BUILD A STRONGER ELECTROMAGNET

PLANNING YOUR EXPEDITION

Batteries will need to be charged for this activity. Students should be warned about the heat generated when working with electromagnets.

Using these activities in conjunction with "Use Electricity to Make a Magnet" allows students to extend their experience to include working with specifications, defining parameters, manipulating variables, graphing the results of their work, publicly presenting the results, and defending the procedures they chose. This is a series of activities that asks students to apply math concepts to analyze data. Each part of the Itinerary addresses a different variable.

There is great value in modeling science as a human endeavor, rather than something done by men in lab coats in isolation. In reality, scientists have many constraints upon the way in which they conduct their research and are often working to others' requirements and specifications. Scientists are also subject to the same issues as others in the workforce, for example consideration of environmental issues, regard for how the work they are doing reflects upon the scientific community, and how their work affects the community in general.

Scientists in real-world settings reflect upon their work and discuss it in both large and small groups. In this way men and women involved in scientific endeavors clarify their thoughts and validate their research. Giving students the opportunity to manipulate variables and data and then design a way to present their findings models how scientists work and also models how private industry conducts business that impacts our everyday lives. Diverse groups of people are often required to work together to achieve a common goal; they may not speak the same language or follow the same customs; their cultures may be so varied that understandings need to be mutually decided upon, but the assigned task must be completed.

Some processes that students will employ in completing this activity are prediction, explanation, description, and analysis. These will be apparent as students answer questions posed by the activity in their Alpha Logs. It is expected that, at the end of this series of investigations, students will write up their results in a manner that can be presented to someone who was not involved in the activities.

1. Provide students with options for recording their data: a teacher-generated data table or

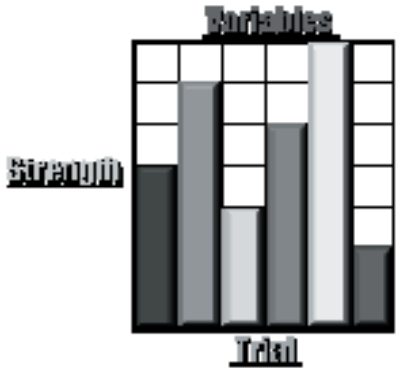
instruct the groups to design their own.* After gathering materials, students will first test the effect of the number of winds of insulated wire. Groups then must decide how they will measure the strength of their magnets. Students should be instructed to use any device **other than paper clips.**

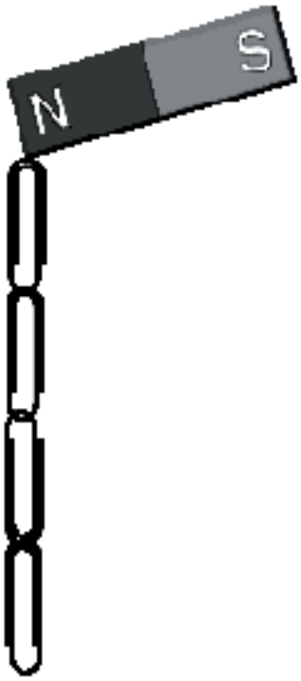
*If you decide to create a data table for the students to fill in, it should have the magnet numbers listed vertically with "winds," "style," "core material," and "average strength" as column titles. Interpreting tables is a skill that students will be required to use in all subjects in school. Creating their own method for recording and maintaining data will give students a deeper knowledge of the kinds of information that are best displayed on tables as opposed to graphs, lists, or diagrams.

2. Students will need to choose one variable to manipulate (the number of winds, the style of the winding, or the core material) and make predictions about the effect of that variable before constructing and testing the magnet.

3. Step 2 is repeated for each variable.

4. Students will construct a graph of the strength of each of the five magnets they made. One line graph could be used with a different color for each magnet; a bar graph could display magnets side by side. The x-axis (horizontal) should be the variable and the average strength of the magnet (determined by 5 trials) on the y-axis (vertical).





5. **As a culminating activity,** groups are assigned a certain number of paper clips to be picked up by the electromagnet that they construct. The group that constructs a magnet that picks up that particular number (no more and no less) most quickly receives a reward of your choosing (bonus points, extra credit, students of the week, a certificate, or some other incentive already in place in your classroom). A certificate is included in Appendix D. There is no Itinerary for this part of the activity since you will want your students to use any and all of the materials that are available in order to meet your specifications.

BACKGROUND INFORMATION

Variable refers to the one factor that is being tested or observed in an experiment. Most often, scientists work with only one variable at a time. There are many variables that can affect the strength of an electromagnet. For example, the number of winds, the size of the wire, the style of the winding, the core material, the coil diameter, or the amount of current. Students may add to the list length of the wire, size of the battery, or the core diameter. This activity, however, will deal only with number of winds, style of winding, and core material.

Encourage students to come up with other variables and ways to test them. With the available materials, allow students to experiment and test their ideas. Students will discover that testing one variable at a time is the only way to generate accurate information. Urge students to bring other materials to class and, after getting your approval, test these variables as well. You could offer some incentive like bonus points, extra credit, group of the week, etc., to give added incentive to students to launch their own investigations.

EXCURSIONS

Research an historical experiment, invention, or innovation. Report on how variables were manipulated to achieve the desired outcome. The report could be in the form of role-playing, videotape reenactment, poster presentation, written report, timeline, or diary. Student products demonstrate use of technology to complete research and knowledge of the fact that the questions that arise when one scientific discovery is made lead to further scientific inquiry and discovery.

SC.H.1.3.1-7, 3.3.5-7

LA.A.1.3.1-4, 2.3.1-8, LA.B.1.3.1-3, 2.3.1-4

SS.A.1.3.1-3, 2.3.2-3, 3.3.1-2, SC.H.1.3.1-7, 3.3.5-7

Students could design another competition (other than the paper clip speed competition) that could be held using only the materials they have at their disposal in the classroom. The design should show that students understand that by manipulating any of a number of variables, they can affect the performance of the electromagnet.

SC.C.2.3.1-3, SC.H.1.3.1-7, 3.3.5-7

MA.A.4.3.1, MA.B.1.3.2-4, 3.3.1, 4.3.1-2, MA.E.2.3.1

Have students design an invention that is based on one of their magnets. Describe the problem that the invention solves, identify who would use this product, and explain how the invention would be used. Include a labeled diagram of the invention, a list of materials and their approximate cost, as well as the final cost to the consumer. This assignment blends the experimental with the practical in that students will realize that there are many steps involved in taking a scientific discovery or innovation from the laboratory to general usage.

SC.C.2.3.1-3, SC.H.1.3.1-7, 3.3.5-7

MA.B.1.3.2-4, 3.3.1, 4.3.1-2

LA.B.1.3.1-3, 2.3.1-4, LA.D.2.3.1-2

SS.A.2.3.2-3

Notes:

FOR YOUR PLANBOOK: Build A Stronger Electromagnet

Suggested time: 1-5 hours

Gear: 1 D-cell battery, 1 battery holder, 200 cm insulated wire, iron rod, wooden dowel, aluminum rod, paper clips, graph paper.

National Science Content Standards: A, B, C, D, E, F, G

Sunshine State Standards Benchmarks: SC.B.1.3.4, SC.C.2.3.1, SC.C.2.3.2, SC.D.1.3.3, SC.D.2.3.2, SC.G.1.3.4, SC.G.2.3.3, SC.G.2.3.4, SC.H.1.3.1, SC.H.1.3.2, SC.H.1.3.3, SC.H.1.3.4, SC.H.1.3.5, SC.H.1.3.6, SC.H.1.3.7

Sunshine State Standards Benchmarks -- Math: MA.A.4.3.1, MA.B.3.3.1, MA.B.4.3.2, MA.D.1.3.1, MA.D.1.3.2, MA.E.1.3.1, MA.E.3.3.1

Sunshine State Standards Benchmarks -- Language Arts: LA.A.1.3.1-3, 2.3.1-4, LA.C.3.3.3, LA.D.1.3.1-4, 2.3.1-2

Homework: Have students list things in nature that depend upon cooperation or working in groups. Examples may range from complex food webs, food chains, entire ecosystems, and habitats to animals that live in packs/pods, etc. Earth Science students could make the connection between human interaction and the atmosphere or the ocean.

Cooperation at all levels is necessary for survival -- even if it is survival in science class or getting a good grade for finishing the activity. Getting students to reflect on their groups and each person's contribution to getting the job done will improve the group's dynamics.

Homework Assessment: Have students compare and contrast the group that they identified in nature with their group in science class. Students hand in the comparison in table or written form. Assignments should reflect the idea that each of the components of the group is dependent upon the others for survival (or a grade); that each group member has a well-defined job; and that the task could not be completed by only one member.

Assessment: Individually or in groups, students produce graphs that display variables on the x-axis and magnet strength on the y-axis. In a student-teacher conference, students explain their choice of data display and what it means to someone from outside of the classroom looking at the data. The graphs could be computer-generated or drawn by hand. There should be a graph for each of the variables investigated. Students demonstrate that they can construct a graph and understand that a graph is one of many ways to compare data.

Write a summary of the results of all parts of this investigation. The summary should discuss the three variables, results for each, and suggestions for other experiments involving the strength of an electromagnet. The results should be understandable to someone who was not involved in this series of activities.

Alpha Logs include analysis of results based on their answers to critical questions included in the Itinerary, explanations of (in written or graphic form) variables that were manipulated, and observations made during the trials. Answers to questions indicate that the more winds of the wire, the stronger the electromagnet becomes. Answers should also state that the wire and battery holder get warmer as the magnet gets stronger. If the wire is overlapped and pointing in one direction, the magnet will be stronger but if the wire is overlapped and pointing in different directions, the magnet will become weaker. Answers to questions in the activity should also state that the movement of electrons is what is causing the magnetic field.

Presentation of results for each group indicates participation of each group member and displays evidence that students distinguished between constants and variables, that they were able to replicate their results, and that they chose a graphic representation to compare results from each trial.

Culminating Activity: Electromagnets are manipulated so that the group picks up the exact number of paper clips assigned. For example, present the challenge to pick up only 8 paper clips, no more and no less. Or, one group could challenge another group to pick up a designated number of paper clips (e.g., 15) or some other item of their choosing. If groups choose the items involved in the challenge, the choice would demonstrate their knowledge of those objects that can be picked up by a magnet and those that cannot.

BUILD A STRONGER ELECTROMAGNET

Itinerary - Part I

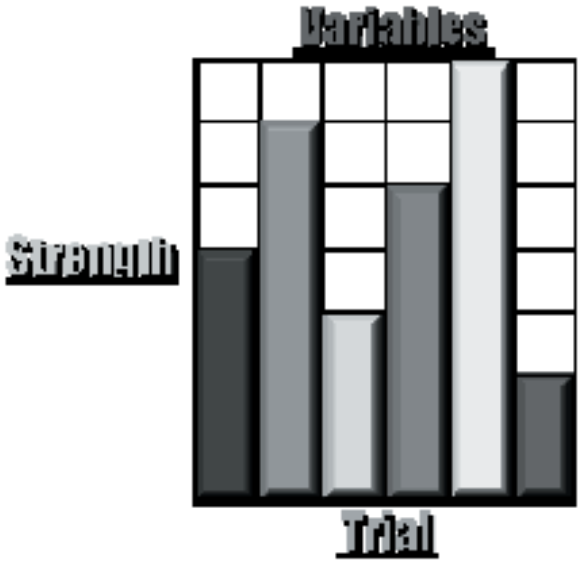
Variable refers to the one factor that is being tested or observed in an experiment. Most often, scientists work with only one variable at a time. There are many variables that can affect the strength of an electromagnet. Using what you already know about an electromagnet, what do you think some of these variables might be? Record the answer in your Alpha Log.

Variables that you will manipulate to try to increase the strength of your electromagnet will be: (1) the number of winds; (2) the style of the winding; (3) the core material.

Why would you manipulate only one of the above variables at a time if you are trying to build a stronger electromagnet? Record your explanation in your Alpha Log.

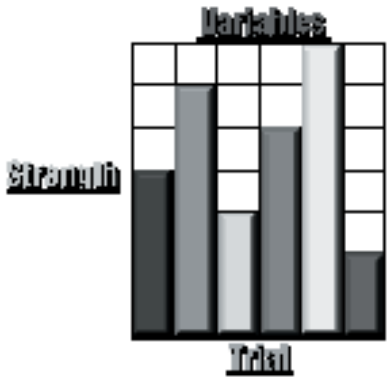
1. Assemble all of the materials that you need to run this series of experiments: 1 D-cell battery, 1 battery holder, 200 cm insulated wire, an iron rod, a wooden dowel, an aluminum rod, paper clips. You will also need graph paper.
2. Prepare your Log to record all data, observations, answers to questions, and drawings.
3. Invent a way to measure your magnet that **does not involve the use of paper clips.**
4. Construct an electromagnet by winding the iron rod with between 20 and 30 winds of wire. Make sure you leave enough wire at both ends to connect to the battery. Record the exact number of winds, then test the strength of your magnet using the system you have devised in Step 3. Repeat this test 5 times to verify the strength of the magnet and then calculate the average strength of your magnet.
5. Do you think the strength of the magnet would be affected by adding more winds? Write your prediction in your Log and add more winds to the iron rod to test your prediction. Use a total of 40 winds. Again, record the exact number of winds in your Log and measure the strength of your magnet. Repeat this test the same number of times that you chose in Step 2.
6. Add more winds so that you have between 50 and 60 winds in your magnet. How strong do you think your magnet will be now? Write your prediction in your Log and then test your magnet to determine its strength. (Remember: repeat each test 5 times to determine an average strength.)

7. Add more winds to your magnet so that you have between 65 and 75 winds, test and record your results as before.
8. Make a graph of the average strength of the five magnets you made. Plot the number of winds on the x-axis (horizontal) and the strength of the magnet on the y-axis (vertical). If you were to wind your magnet with 500 winds, how strong would you predict it to be?
9. Why is it necessary for you to determine the average strength of each of your magnets? What conditions exist that could explain why your magnet becomes either weaker or stronger in each of the 5 trials? Record your answers in the Log.



In this part of the experiment, you will change the manner in which you wind the wire around the iron core to determine what effect, if any, the style or compactness of the wire winds has on the strength of the magnet. Use the same system that you devised in Part I to measure the strength of your magnets. Again, as in Part I, you will want to replicate (repeat) each of the trials 5 times to determine average magnet strength.

1. Construct your electromagnet, sloppily winding the wire around the iron rod to make 20 winds. Do not worry about neatness or in which direction the wire is wound but leave enough space at the ends to connect the wire to the battery. Test the strength of the magnet; repeat the test five times and record your data in the Alpha Log.
2. Make another electromagnet with 20 winds. This time, wind the wire neatly around the rod taking care to place the winds next to, but not overlapping, each other. Test the magnet's strength, repeat the test five times, and record the data.
3. Now you will investigate the effect of the compactness of the wire on the strength of the magnet. As you construct your electromagnet, spread out the winds so that they are not touching. Try to have the same space between each wind. Measure the space between each so that they are consistent. Perform five tests to measure the strength of your magnet and record your results. You can determine the average distance between the winds by dividing the length of the winds by the number of winds. You will need this information later when constructing your graph.
4. Using the electromagnet that you have created, spread the winds even farther apart, leaving the same amount of space between each wind. Perform five tests of the strength of your magnet and record the results in your Log.
5. Find the average strength for each of the coil compressions (how close together they are). What conclusions can you draw about the importance of the compression of the winds?
6. Using the techniques from Part I, make a graph of the average strengths of each of the coil compressions, with average distance between the winds on the x-axis (horizontal) and the strength of the magnet on the y-axis (vertical).

In this experiment, you will work with the final variable, core material, to determine what effect, if any, it has on the strength of the magnet. The procedure will be the same as in the first two parts of this Expedition: you will repeat the tests five times; record your data on a table, compute average strength, and then make a graph. This time you will be expected to share all of your results with the class.

1. Using one of the core materials (iron rod, wooden dowel, aluminum rod, pen, or pencil), make an electromagnet as you have done before, with 30 winds of the insulated wire. Test the strength of your magnet five times and record your results in the Alpha Log.
2. Using a second core material, make another electromagnet also with 30 winds. Test its strength.
3. Make three additional electromagnets using each of the remaining core materials. Test each magnet five times and record your data.
4. Find the average strength for each of the core materials. What conclusions can you draw about the importance of the core material? Record your answers and any other observations in your Log..
5. Make a graph of the average strength of each of the core materials. Plot the core material on the x-axis and the average strength of the magnet on the y-axis.