

Electromagnetism Observation sheet

Name _____

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

<http://studentorgs.vanderbilt.edu/vsvs>

Electromagnetism

Spring 2016

(Adapted from Student Guide for Electric Snap Circuits by Elenco Electronic Inc.)

Goals: 0807.12.2 Produce an electromagnet using a bar magnet and a wire coil.

0807.12.3 Experiment with an electromagnet to determine how to vary its strength.

Materials

10 sets (of 2) D-batteries in holder

10 bags containing

1 set of 2 nails wrapped with copper wire (1 nail has 50 coils and the other 10 coils)

1 bag of 10 paper clips

2 single alligator clips,

1 double alligator clip,

1 push switch

10 bags containing:

1 case Iron fillings (white paper glued beneath for better visibility)

1 bag containing pair of paper clips attached to each other

10 magnets

10 bags containing circuit boards with:

4 # 2 snaps

1 # 1snap

1 # 3 snaps

1 electromagnet coil

1 switch

1 red and 1 black lead

1 iron rod and grommet

1 battery holder with batteries

10 voltmeter/ammeter

10 simple motors

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20 circuit diagrams

1. Before the lesson:

In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

1. Why does the needle of a compass point North?
2. How is an electromagnet different from a regular magnet?
3. How can we make a current to flow using magnets and no battery?
4. Explain how a motor works.

2. During the Lesson:

Here are some Fun Facts for the lesson

Wind turbines generate electricity by using the wind to turn their blades. These drive magnets around inside coils of electric wire

Electromagnets are used in junk yards to pick up cars and other heavy metal objects

Electromagnetics are used in home circuit breakers, doorbells, magnetic door locks, amplifiers, telephones, loudspeakers, PCs, medical imaging, tape recorders

Magnetic levitation trains use very strong electromagnets to carry the train on a cushion of magnetic repulsion. Floating reduces friction and allows the train to run more efficiently.

Unpacking the Kit

II. Making an Electromagnet Using Batteries, a Nail and Copper Wire.

10 sets (of 2) D-batteries in holder,

10 bags containing sets (of 2) nails wrapped with copper wire (1 nail has 50 coils and the other 10 coils), 1 bag of 10 paper clips, 2 single alligator clips, 1 double alligator clip, 1 push switch

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III. Comparing Properties of Magnets and Electromagnet

10 bags containing: 2 paper clips (paired), 1 case Iron fillings (white paper glued beneath for better visibility)

10 magnets

10 circuit boards with: 4 # 2 snaps, 1 # 1snap, 1 # 3 snaps. 1 electromagnet, 1 battery holder with batteries, 1 switch
1 red and 1 black lead, Iron rod

20 circuit diagrams (2 per group)

IV. Making Electricity with Magnets and Coil

Add 10 voltmeter/ammeters – M6's

V. Applications of Electromagnets - Using Electricity and an Electromagnet to make a Motor

10 simple motors

I Introduction

A. What is a Magnet?

Ask students to tell you what they know about **magnets**. Make sure the following information is included:

All magnets have the same properties:

All magnets have 2 magnetic poles.

The poles in the bar magnet are at the ends. One pole is labeled **N**

The poles are the places where its magnetism is strongest.

Same poles repel each other:

If the **N** pole is brought close to the **N** pole of a second magnet they will repel each other, the same is true for 2 **S** poles brought together.

Your Notes:

Opposite poles attract each other.

If the **N** pole of one magnet is brought close to the **S** pole of another magnet, they will attract each other.

All magnets have a magnetic field, which can be visualized using iron filings.

B. What is an electromagnet?

Ask students if they know what an electromagnet is and accept answers.

An electromagnet is made by wrapping copper (the metallic reddish-colored) wire into a coil. It generates a magnetic field when an electric current passes through the wire.

An iron rod placed inside the coil will increase the magnetic force.

Magnetic fields are produced by moving electric charges

Explain that an electromagnet is a magnet that works only when an electric current passes through it (e.g. when it is connected to a battery). Electromagnets differ from permanent magnets in that they have an inducible or temporary magnetic field. Their magnetic field can be turned off by removing the electric current.

Divide class into 10 groups.

II. Making an Electromagnet Using Batteries, a Nail and Copper Wire.

10 bags containing:

1 set of 2 nails wrapped with copper wire (1 nail has 50 coils and the other 10 coils)

1 bag of 10 paper clips

2 single alligator clips,

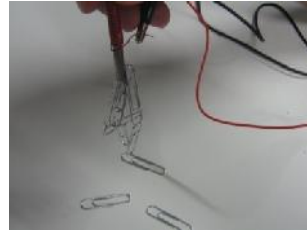
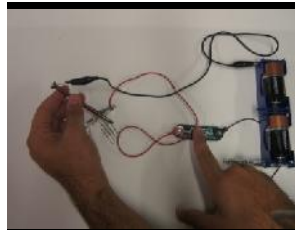
1 double alligator clip,

1 push switch

Tell students to:

1. Look at the 2 nails – one has 50 coils of copper wire, and the other has only 10. Tell students that they will be testing the strength of the 2 electromagnets by finding out how many paper clips each one can hold.
2. Take the nail with the 50 coils and test the nail to make sure it is not magnetized by attempting to pick up a paperclip with the nail. If the nail does pick up the paper clip, have the students carefully tap it on the table until it becomes demagnetized and no longer picks up the paper clip.

Your Notes:



3. Have students look at the diagram on the Instruction Sheet and make the circuit by:
 - a. Snapping the 2 wires containing snaps onto the switch.
 - b. Clipping one of these wires to the metal bar protruding from the battery holder, using the alligator clip.
 - c. Clipping the other wire to one of the ends of the copper coil on the nail, using the alligator clip.
 - d. Take the 3rd wire (with alligator clips on **both** ends) and clip one end onto the other metal bar on the battery holder and the remaining end of the copper wire coil.
 - e. Ask students what they need to do to complete the circuit (press and hold the switch).
 - f. Tell students to press the switch and to try to pick up a paper clip with the tip of the nail.
 - g. **Warn students not to hold switch too long as the batteries can become very hot and drained.**
 - h. Tell students to see how many paper clips they can hang from the nail while the circuit is complete.
 - i. What happens when the circuit is broken?
 - j. Repeat the test with the nail with 50 coils.

Collect all battery holders, etc.

III. Comparing Properties of Magnets and Electromagnet

Materials

- 10 paired paper clips
- 10 cases Iron fillings (white paper glued beneath for better visibility)
- 10 circuit boards with:
 - 4 # 2 snaps, 1 # 1snap, 1 # 3 snaps, 1 battery holder with batteries,
 - 1 electromagnet, 1 switch, 1 red and 1 black lead, Iron rod
- 10 bar magnets

Give each group one electromagnetism circuit board kit, one bar magnet, paired paper clips and 1 case iron fillings. Have students connect battery holder, switch, and electromagnet using black and red jumper wires and insert iron core rod into the center of the electromagnet.



Your Notes:

Explanation:

Tell students to examine the electromagnet from the kit and notice that this commercial electromagnet has copper wire that is coiled many more times compared with the nail used in the previous experiment.

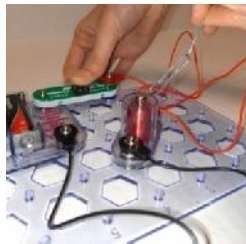
The iron core rod replaces the nail in the previous experiment.

Ask students to predict if this electromagnet will be stronger or weaker than the one they made with the nail and wire? Why?

The snap circuit electromagnet should be stronger, since it has more coils.

A. Testing the Magnetic attractiveness of the magnet and electromagnet

1. Move the **magnet** towards the paper clip. Is the paper clip attracted to the magnet? – *yes*
2. Testing the **electromagnet**:
Dangle the paired paper clips close to the top of the iron rod in the electromagnet. Is there any attraction? *No.*
3. Press and hold the switch **down** and repeat step 3. Is there any magnetic attraction? *Yes, the paper clip is attracted to the electromagnet.*
4. Release the switch to **OFF** and notice what happens. *The paper clip is no longer attracted.*
5. Place the paper clip near the rod **under** the electromagnet and notice what happens when the switch is turned **ON**. *The paper clip is attracted to the electromagnet when the switch is on.*



Explanation:

Explain to students that all materials have tiny particles with magnetic charges, which are usually so well balanced that you do not notice them.

A **magnet** is a material that concentrates the magnetic charges at opposite ends (the poles).

In an **electromagnet**, the electric current that flows in the wire has a tiny magnetic field. By

looping a long wire into a coil the tiny magnetic field is concentrated into a large one.

The strength of the magnetic field depends on how much current is flowing in the wire and how many loops of wire are present.

2. Comparing the magnetic fields of magnets and electromagnets

Gently shake the **iron filings pack** so that the filings are spread evenly and thinly

Your Notes:

Place the magnet underneath the pack and notice how the filings produce a distinct pattern. The pattern you see shows the magnetic field of the magnet. The field has areas of strong and weak magnetism.

How is the magnetic field around the electromagnet similar to that found around a magnet? Place the iron filings container above the electromagnet and turn the switch on. What happens to the filings?

A similar pattern is formed, but much weaker



IV. Making Electricity with Magnets and Coil

Show students the meter and tell them that it is capable of measuring both current (as an ammeter) and voltage (as a voltmeter).

Voltage is measured in volts (V).

Current is measured in amperes (A) or milliamps (mA, 1/1000 of an ampere).

Build the circuit shown in **figure 2** on the *Instruction sheet*. (Do not place the rod into the core yet.)



Figure 2



Figure 3



Figure 4

1. Set the meter to the middle setting, 0.5mA. (The current produced by the circuit you have built will be very small, and will not be detected with the 50mA setting.)
2. Place the board flat on the table surface (you are going to be looking for small movements in the meter needle, so the board needs to be stable).
3. Hold the bar magnet against the coil (vertically or horizontally) and move it up and down or across back and forth (see **figures 3 & 4** below). Observe the meter needle while moving the magnet. Very small movements will be detected.
4. Place the iron core rod into the coil and repeat. The meter needle movement will be larger.
5. Place the magnet on the top of the rod and use it to move the rod up and down.

Your Notes:

- The movement of the meter needle indicates that a small current is being produced.
- Remember that NO batteries are being used – the electric current has been induced by the movement of the bar magnet and copper wire coil.
- Moving the bar magnet changes the magnetic field around the coil. This change produces an electric current. Alternatively, the coil could be moved instead of the magnet, and an electric current would still be produced.

V. Applications of Electromagnets - Using Electricity and an Electromagnet to make a Motor.

Pass out the assembled motors.

Tell students to look at the motor and identify the following parts: a permanent magnet, an electromagnet, copper wire, and a battery.

Point out the copper supports that connect the battery to the coil.

Point out that the copper wire is covered with an enamel coating for insulation. Tell students to look closely at the 2 straight ends of the copper coil. Both ends have had the enamel coating stripped from one side of the wire (it does not have the same shiny copper color as the other side). The coated side will not conduct electricity, whereas the stripped side will allow a current to flow through the coil.

Tell students to:

1. Place the straightened wires from the coil into the U of the copper supports. The shiny (insulated) side must be facing UP.
2. Give the coil a gentle tap. If it spins continuously, the student has succeeded in making a motor.
3. If the coil does not spin, have the student tap it in the other direction.

Optional:

4. Flip the magnet over (a different pole will now be facing up). Repeat steps 1-3. What happens?

Explanation:

We know that an electromagnet has a magnetic field when an electrical current flows through it. Magnets also have permanent magnetic fields. The 2 magnetic fields can attract or repel each other.

The motor works because electricity flows through the coil and a magnetic field is formed. The magnetic fields from the magnet and electromagnet repel each other and the coil pushes away from the magnet with enough force to turn it around. As the coil rotates around, the coated side makes contact with the copper supports and breaks the electrical circuit. Momentum carries the coil around to its starting position, where the stripped wire now comes back into contact with the copper supports. The circuit is again completed, so the magnetic field in the electromagnet is created again, and the coil continues to spin. Motors are commonly used to convert electricity to mechanical energy, as in wind mills, hydroelectric dams and other kinds of turbines.

Lesson written by Pat Tellinghuisen, Coordinator of VSVS, Vanderbilt University
Leandra Fernandez, VSVS Lab Worker, Vanderbilt University

Your Notes:

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1. How many paper clips can you pick up with the nail plus 50 coils?

2. What happens when the circuit is broken (the switch no longer pressed)?

3. How many paper clips can you pick up with the nail plus 10 coils?

4. What materials are necessary to make an electromagnet?

5. What makes an electromagnet stronger?

6. Is the magnetic field around the electromagnet similar or different to that around a magnet? How?

7. What happens when you move the magnet over the coil plus the iron rod?

8. What does the movement of the meter needle tell us?

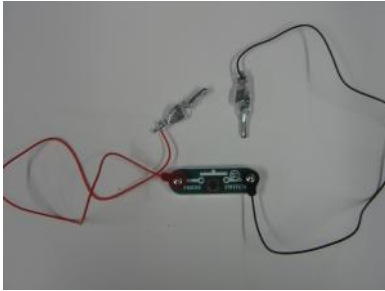
9. What materials are necessary to make a motor?

Electromagnetism Instruction Sheet

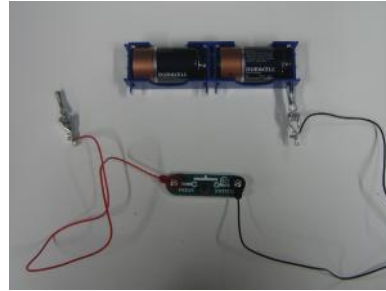
I. Introduction

II. Making an Electromagnet Using Batteries, a Nail and Copper Wire

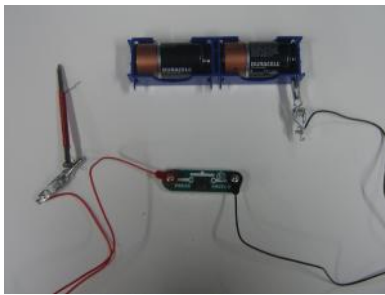
1. Build the circuit shown in **figure 1** below



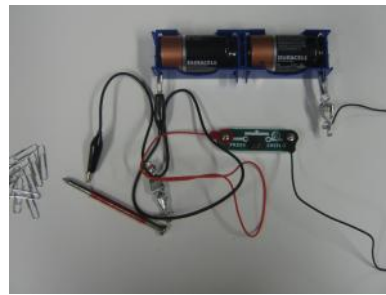
Snap the 2 wires containing snaps onto the switch



Clip one of these wires to the metal bar extending from the battery holder.

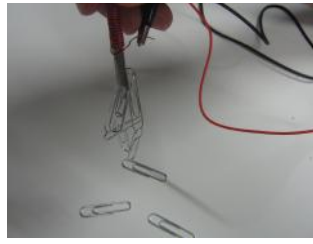
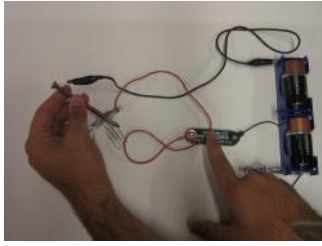


Clip the other wire to one of the ends of the copper coil on the nail, (use the nail that has 10 coils)



Take the 3rd wire and clip one end to the other metal bar on the battery holder and the other end of the copper wire coil

2. Look at the 2 nails – one has 50 coils of copper wire, and the other has only 10.
3. Take the nail with the 10 coils and test the nail to make sure it is not magnetized by attempting to pick up a paperclip with the nail.
4. Put the paper clips in a pile on the desk.
5. Make sure the button is not pressed. Put the tip of the nail plus 10 coils into the paperclips. Is there any magnetic attraction?
6. Hold down the button and repeat step 5. Is there any magnetic attraction?
7. Let go of the switch and notice what happens.
8. Replace with the nail with 50 coils and repeat steps 3-7.



III. Comparing Properties of Magnets and Electromagnets

A. Testing the magnetic attractiveness of the magnet and electromagnet

1. Take two paperclips and loop them together. Next, move them close to the magnet. Observe how the paperclips react.



2. Construct the circuit as shown above. Be aware that there is a 1 connector beneath the switch to make it even with the battery pack. Test the electromagnet by holding the paperclip close to the top of the iron rod in the electromagnet.
3. Press and hold the switch down and repeat step 2.
4. Place the paper clip near the rod under the electromagnet and notice what happens when the switch is turned ON.

B. Comparing the magnetic fields of magnets and electromagnets

1. Gently shake the iron filings pack so the filings are spread
2. Place the magnet underneath the pack and notice how the filings produce a distinct pattern.
3. Repeat step 1 and place the pack over the electromagnet and turn the switch on. Notice what happens to the filings.



IV. Making Electricity with Magnets

Note: The 5 V setting measures voltage, and the 0.5 mA and 50 mA settings measure current.

Voltage is measured in volts (V).

Current is measured in amperes (A) or milliamps (mA, 1/1000 of an ampere).

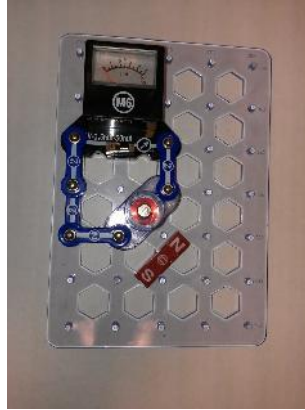


Figure 1

Build the circuit shown in **figure above**. (Do not place the rod into the core yet.)

1. Set the meter to the middle setting, 0.5mA. (The current produced by the circuit you have built will be very small, and will not be detected with the 1A setting.)
2. Place the board flat on the table surface (you are going to be looking for small movements in the meter needle, so the board needs to be stable).
 - a. Hold the bar magnet against the coil (vertically or horizontally) and move it up and down or across back and forth (see **figures 3 & 4** below). Observe the meter needle while moving the magnet.
 - b. Place the iron core rod into the coil and repeat. Is the meter needle movement larger?
 - c. Place the magnet on the top of the rod and use it to move the rod up and down.

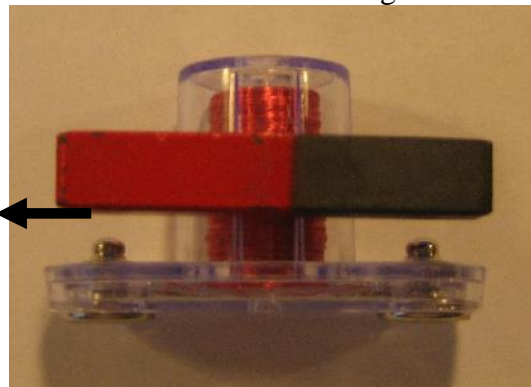


Figure 2

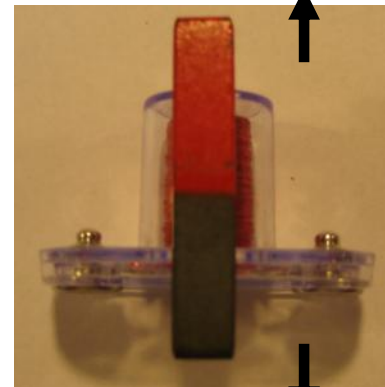
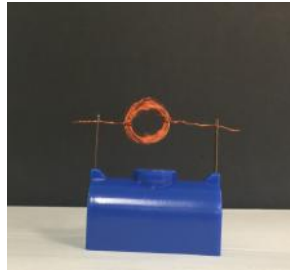


Figure 3

V. Applications of Electromagnets - Using Electricity and an Electromagnet to make a Motor.

Look at the motor and identify the following parts: a permanent magnet, an electromagnet (copper wire coil and a battery), and copper supports that connect the battery to the coil.

Note that the copper wire is covered with an enamel coating for insulation. Look closely at the 2 straight ends of the copper coil - both ends have had the enamel coating stripped from one side of the wire (it does not have the same shiny copper color as the other side).



5. Place the straightened wires from the coil into the U of the copper supports. The shiny (insulated) side must be facing UP.
6. Give the coil a gentle tap – it should spin
7. If the coil does not spin, tap it in the other direction.

Optional:

8. Flip the magnet over (a different pole will now be facing up). Repeat steps 1-3. What happens?