National High Magnetic Field Laboratory

Center for Integrating Research & Learning

Project MagLab Recertification

1800 East Paul Dirac Drive Ì Tallahassee, Florida 32310

CONTENTS

Project Description

Modules:

- Investigating Magnetic Field Lines
- Using Electricity to Make a Magnet
- Build a Stronger Electromagnet
- Magnetism and Temperature
- Molarity: Making Solutions for use in Voltaic Cells
- Electrical Conductivity of Solutions
- Voltaic Cells: Using Chemical Reactions to Generate Electricity
- Lemon Battery: Using a Lemon to Create a Voltaic Cell

Helpful Hints

- Activities 1-4 focus on magnetism, while activities 5-8 focus on electrochemistry. Both groups of activities are arranged in the order that you would do them if you were going to complete the kit. However, each activity can be done separately. Activities 1 and 5 are great lead-ins for the three activities that follow them.

- Activities 1-4 are closely related, and the electromagnets that you make in one activity can be used in subsequent activities. With this in mind, you may want to gather data from all four activities before doing your post-lab discussions.

- In doing activities 5-8, you may want to combine the molarity and the conductivity labs since the solutions that are made in the molarity activity can be used in the conductivity activity.

- Teacher Reading Assessment Forms, and Teacher Project Assessment Forms are available at http://ecucation.magnet.fsu.edu/curriculum/recertification/index.asp They can be completed online. Once completed, check with your district's Staff Development Office for directions on where to send or email them.

	Box	1	2	3	4	5	6	7	8
SPOT PLATES	8							X	
COPPER SULFATE	1					X		X	
ZINC SULFATE	1					X		X	
POTASSIUM SULFATE	1							X	
FILTER PAPER	1							X	
COPPER STRIPS	8							X	X
ZINC STRIPS	8							X	X
VOLTMETERS	8						X	X	X
WIRES / ALLIGATOR CLIPS	16						X	X	X
DROPPER BOTTLES	17							X	
ALUMINUM RODS	8		X	X					
IRON RODS	8		X	X	X		X		
WOODEN DOWELS	8		X	X					
400ML BEAKERS	8								
D-CELL BATTERY	8		X	X	X		X		
BATTERY HOLDERS	8		X	X	X		X		
SMALL VIALS	27					X			
200CM INSULATED WIRE	8		X	X	X				
PAPER CLIPS	1		X	X	X				
MAGNETIC FIELD VIEWERS	8	X							
WAND MAGNETS	8	X							
ROUND MAGNETS	8	X							
SQUARE MAGNETS	8	X							
COMPASSES	48	X							
RULERS	8	X							
THERMOMETERS	8				X				
MASKING TAPE	1	X							
IRON FILINGS	3	X							.
ALUMINUM NAILS	8								X

Investigating Magnetic Field Lines

Project Overview:

This project will enable middle and high school teachers to earn 10 recertification points. All of the materials needed to complete the activity are in the box. The project focuses on magnets and the magnetic fields they produce.

- There is a reading component for the teacher to complete, along with a set of questions that will cover that reading.
- There is a lab component for this activity that will take one or two class periods to complete.
- There are follow-up reports that must be completed by the teacher and students.

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read the Preface to *Driving Force: The Natural Magic of Magnets.* This reading will peak your interest and perhaps give you some ideas that you can use if you decide to expand this project.
3. Read chapter one of *Driving Force: The Natural Magic of Magnets.* Figure 1.1 shows magnetic field lines around an electromagnet, and a permanent magnet. These lines are similar to the lines your students will draw for the project. Also read pages 19-20 and 27-33. These reading assignments are not recreational reading and you may have to go over the material several times to understand it. If you are not familiar with some of the terms you may have to reference other parts of the book. The glossary may be helpful for this.
4. Complete the lab yourself by following the lab instructions.
5. Have your students complete the lab according to the lab instructions.
6. Have your students complete the Student Assessment Forms after their lab reports have been handed in. These forms must be submitted. They will be used to evaluate the project, but will not be a contributing factor in earning recertification points.
7. Complete the Teacher Reading Assessment Form and the Teacher Project Assessment Form.
8. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at *mchenryr@mail.leon.leon.k12.fl.us*, or Dave Rodriguez at *rodriguezd@mail.raa.leon.k12.fl.us*

Materials Needed:

Each group of four students will need the following materials.
Magnetic field viewers
Wand magnets
Bar magnets
Round magnets
Square magnets
Rulers
Compasses – 6 per group
Assemble the magnetic field viewers by placing the acetate sheet on the acetate (clear plastic) tray, and sealing the edges with masking tape. Tape two adjoining edges and then place about a teaspoon full of iron filings onto the tray. Tape the two remaining edges together to seal the iron filings inside the viewer.

Lab Instructions:
Part One:

1. Place the bar magnet on top of the magnetic field viewer so that the magnet is in the middle. Tap the viewer until you get a clear view of the magnetic field. Draw and label a diagram of what you see.
2. Repeat Step 1 for each of the remaining three magnets.
3. When you have finished your investigation, write a few paragraphs summarizing what you have learned. Be sure to include information about the distance between field lines.

Part Two:

1. Place a bar magnet on your desk with the north pole pointing away from you.
2. Put the compasses randomly around the magnet.
3. Observe how the compasses respond to the magnet. Draw a picture of what you see. Indicate the direction the compass needles are pointing.
4. Put the magnetic field viewer on top of the magnet and compasses and tap the sides of the top of he viewer in order to get the clearest view of the magnetic field lines.
5. Observe how the compasses and the magnetic field lines respond, and draw a picture of what you see.
6. Remove the magnetic field viewer and rearrange the compasses. Place the magnetic field viewer back on top of the magnet and compasses and tap the sides of the top of the viewer in order to get the clearest view of the magnetic field lines.
7. Observe how the compasses and the magnetic field lines respond, and draw a picture of what you see.
8. Have students discuss their observations.

Magnetic Field: investigating Magnetic Field Lines
Student Assessment Form

1. How did this activity increase your knowledge of magnetic fields?

2. How did the shape and/or strength of the magnet affect the magnetic field lines?

3. Describe how you can apply knowledge gained from this activity to a real-life situation.

4. List as many items as you can that need magnets and magnetic fields to work.

Magnetic Field: Investigating Magnetic Field Lines
Teacher Reading Assessment Form

1. Compare and contrast the magnetic field lines of permanent and electromagnets.

2. Explain how you can demonstrate that magnetic field lines pass through some materials but not others.

3. What are the units used for measuring magnetic fields and how are they related?

4. Draw the earth's magnetic field lines and show how they affect a compass needle.

Magnetic Fields: Investigating Magnetic Field Lines
Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. How did your students react to the observations in this activity?

3. What areas of student performance were at or above expectations?

4. How did your students understanding improve as a result of the work and knowledge gained from this activity?

5. How did various sub-populations of students perform? Consider factors such as gender, race, socio-economic status, etc.

6. How will your students transfer this knowledge to their everyday lives?

7. How does this activity align with your IPDP?

8. If your school improvement plan has addressed science, how will this training module be an integral part of the process?

9. Were the instructions this activity complete and easy to understand? If not, please make suggestions as to how it can be improved.

Investigating Magnetic Field Lines
Sunshine State Standards

Middle School:

- The student understands that types of motion may be described, measured, and predicted. (SC.C.1.3)
- The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted. (SC.C.2.3)
- The student understands the need for protection of the natural systems on Earth. (SC.D.2.3)
- The student understands the interaction and organization in the Solar System and the universe and how this affects life on Earth. (SC.E.1.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.3)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.3)

High School:

- The student understands that types of motion may be described, measured, and predicted. (SC.C.1.4)
- The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted. (SC.C.2.4)
- The student understands the need for protection of the natural systems on Earth. (SC.D.2.4)
- The student understands the interaction and organization in the Solar System and the universe and how this affects life on Earth. (SC.E.1.4)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.4)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.4)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.4)

Investigating Magnetic Field Lines
National Education Science Standards

Middle School:

Content Standard A: Science as Inquiry

- As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.
- Understanding about scientific inquiry

Content Standard B: Physical Science

- As a result of activities in grades 5-8, all students should develop an understanding of properties and changes of properties in matter.
- Transfer of energy

Content Standard E: Science and Technology

- As a result of activities in grades 5-8, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 5-8, all students should develop understanding of personal health
  Science and technology in society

Content Standard G: History and Nature of Science

- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor
- Nature of science
- History of science

High School:

Content Standard A: Science as Inquiry

- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science

- As a result of activities in grades 9-12, all students should develop an understanding of motions and forces.
- Conservation of energy and increase in disorder
- Interactions of energy and matter

Content Standard E: Science and Technology

- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives

Using Electricity To Make A Magnet

Project Overview:

Middle and high school science teachers will earn 10 recertification points upon the completion of this activity. All of the materials needed to complete the activity are included in the box. This activity focuses on using electricity to create a magnet. There are three components to this activity:

- There is a reading component for the teacher to complete, along with a set of questions that covers the reading.
- There is a lab component for this activity. The lab will take one class period.
- There are follow-up reports that must be completed by the teacher and students.

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read Chapter 1 of *Driving Force: The Natural Magic of Magnets.*
3. Complete the lab yourself by following the lab instructions.
4. Have your students complete the lab according to the lab instructions.
5. Have your students complete the Student Assessment Forms after their lab reports have been handed in. These forms must be submitted. They will be used to evaluate the project, but will not be a contributing factor in earning recertification points.
6. Complete the Teacher Reading Assessment, and the Teacher Project Assessment Form.
7. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at ***mchenryr@mail.leon.leon.k12.fl.us***, or Dave Rodriguez at ***rodriguezd@mail.raa.leon.k12.fl.us***

Materials Needed:

1 D-cell battery
1 battery holder
200 cm insulated wire
Compass
Iron rod
Wooden dowel
Aluminum rod

Small paper clips (#1 size)

Lab Instructions:

1. Before you begin to build your electromagnet, check to see if the iron rod is a magnet. If it is, tap it several times on a hard surface. This will demagnetize the rod.
2. Connect the insulated wire to the battery. Be sure the ends of the wire are bare. Insert the battery into the battery holder. Place the compass underneath the wire. Is there any reaction?
3. Detach the wire from the battery. Now wrap the wire around the iron rod 15 times before re-connecting the wire to the battery. Place the compass under the wrapped rod. Is there any reaction? Try to pick up paper clips with the magnet. Record your observations.
4. Remove the iron rod from the wire without unwinding it. Will the wire pick up any paper clips? Will the rod alone pick up any paper clips? How can you explain your observations? ***Be sure to disconnect the wire from the battery between trials to save on battery life.***
5. Use the wooden dowel and then the aluminum rod as a core around which you will again wrap the insulated wire 15 times. Place a compass under the wrapped rods. Do you get the same reaction that you got in step 3? Does either of these pick up paper clips?
6. Write an explanation of what you have learned from this activity. This can be a summary of what happened and why.

Using Electricity to Make a Magnet
Student Assessment Form

1. How did this activity increase your knowledge of electricity and magnetism?

2. Describe one way you can apply this knowledge to a real-life situation.

3. Why did the magnetic field change as more wire was wrapped around the iron rod?

4. Explain why the iron rod maintained its magnetic properties after the wire was removed.

Using Electricity To Make A Magnet
Teacher Reading Assessment Form

1. Compare and contrast permanent and temporary magnets.

2. Explain how an electromagnet works.

3. Cite three examples of how magnets are used to power VCRs.

4. Explain why electromagnets have had more applications in 20th century technology than permanent magnets.

5. Describe the relationship between moving electric currents and magnetism.

Using Electricity To Make A Magnet
Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. How did your students react when their electromagnets began to work?

3. What areas of student performance are at or above expectations?

4. Does this activity represent improvements in student's work as a result of the work done and knowledge gained from this activity?

5. How did various sub-populations of students perform? Consider factors such as gender, race, socio-economic status, etc.

6. How will your students transfer this knowledge to their everyday lives?

7. How does this activity align with your IPDP?

8. If your school improvement plan has addressed science, how will this training module be an integral part of the process?

Using Electricity to Make a Magnet
Sunshine State Standards

Middle School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.3)
- The student understands the basic principles of atomic theory. (SC.A.2.3)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.3)
- The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted. (SC.C.2.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.3)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.3)

High School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.4)
- The student understands the basic principles of atomic theory. (SC.A.2.4)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.4)
- The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted. (SC.C.2.4)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.4)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.4)

Using Electricity to Make a Magnet
National Education Science Standards

Middle School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 5-8, all students should develop an understanding of transfer of energy.

Content Standard E: Science and Technology
- As a result of activities in grades 5-8, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives
- As a result of activities in grades 5-8, all students should develop understanding of personal health.
- Science and technology in society

Content Standard G: History and Nature of Science
- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor.
- Nature of science
- History of science

High School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 9-12, all students should develop an understanding of motions and forces.
- Conservation of energy and increase in disorder
- Interactions of energy and matter

Content Standard E: Science and Technology
- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives

Build A Stronger Electromagnet

Project Overview:

Middle and high school teachers will earn 15 recertification points upon the completion of this activity. All of the materials needed to complete the activity are included in the box. The activity focuses on variables that affect electromagnetism. There are three separate itineraries for this unit. Although you may have three lab reports, there is only one Student Assessment Form for the project. There are three components to this activity.

- There is a reading component for the teacher to complete along with a set of questions that covers the reading.
- There is a lab component for this activity. The labs in this activity will take 1-3 class periods.
- There are follow-up reports that must be completed by the teacher and students.

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read Chapter 1 of *Driving Force: The Natural Magic of Magnets.*
3. Complete the lab yourself by following the lab instructions.
4. Have your students complete the lab according to the lab instructions.
5. Have your students complete the Student Assessment Forms. These forms should be distributed after the students have turned in their lab reports. These forms must be submitted. They will be used to evaluate the project but will not be a contributing factor in earning recertification points.
6. Complete the Teacher Reading Assessment Form, and the Teacher Project Assessment Form.
7. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at ***mchenryr@mail.leon.leon.k12.fl.us***, or Dave Rodriguez at ***rodriguezd@mail.raa.leon.k12.fl.us***

Materials Needed:

Each group of four students will need the following materials.

1 D-cell battery
1 battery holder

200 cm insulated wire
iron rod, wooden dowel
aluminum rod
paper clips
graph paper

Lab Instructions:

Part One: In this part of the experiment, you will change the number of wire winds around the core to determine what effect, if any, the number of winds has on the strength of the magnet.

1. Measure the strength of your magnet. Use the magnet to pick up one paper clip, and then carefully attached slightly opened paper clips, one at a time, making a long chain.
2. Construct an electromagnet by winding the iron rod with 15 winds of wire. Make sure you leave enough wire at both ends to connect to the battery holder. Also make sure the wire coating at the ends of the wire has been removed to expose the bare wire. Insert a D-battery into the battery holder. Connect the ends of the wire to the battery holder connections. Test the strength of your magnet using the system you devised in Step 1. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class. ***Be sure to disconnect the wire from battery between trials to save on battery life.***
3. Add 15 more winds to the iron rod, for a total of 30 winds. Measure the strength of your magnet. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
4. Add more winds so that you have 60 winds in your magnet. Measure the strength of your magnet. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
5. Make a graph of the average strength of the magnets in class. Plot the number of winds on the x-axis, and the strength of the magnet on they y-axis.
6. Predict how strong the magnet would be if there were 500 winds.

Part Two: 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 of compactness of the wire winds has on the strength of the magnet

1. Construct your electromagnet, by winding the wire around the iron rod 20 times. The windings should be loose and crisscrossed. Connect the end of the wires to battery holder connections.
2. Test the strength of the magnet. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
3. 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 strength of the magnet. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.

4. Now you will investigate the effect of the compactness of the wire on the strength of the magnet. As you construct your electromagnet (20 winds), 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. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
5. Using the electromagnet you constructed spread the winds even farther apart, leaving the same amount of space between each wind. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
6. Find the average strength for each of the coil compressions (how close together they are).
7. Using techniques from Part One, make a graph of the average strengths of each of the coil compressions, with the average distance between the winds on the x-axis, and the strength of the magnet on the y-axis.

Part Three: 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.

1. Using an aluminum rod, make an electromagnet as you have done before, with 20 winds. Test its strength. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
2. Using a wooden rod, make another electromagnet also with 20 winds. Test its strength. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
3. Make a graph of the average strength of each of the core materials. Plot the core material of the x-axis and the average strength of the magnet on the y-axis.

Build A Stronger Electromagnet
Student Assessment Form

1. How did this activity increase your understanding of electromagnetism?

2. What variables would you change in order to convert a weak magnet into a strong magnet?

3. Describe one way you can apply this knowledge to a real-life situation.

4. Of the three variables that you tested, which one had the most affect on the strength of the magnet?

Build A Stronger Electromagnet
Teacher Reading Assessment Form

1. Illustrate the magnetic field patterns of the following types of magnets: permanent magnet, air-core electromagnet, iron core electromagnet.

2. List five facts about magnetism that you learned from the reading section.

3. Explain what must happen to a non magnetic piece of iron or steel in order for it to gain properties of magnetism.

4. Scientists have developed many materials to be permanent magnets, and have also developed many materials to be temporary magnets. Why has there not been more development of materials that have properties of both temporary and permanent magnets?

Build A Stronger Electromagnet
Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. How did your students react when they saw the various materials yielding different levels of magnetism?

3. What areas of student performance are at or above expectations?

4. Does this activity represent improvements in student's work as a result of the work done and knowledge gained from this activity?

5. How did various sub-populations of students perform? Consider factors such as gender, race, socio-economic status, etc.

6. How will your students transfer this knowledge to their everyday lives?

7. How does this activity align with your IPDP?

8. If your school improvement plan has addressed science, how will this training module be an integral part of the process?

Build a Stronger Electromagnet
Sunshine State Standards

Middle School:

- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.3)
- The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted. (SC.C.2.3)
- The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth. (SC.D.1.3)
- The student understands the need for protection of the natural systems on Earth. (SC.D.2.3)
- The student understands the competitive, interdependent, cyclic nature of living things in the environment. (SC.G.1.3)
- The student understands the consequences of using limited natural resources. (SC.G.2.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)

High School:

- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.4)
- The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted. (SC.C.2.4)
- The student recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth. (SC.D.1.4)
- The student understands the competitive, interdependent, cyclic nature of living things in the environment. (SC.G.1.4)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.4)

Build a Stronger Electromagnet
National Education Science Standards

Middle School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 5-8, all students should develop an understanding of transfer of energy.

Content Standard E: Science and Technology
- As a result of activities in grades 5-8, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives
- As a result of activities in grades 5-8, all students should develop understanding of personal health.
- Science and technology in society

Content Standard G: History and Nature of Science
- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor.
- Nature of science
- History of science

High School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 9-12, all students should develop an understanding of motions and forces.
- Conservation of energy and increase in disorder
- Interactions of energy and matter

Content Standard E: Science and Technology
- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives

Magnetism and Temperature

Project Overview:

Middle and high school teachers will earn 10 recertification points upon the completion of this activity. All of the materials needed to complete the activity are included in the box. The activity explores the relationship between magnetism and temperature. There are three components to this activity.

- There is a reading component for the teacher to complete, along with a set of questions that will cover the reading.
- There is a lab component for this activity that will take one or two class periods to complete.
- There are follow-up reports that must be completed by the teacher and students.

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read pages 38-42, 68-69 of *Driving Force: The Natural Magic of Magnets.*
3. Complete the lab yourself by following the lab instructions.
4. Have your students complete the lab according to the lab instructions.
5. Have your students complete the Student Assessment Forms. These forms should be distributed after the students have turned in their lab reports. These forms must be submitted. They will be used for project evaluation but will not be a contributing factor in earning recertification points.
6. Complete the Teacher Reading Assessment Form, and the Teacher Project Assessment Form.
7. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at ***mchenryr@mail.leon.leon.k12.fl.us***, or Dave Rodriguez at ***rodriguezd@mail.raa.leon.k12.fl.us***

Materials Needed:

1 D-cell battery
1 battery holder
200cm insulated wire
2 styrofoam cups
1 iron rod
Thermometer
Ice
Very hot water
Paper clips (size #1)

Lab Instructions:

1. Prepare a chart for recording the following data: magnet strength, temperature, average strength, and average temperature.
2. Construct an electromagnet by wrapping the iron rod with 60 coils of wire. Make sure you leave enough wire at both ends to connect to the battery holder. Also, make sure the coating at the ends of the wire has been removed to expose bare wire. Insert a D-cell battery into the battery holder.
3. Test your electromagnet using the paper clips. We used the magnet to pick up one paper clip, and then carefully attached slightly opened paper clips, one at a time, making a long chain. Record both the room temperature and the number of paper clips that your magnet holds (its strength). Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
4. Detach the wrapped iron rod from the battery. Place it in a styrofoam cup.
5. Add crushed ice to the cup to cover the rod. Add a little water to make a slushy solution that covers the rod completely. Allow the rod to remain in the solution for a few minutes.
6. Record the temperature of the solution.
7. Take the wrapped iron rod from the cup. Test the strength of your cooled magnet. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
8. Place the magnet in the styrofoam cup and carefully pour very hot water to cover the rod.
9. Record the temperature of the water. Test the strength of the heated magnet. Have each group report the strength of their magnet. Calculate the average strength of the magnets in class.
10. Find the average strength for each of the three temperatures that you tested.
11. Design a way to graph your results. Construct your graph in a way that can be shared with the class.

Magnetism and Temperature
Student Assessment Form

1. How did this activity increase your understanding of the relationship between magnetism and temperature?

2. Why does changing the temperature affect the magnetism of electomagnets?

3. Describe one way you can apply this knowledge to a real-life situation.

4. Which temperature scale would a scientist use to study the effect of very low temperatures on magnetism? Why?

Magnetism And Temperature
Teacher Reading Assessment Form

1. Discuss the origin of the earth's magnetic field. Include interactions between the sun and the earth's core.

2. How are the magnetic fields deep in the earth and those on the surface related?

3. How does temperature affect the resistance of metals?

4. What is superconductivity?

Magnetism and Temperature
Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. How did your students react to the observations during the activity?

3. What areas of student performance are at or above expectations?

4. Does this activity represent improvements in student's work as a result of the work done and knowledge gained from this activity?

5. How did various sub-populations of students perform? Consider factors such as gender, race, socio-economic status, etc.

6. How will your students transfer this knowledge to their everyday lives?

7. How does this activity align with your IPDP?

8. If your school improvement plan has addressed science, how will this training module be an integral part of the process?

Magnetism and Temperature
Sunshine State Standards

Middle School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.3)
- The student understands the basic principles of atomic theory. (SC.A.2.3)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.3)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.3)

High School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.4)
- The student understands the basic principles of atomic theory. (SC.A.2.4)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.4)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.4)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.4)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.4)

Magnetism and Temperature
National Education Science Standards

Middle School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.
- Understanding about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 5-8, all students should develop an understanding of properties and changes of properties in matter.
- Transfer of energy

Content Standard E: Science and Technology
- As a result of activities in grades 5-8, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives
- As a result of activities in grades 5-8, all students should develop understanding of personal health
- Science and technology in society

Content Standard G: History and Nature of Science
- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor
- Nature of science
- History of science

High School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 9-12, all students should develop an understanding of motions and forces.
- Conservation of energy and increase in disorder
- Interactions of energy and matter

Content Standard E: Science and Technology
- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives

Molarity: Making Solutions For Use In Voltaic Cells

Project Overview:

Middle and high school science teachers will earn 10 recertification points upon the completion of this activity. All of the materials needed to complete the activity are included in the box. The project focuses on making solutions with various molarities. There are three components to this activity.

- There is a reading component for the teacher to complete, along with a set of questions that covers the reading.
- There is a lab component for this activity. The lab will take one class period.
- There are follow-up reports that must be completed by the teacher and students.

Background Information:

Moles and molarity are two scientific terms that often confuse science teachers. The two terms are actually quite easy to understand. The mole is a counting unit just like a dozen. Where a dozen indicates 12, a mole indicates 6.02×10^{23}. We use this large number to count very small things like atoms, ions, molecules, etc. A nice fact that doesn't occur by chance is that a mole of atoms of any element has a mass equal to its atomic mass in grams. If you weigh out one mole of particles (molecules, formula units, atoms) and add enough water to make one liter of solution, the solution will have a molarity of one. To make a .1 molar (M) solution you will weigh out .1moles of particles and add enough water to make 1 liter of solution. If you want to make a smaller amount of solution you will use a proportionally smaller amount of salt. For example to make a 1 molar solution you could weigh out .1 moles of salt and add enough water to make .1 liters (100 ml) of solution. Many crystals have water molecules locked in the structure. The cupric sulfate crystal has 5 water molecules in it so it is called a pentahydrate. The proper name for these crystals is cupric sulfate pentahydrate.

Another way to make a particular molarity of solution is to dilute an existing solution. When making a dilution the following formula is useful.
$\text{Molarity}_1 \times \text{Volume}_1 = \text{Molarity}_2 \times \text{Volume}_2$

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read Chapter 4 page 29 Formula or Molecular weight and answer question 10 on page 30. Most chemistry books describe a mole of a substance as the gram atomic mass (the mass of an atom or a molecule or an ion which is gotten from the periodic table) measured in grams.

3. Read Chapter 8 pages 58-60. Make sure that you understand molarity. The other measurements of concentration are needed in order to understand other chemistry concepts. Answer questions 1 & 6 on page 61.
4. Prepare the solutions according to the lab instructions included in this packet.
5. Have your students complete the lab according to the instructions.
6. Have your students complete the Student Assessment Forms. These forms should be distributed after the students have turned in their lab reports. These forms must be submitted. They will be used for project evaluation but will not be a contributing factor in earning recertification points.
7. Complete the Teacher Reading Assignment Form, and the Teacher Project Assessment Form.
8. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at *mchenryr@mail.leon.leon.k12.fl.us*, or Dave Rodriguez at *rodriguezd@mail.raa.leon.k12.fl.us*

Materials needed:

Cupric sulfate
Zinc sulfate
Balance
Graduated cylinder
6 one-liter bottles
24 vials

Lab Preparation:

Prepare a 1M solution by stirring 250.7 grams of Cupric Sulfate pentahydrate into 1 liter of water. One-liter beverage bottles work well for this. Put the measured amount of cupric sulfate into the bottle and add water to almost the top. Leave a little room so that you can speed up dissolving by capping and then shaking the bottle. If you use a .5-liter bottle mass out ½ the amount of cupric sulfate. Take .5 liters of this solution and dilute it to 1liter to make a .5M solution. In another bottle measure .1 liters and dilute it to 1 liter to make a .1liter solution. Compare the colors of the 3 samples.

To prepare 1 liter of 1M Zinc Sulfate solution, stir 287.6 g of Zinc Sulfate Heptahydrate into 1 liter of water. Follow the same procedure you used to make Cupric Sulfate solutions to make Zinc Sulfate solutions. Zinc Sulfate is a clear solution, so you will not be able to compare the solutions by color like you did with the Cupric Sulfate. **Save these solutions for the other activities in this kit.**

Lab Instructions:

It will take a lot of Cupric Sulfate and Zinc sulfate to have the students make 1 liter of 1 M solutions. An alternative would be to have students take a sample of each of your 3 cupric sulfate solutions in a vial and compare their color. Another alternative would be to

have students make more diluted solutions of smaller volumes. A third alternative would be having students using your original 1M cupric sulfate solution to make dilutions and then compare the colors.

Safety Precautions:

Cupric Sulfate and Zinc Sulfate are toxic. Safety glasses should be worn. Material Safety Data Sheets (MSDS) for each chemical are provided.

Disposal Of Solutions:

Cupric Sulfate and Zinc Sulfate may be disposed of with copious amounts of water added and then poured down a drain with more water.

Molarity: Student Assessment Form

1. How did this lab increase your knowledge of solutions and molarity?

2. Describe how a scientist could apply this knowledge to his or her work.

3. Describe how you can apply this knowledge to your everyday life.

4. Identify the technical terms that are used in making solutions and identify them in your solution.

5. Describe how a solution with a particular molarity is made.

6. Explain how you would make a .1 molar solution if you had a 1.0 molar solution to start with.

Molarity: Teacher Reading Assessment Form

1. How do you calculate the formula weight of a compound?

2. What is the relationship between a mole of a compound and its formula weight?

3. Explain how you would calculate the formula weight of water (H_2O).

4. Explain how you would make 50ml of a .25 molar solution of Cupric Sulfate using a balance and a 50ml volumetric flask.

5. Explain how you would make a .1 molar solution from a 1.0 molar solution.

Molarity: Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. What explanation did your students give for the difference in color of the solutions?

3. What areas of student performance are at or above expectations?

4. How did this activity improve student's knowledge of the molarity concept?

5. How did various sub-populations of students perform? Consider such factors such as gender, race, socio-economic status, etc.

6. How will students be able to transfer the knowledge gained from doing this activity to their everyday life experience.

7. How does this activity align with your IPDP?

8. If your School Improvement Plan has addressed science, how will this training module be an integral part of the process?

9. Were the instructions in this activity complete and easy to understand? If not, please make suggestions as to how they can be improved.

Molarity: Making Solutions for Use in Voltaic Cells
Sunshine State Standards

Middle School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.3)
- The student understands the basic principles of atomic theory. (SC.A.2.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.3)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.3)

High School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.4)
- The student understands the basic principles of atomic theory. (SC.A.2.4)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.4)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.4)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.4

Molarity: Making Solutions for use in Voltaic Cells
National Education Science Standards

Middle School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.
- Understanding about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 5-8, all students should develop an understanding of properties and changes of properties in matter

Content Standard E: Science and Technology
- As a result of activities in grades 5-8, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives
- As a result of activities in grades 5-8, all students should develop understanding of personal health.
- Science and technology in society

Content Standard G: History and Nature of Science
- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor.
- Nature of science

High School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understanding about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 9-12, all students should develop an understanding of structure of atoms.
- Structure and properties of matter
- Conservation of energy and the increase in disorder

Content Standard E: Science and Technology
- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives

Electrical Conductivity of Solutions

Project Overview:

Middle and high school teachers will earn 10 recertification points upon the completion of this activity. The project focuses on the electrical conductivity of various solutions. All of the materials you need to complete the activity are included in the kit, except for salt, sugar and distilled water. There are three components to the project.

- There is a reading component for the teacher to complete, along with a set of questions that covers the reading.
- There is a lab component for this activity that will take one class period to complete.
- There are follow-up reports that must be completed by the teacher and students.

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read pages 68-72, up to "Sample Ionic Reactions" in *Chemistry Made Simple.*
3. Prepare the materials for the Electrical Conductivity Of Solutions lab according to the lab preparation section in this packet.
4. Complete the lab yourself by following the instructions in this packet.
5. Have your students complete the lab according to the instructions.
6. Have your students complete the Student Assessment Form after their lab reports have been handed in. These forms must be submitted. They will be used to evaluate the project, but will not be a contributing factor in earning recertification points.
7. Complete the Teacher Reading Assessment Form, and the Teacher Project Assessment Form.
8. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at *mchenryr@mail.leon.leon.k12.fl.us*, or Dave Rodriguez at *rodriguezd@mail.raa.leon.k12.fl.us*

Background Information:

Electrolytes are compounds that conduct electricity in water-based solutions. Ionic compounds are electrolytes in which the electrolytes form positively and negatively charged ions in solution. Electrolytes are divided into three substances: Acids, Bases, and Salts. Not all electrolytes conduct electricity to the same degree. Nonelectrolytes

are compounds that do not conduct electric currents in water based solutions. Most molecular (covalent) compounds are nonelectrolytes. They are non electrolytes because they are nonionic, which means there are no positively and negatively charged ions in solution to conduct the electrical charges. A circuit can be created to test the conductivity of various solutions. In this activity, you will use a simple circuit with a battery and a voltmeter to compare the conductivity of several solutions. The different settings on the voltmeter will give you different numbers of significant figures.

Materials:

Voltmeter
Battery
Battery holder
Wire with clips
Beaker
Iron rods
Sugar
Salt
Tap water
Distilled water
Soft drink
Spoon

Lab Preparation:

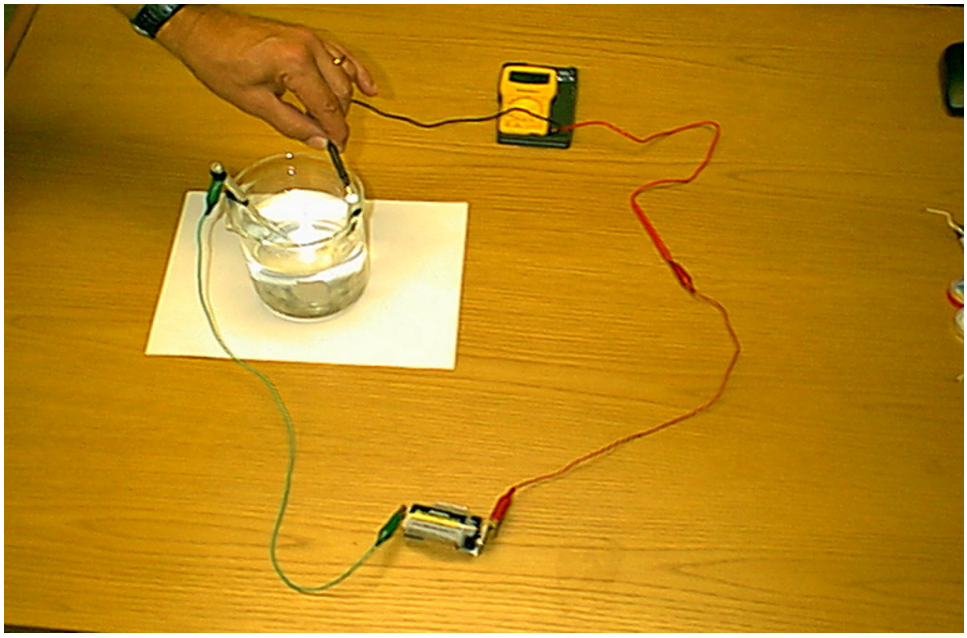
1. Place the following items at each lab station:
    - Voltmeter: Set these at the 20V or 2V setting within the DCV section of the voltmeter face.
    - Batter and battery holder
    - Wires and clips
    - Iron rods
    - Beaker
    - Spoon
    - Consumable materials: You can either set up the other materials needed (sugar, salt, distilled water, tap water, etc.) at each station, or have one of the group members responsible for measuring and collecting these supplies from a central location in the room.

Lab Instructions:

1. Fill the plastic beaker half way with distilled water.

2. Place two metal rods into the water. It is important that they do not touch each other. You may need to tape them to the sides of the beaker to keep them from touching. Any kind of tape will do.
3. Connect the battery, wires, and voltmeter as shown in the photo in the instructions. *The positive terminal of the battery must connect to the red probe of the voltmeter.*
4. Touch the black voltmeter probe to the top of the metal rod as shown in the photo.
5. Observe and record the voltage from the voltmeter.
6. Now add one spoonful of salt to the beaker and stir.
7. Repeat steps 4 and 5.
8. Empty and rinse the beaker.
9. Repeat steps 1-8 but use sugar instead of salt.
10. Have students test the conductivity of tap water

    Note: You can test a number of different substances. Students may want to compare soft drinks, milk, etc.



Electrical Conductivity Of Solutions
Student Assessment Form

1. How did this activity increase your knowledge of ionic and covalent bonding and the conduction of electricity?

2. Describe on way you can apply this knowledge to a real-life situation.

3. Explain why distilled water and tap water do not conduct electricity to the same degree.

4. Explain why there are differences in the conductivity for sugar water and salt water.

Electrical Conductivity Of Solutions
Teacher Reading Assessment Form

1. What is an electrolyte?

2. Describe two major differences between the properties of electrolytes and nonelectrolytes.

3. Why are most covalent compounds nonelectrolytes?

4. Why does tap water conduct electricity while distilled water does not?

5. Complete the following equations which show the dissociation of electrolytes into their ions:

   HCl =

   NaCl =

   $CaCl_2$ =

Electrical Conductivity Of Solutions
Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. How did your students react when they realized that pure water (distilled) and tap water do not conduct electricity the same?

3. What areas of student performance are at or above expectations?

4. Does this activity represent improvements in students work as a result of the work done and knowledge gained from this experiment?

5. How did various sub-populations of students perform? Consider factors such as gender, race, socio-economic status, etc.

6. How will your students transfer this knowledge to their everyday lives?

7. How does this activity align with your IPDP?

8. If your school improvement plan has addressed science, how will this training module be an integral part of the process?

9. Were the instructions to this activity complete and easy to understand? If they were not, please make suggestions as to how they can be improved.

Electrical Conductivity of Solutions
Sunshine State Standards

Middle School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.3)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.3)
- The student understands the interaction of matter and energy. (SC.B.2.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.3)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.3)

High School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.4)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.4)
- The student understands the interaction of matter and energy. (SC.B.2.4)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.4)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.4)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.4)

Electrical Conductivity of Solutions
National Education Science Standards

Middle School:

Content Standard A: Science as Inquiry

- As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science

- As a result of activities in grades 5-8, all students should develop an understanding of properties and changes of properties in matter.
- Transfer of energy

Content Standard E: Science and Technology

- As a result of activities in grades 5-8, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 5-8, all students should develop understanding of personal health.
- Science and technology in society

Content Standard G: History and Nature of Science

- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor.
- Nature of science
- History of science

High School:

Content Standard A: Science as Inquiry

- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science

- As a result of activities in grades 9-12, all students should develop an understanding of structure of atoms.
- Structure and properties of matter
- Interactions of energy and matter

Content Standard E: Science and Technology

- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives

Voltaic Cells: Using Chemical Reactions to Generate Electricity

Project Overview:

Middle and high school science teachers will earn 10 recertification points upon the completion of this activity. This project focuses on electrochemistry and the construction of a voltaic cell, also called a galvanic cell. All of the materials needed to complete the project are included in the box. There are three components to the project.

- There is a reading component for the teacher to complete, along with a set of questions that covers the reading.
- There is a lab component for this activity. The lab will take one class period.
  - * The instructions to make the solutions needed in this activity are in the Molarity: Making Solutions For Use In Voltaic Cells activity.
- There are follow-up reports that must be completed by the teacher and students.

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read pages 83-84 in *Chemistry Made Simple,* up to "Balancing Redox Equations", and 90-93 up to "Dry Cells."
3. Prepare the materials for the Voltaic Cell lab according to the lab preparation section in this packet.
4. Complete the lab yourself by following the instructions in this packet.
5. Have your students complete the lab according to the instructions.
6. Have your students complete the Student Assessment Form after their lab reports have been handed in. These forms must be submitted. They will be used to evaluate the project, but will not be a contributing factor in earning recertification points.
7. Complete the Teacher Reading Assessment Form, and the Teacher Project Assessment Form.
8. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at *mchenryr@mail.leon.leon.k12.fl.us*, or Dave Rodriguez at *rodriguezd@mail.raa.leon.k12.fl.us*

Materials List:

Cupric sulfate solutions (from molarity activity)
Zinc sulfate solutions (from molarity activity)
Potassium nitrate solution
Filter paper
Spot plates
Zinc strips
Copper strips
Voltmeter

Background information:

Elements can gain or lose electrons. When an atom gains or loses an electron it forms an ion. When one element loses an electron a different element has to gain an electron. Loss of Electrons is Oxidation (LEO), and the Gain of Electrons is Reduction (GER). Thus the mnemonic device "LEO the lion goes GER" will help you and students remember what is happening in each ½ reaction. When these electrons are transferred through a wire, we have electricity. A voltaic cell allows for the transfer of electrons through a wire as a result of chemical reactions. In this cell each zinc atom loses 2 electrons (oxidation) and each copper ion gains 2 electrons (reduction). The piece of zinc will diminish in size as the zinc atoms lose electrons and go into solution as ions. The copper ions in solution gain electrons and become atoms, which form on the piece of copper causing it to increase in size. The salt bridge (strip of filter paper) will allow sulfate ions to flow from the copper (II) sulfate solution where they are no longer needed to the zinc nitrate solution where the increase in zinc ions creates a demand for them.

Lab preparation:

1. Pour the sulfate solutions into the dropper bottles. The dropper bottles are marked cupric sulfate or zinc sulfate. There is one set of bottles for each lab group. The same samples and salt bridges can be used for multiple classes.
2. The potassium nitrate solution can be prepared by dissolving a small amount of solid in water. This can be done in the dropper bottle. The concentration of this solution is not critical.
3. Cut strips of filter paper about ½ cm wide and 5 cm long.

Lab Instructions:

1. Fill one of the wells of the spot plate about ¾ full with copper (II) sulfate solution. Fill another adjoining well about ¾ full with zinc sulfate solution.
2. Drop a few drops of potassium sulfate solution on to the thin strip of filter paper until it is saturated.
3. Insert a strip of copper into the copper (II) sulfate solution and a piece of zinc into the zinc sulfate solution.

4. Attach one end of the lighter colored wire to the positive post of the voltmeter and the other end of the wire to the copper strip. Attach one end of the darker colored wire to the negative post of the voltmeter and the other end of the to the zinc strip. Observe and record the reading on the voltmeter.
5. Dispose of solutions as directed by your teacher.

Safety precautions:

All three solutions, Copper (II) sulfate and zinc sulfate, and potassium sulfate are toxic. Safety glasses should be worn.
Disposal of solutions: Dilute with copious amounts of water until the solution has a pH of approximately 7. The solution can then be poured down the drain. The Material Safety Data Sheet (MSDS) for each chemical is provided.

Voltaic Cells: Using Chemical Reactions to Generate Electricity
Student Assessment Form

1. How did this lab increase your knowledge of the relationship between chemical reactions and electricity?

2. Describe one way you can apply this knowledge to a real-life situation.

3. Identify two new terms you learned during this activity.

4. Describe how a voltaic cell is created.

5. Draw and label the features of a voltaic cell.

Voltaic Cells: Using Chemical Changes to Generate Electricity
Teacher Reading Assessment Form

1. Why does a redox reaction occur?

2. How does the law of conservation of mass apply to redox reactions?

3. Explain what happens if an iron nail is put into a solution of copper sulfate. What would you be able to observe?

4. Make a drawing of a voltaic cell using aluminum and silver as the two metal electrodes (anode and cathode). Show the direction of the electron flow and calculate the total emf of the cell.

Voltaic Cells: Using Chemical Reactions to Generate Electricity
Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. How did your students react when they saw the voltmeter indicate that electricity was being produced?

3. What areas of student performance are at or above expectations?

4. Does this activity represent improvements in students work as a result of the work done and knowledge gained from this experiment?

5. How did various sub-populations of students perform? Consider factors such as gender, race, socio-economic status, etc.

6. How will your students transfer this knowledge to their everyday lives?

7. How does this activity align with your IPDP?

8. If your school improvement plan has addressed science, how will this training module be an integral part of the process?

9. Were the instructions in this activity complete and easy to understand? If not, please make suggestions as to how they can be improved.

Voltaic Cells: Using Chemical Reactions to Generate Electricity Sunshine State Standards

Middle School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.3)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.3)
- The student understands the interaction of matter and energy. (SC.B.2.3)
- The student understands the basic principles of atomic theory. (SC.A.2.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.3)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.3)

High School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.4)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.4)
- The student understands the basic principles of atomic theory. (SC.A.2.4)
- The student understands the interaction of matter and energy. (SC.B.2.4)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.4)
- The student understands that most natural events occur in comprehensible, consistent patterns. (SC.H.2.4)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.4)

Voltaic Cells: Using Chemical Reactions to Generate Electricity
National Education Science Standards

Middle School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.
- Understanding about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 5-8, all students should develop an understanding of properties and changes of properties in matter.
- Transfer of energy

Content Standard E: Science and Technology
- As a result of activities in grades 5-8, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives
- As a result of activities in grades 5-8, all students should develop understanding of personal health.
- Science and technology in society

Content Standard G: History and Nature of Science
- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor.
- Nature of science
- History of science

High School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 9-12, all students should develop an understanding of structure and properties of matter.
- Chemical reactions
- Conservation of energy and the increase in disorder

Content Standard E: Science and Technology
- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives

Lemon Battery: Using a Lemon to Create a Voltaic Cell

Project Overview:

Middle and high school teachers will earn 10 TEC points upon the completion of this activity. This activity focuses on making a voltaic cell using a lemon. This activity can be done with your class either before or after you complete the Voltaic Cell activity in this kit. With the exception of pennies, paper clips, and lemons, all of the materials needed to complete the activity are included in the box. There are components to the project.

- There is a reading component for the teacher to complete, along with a set of questions that covers the reading.
- There is a lab component for this activity. The lab will take one class period.
- There are follow-up reports that must be completed by the teacher and students.

Background Information:

The lemon battery acts as a voltaic cell. Oxidation and reduction reactions occur when the metals are placed in the lemon. Electrons are lost (oxidation) at the iron paper clip electrode. Electrons are gained (reduction) at the copper penny electrode. The electron flow, from iron to copper is channeled through the wire and voltmeter. This flow of electrons is electricity. The voltage created by this flow is less than one volt, but will be measurable on the voltmeter.

Instructions:

1. Contact your school district's staff development office for pre-approval before beginning the project.
2. Read pages 83-84 in *Chemistry Made Simple* up to "Balancing Redox Equations," and pages 90-93 up to "Dry Cells."
3. Prepare the materials for the Lemon Battery lab according to the lab preparation section in this packet.
4. Complete the lab by yourself by following the instructions in this packet.
5. Have your students complete the lab according to the instructions.
6. Have your students complete the Student Assessment Form after their lab reports have been handed in. These forms must be submitted. They will be used to evaluate the project, but will not be a contributing factor in earning recertification points.

7. Complete the Teacher Reading Assessment Form, and the Teacher Project Assessment Form.
8. Contact your school district's staff development office for instructions on where to send the forms. If you have any questions about the project, please email Rich McHenry at *mchenryr@mail.leon.leon.k12.fl.us*, or Dave Rodriguez at *rodriguezd@mail.raa.leon.k12.fl.us*

Materials Needed:

Each group of four students will need the following materials. Lemons, pennies and paper clips are not provided.

Voltmeter
Lemon
Penny
Paper clip
Small strip of zinc
Aluminum nail
Two wires with alligator clips on each end

Lab Instructions:

1. Have the students roll the lemons on a flat surface while applying pressure. This is important to soften the inside of the lemon for better results.
2. Push the penny and the paper clip into the lemon. Be sure each is inserted into the fruit of the lemon below the skin. The penny and paper clip should be on the same side of the lemon. This will make handling the wires and clips much easier.
3. Connect the red wire from the voltmeter to the penny. Connect the black wire from the voltmeter to the paper clip. Set the voltmeter to the 20V setting within the DCV portion of the voltmeter face.
4. Observe and record voltage reading.
5. Substitute a piece of zinc for the paper clip and repeat step four.
6. Substitute a piece of pure copper for the penny and repeat step four.
7. Substitute an aluminum nail for the paper clip and repeat step four.

* You may want to test the effect of different materials in place of the penny and paper clip as an extension.

Lemon Battery: Using A Lemon To Create A Voltaic Cell
Student Assessment Form

1. How did this activity increase your knowledge of the relationship between chemical reactions and electricity?

2. Describe what happens in the lemon to generate electricity.

3. Draw and label the main features of the lemon battery.

4. Describe one way you can apply this knowledge to a real-life situation.

Lemon Battery: Using A Lemon Battery To Create A Voltaic Cell
Teacher Reading Assessment Form

1. Why does a redox reaction occur?

2. How does the law of conservation of mass apply to redox reactions?

3. Explain what happens if an iron nail is put into a solution of copper sulfate. What would you be able to observe?

4. Make a drawing of a voltaic cell using aluminum and silver as the two metal electrodes (anode and cathode). Show the direction of the electron flow and calculate the total emf of the cell.

Lemon Battery: Using A Lemon To Create A Voltaic Cell
Teacher Project Assessment Form

1. Describe the learning process for your students in this activity.

2. How did your students react when they saw the lemon producing electricity?

3. What areas of student performance are at or above expectations?

4. Does this activity represent improvements in students work as a result of the work done and knowledge gained from this experiment?

5. How did various sub-populations of students perform? Consider factors such as gender, race, socio-economic status, etc.

6. How will your students transfer this knowledge to their everyday lives?

7. How does this activity align with your IPDP?

8. If your school improvement plan has addressed science, how will this training module be an integral part of the process?

9. Were the instructions in this activity complete and easy to understand? If they were not, please make suggestions as to how they can be improved.

Lemon Battery
Sunshine State Standards

Middle School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.3)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.3)
- The student understands the interaction of matter and energy. (SC.B.2.3)
- The student uses the scientific processes and habits of mind to solve problems. (SC.H.1.3)
- The student understands that science, technology, and society are interwoven and interdependent. (SC.H.3.3)

High School:

- The student understands that all matter has observable, measurable properties. (SC.A.1.4)
- The student recognizes that energy may be changed in form with varying efficiency. (SC.B.1.4)
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Lemon Battery: Using a Lemon to Create a Voltaic Cell
National Education Science Standards

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- Transfer of energy

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- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives
- As a result of activities in grades 5-8, all students should develop understanding of personal health.
- Science and technology in society

Content Standard G: History and Nature of Science
- As a result of activities in grades 5-8, all students should develop understanding of science as a human endeavor.
- Nature of science
- History of science

High School:

Content Standard A: Science as Inquiry
- As a result of activities in grades 9-12, all students should develop abilities to do scientific inquiry.
- Understandings about scientific inquiry

Content Standard B: Physical Science
- As a result of activities in grades 9-12, all students should develop an understanding of structure and properties of matter.
- Chemical reactions
- Conservation of energy and the increase in disorder

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- As a result of activities in grades 9-12, all students should develop abilities of technological design.
- Understanding about science and technology

Content Standard F: Science in Personal and Social Perspectives

- As a result of activities in grades 9-12, all students should develop understanding of personal and community health.
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor.
- Nature of scientific knowledge
- Historical perspectives