat end) of the battery using the electrical tape.
3. Hold the nail over the compass.
4. Touch the other end of the wire to the positive pole of the battery. What happens to the compass needle when the other end of the wire makes contact with the positive pole of the battery?
5. Repeat this process, but with a slight variation: attach the wire to the **positive** pole of the battery first, then, holding the nail over the compass, complete the circuit by touching the other end of the wire to the negative pole of the battery.

What happens?

How can you increase the strength of an electromagnet?

Do you think you can increase the strength of your electromagnet? Let's try a few combinations and see! The strength of an electromagnet can be increased by using more batteries and/or more wires. Using more nails will increase the electromagnet's capacity to hold more paper clips, without necessarily increasing the magnetic force.

What you need:

- 20 inch strip of insulated copper wire, 1/2 exposed on each end
- 40 inch strip of insulated copper wire, 1/2 exposed on each end
- 2 size "AA" batteries
- 2 iron nails, 4" long
- a bunch of paper clips
- Electrical tape
- Scissors to cut the electrical tape

What to do:

1. How do you think you could increase the strength of an electromagnet? Possible ideas are to:
    1) use more wire;
    2) use more batteries;
    3) use more nails.
2. Start with the electromagnet you put together for the first activity. Write home many paperclips you picked up with the magnet in the table on the next page.
3. Now, disconnect your electromagnet. Replace the short wire with the longer wire, wrapping it around the nail as many times as you can (but still leave a few inches on each end). Connect the ends of the wire to the battery, one to each end and use electrical tape to hold the wires in place. Now how many paperclips can you pick up?
4. Try the different combinations show in the table, and any others you can think of. When you use two batteries, make sure you connect them end to end, making the positive end of one touch the negative end of the other. When you try 2 nails, you can try them end to end or side by side. What happens?

Electromagnetism Table of Results						
1 battery	2 batteries	Short wire	Long wire	1 nail	2 nails	# paper clips
X		X		X		
X			X	X		
X		X			X	
X			X		X	
	X	X		X		
	X		X	X		
	X	X			X	
	X		X		X	

Challenge! The strength of an electromagnet depends on how many loops of wire are packed into certain length. For example, an electromagnet made from wire wrapped 10 times over the length of one nail is not as strong as one with 20 times. Try the combinations below and see if this is true. Remember, you need to cover the same amount of the nails no matter how many loops you use-you are adjusting the number of loops per unit length. Use 2 batteries, the long wire, and 1 nail. Test the strength of the electromagnets by seeing how many paper clips you can pick up.

Number times wire was wrapped around the nail	# paper clips
6	
8	
10	
20	

Electromagnets have lines of force.

A magnetic field is an area around a magnet where it pulls iron containing objects towards itself. The pull spreads out all around the magnet. In this experiment you will draw a picture of a magnetic field.

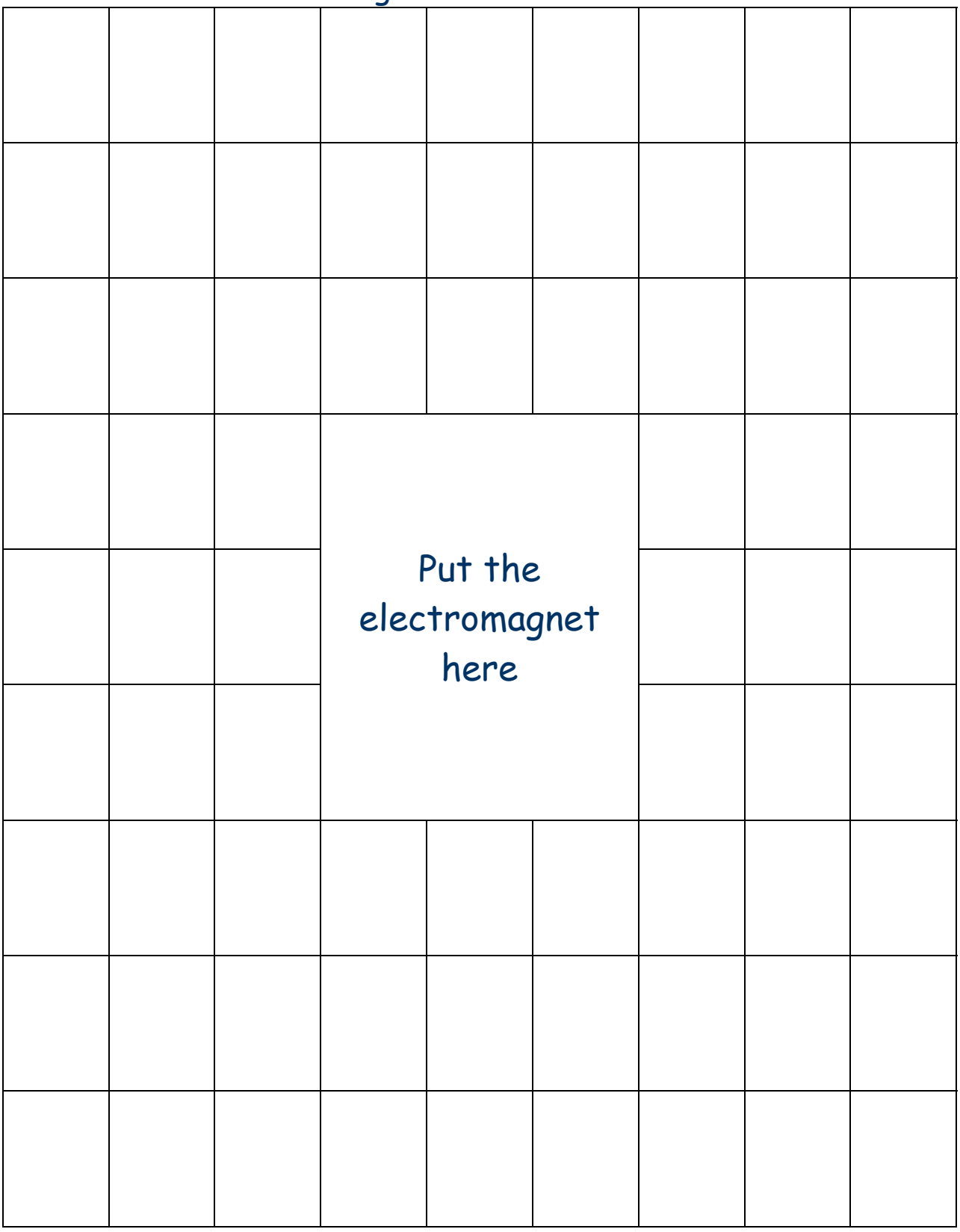
What you need:

- 20 inch strip of insulated copper wire, ½" exposed on each end
- 2 size "AA" batteries
- iron nail, 4" long
- compass
- electrical tape
- scissors
- pencil

What to do:

1. Make the electromagnet described in the first experiment (or one of the other experiments).
2. Place the electromagnet on the middle of the next page.
3. Place the compass in one of the boxes near the magnet. Draw an arrow in the direction the compass is pointing. Repeat this for each box.
4. When you are done, you will have a picture of your electromagnet's magnetic field!

Magnetic Field Picture



Interested in learning more about electromagnets?

Credit where credit is due….
The experiments, discussions, and pictures in this handout were adapted from two sources. The discussions and the experiment mapping the magnetic field lines were taken from The World of Science, Paragon Publishing, 2005 Edition.

The remaining experiments were adapted from:

SMILE PROGRAM PHYSICS INDEX at http://www.iit.edu/~smile/index.html.

The SMILE website is hosted by the Illinois Institute of Technology

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The SMILE website is a collection of almost 200 single concept lessons. These lessons may be freely copied and used in a classroom but they remain the copyright property of the author(s) and the directors of the SMILE program.

The Physics lessons are divided into the following categories: Matter, Mechanics, Fluids, Electricity & Magnetism, Waves, Sound and Optics, and Miscellaneous.

& teachernet

Questionnaire

Were the materials provided appropriate? Yes _____ No _____

Please

explain._____

1. Did you have enough materials for each experiment? Yes_____ No_____

Please

explain._____

2. Did the experiments work? Yes_____ No_____

If not, please

explain_____

3. Please provide any suggestions for improvements or additional

experiments/explanations._____

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