ENGR 2020: Friction Experiments and Barometers

April, 2005

Western Michigan University

Nikki Weddig, Andrew Wadel, Shelby Tomczak, and Jarred Araujo

Introduction

For this project, we chose three experiments to teach elementary level students about various topics in the scientific field. The three experiments that we chose for the students to complete are: 1) a hovercraft, 2) static electricity, and 3) a barometer.

The Hovercraft

The term "hovercraft" is actually a commercial name patented in 1955 for an air-cushion vehicle. This refers to any vehicle that travels above the surface of land or water. Air-cushion vehicles can use one of several methods to "float," but a hovercraft relies on a powerful cushion of downwardly directed air powered by fans and trapped inside a flexible skirt, greatly increasing its lift capacity. When high pressure air pushes up on the hovercraft, the air pressure pushing upward on the hovercraft perfectly balances gravity pushing downward, the hovercraft "floats" on a cushion of high-pressure air. A thrust propeller can allow a craft to move forward. The lesson plan for this project is included in Appendix A and the written assignment is available in Appendix D.

Lecture Material:

1) Force of gravity vs. Force of air pressure.

When lecturing over this material, teach the kids the different forces acting upon the hovercraft. The forces that should be taught are the force of gravity on the hovercraft, the force of the air pressure that is levitating the hovercraft, and the force of the children's bodies. Also, teach them the direction each of the forces is acting.

2) Calculate how many kids it would take to make the hovercraft not be able to float.

This is more of a mathematical type experiment where we will give them the "average weight of a child" in kg and the acceleration due to gravity in terms of 10 m/s^2 for ease of calculation. They will use the force of the air pressure, which will have to be given to them as well. Next, they will calculate how many children it will take for the hovercraft not to work. F= (average mass of a child)*number of children*10. They will then check to see if there calculation is accurate. This will allow them to improve their math skills and their understanding of forces. This will serve as the written assignment the kids will complete. We will have them do this before we do the physical part of the experiment so they can see if their calculations are correct.

3) Students should discuss what it would take to make the hovercraft move side to side and what forces they would need to overcome.

This is an exercise for the students to think of the horizontal forces on the hovercraft and what type of machine could be used in order to get the hovercraft to move from side to side. One idea would be a fan, which is often used when hovercrafts are used as a form of transportation. The force that they would need to overcome would be air. This part of the experiment will also be done before the physical portion. In asking them questions and requiring them to do calculations, we will encourage them to think more scientifically about the experiment they are about to perform.

Assembly (See Figure 1):

- PLYWOOD, 3ft or 4ft square, 3/8 in or ½ in thick (or buy a 48 in precut round tabletop).
- PLASTIC SHEET, 1ft larger than the above wood (Avoid using 1mil thickness garbage bags, instead use a heavy 10mil plastic drop cloth from a paint store, 'Visqueen' sheet, or an old plastic shower curtain)
- LEAF BLOWER (battery powered, gasoline), or use the old-style 'ShopVac' canister vacuum cleaner which has a blower outlet
- SMALL PLASTIC DISK, coffee can lid, or 6" disk 1/8 in thick plastic
- BOLT, 2 in, 1/4-20
- NUT, 1/4-20
- FENDER WASHERS (two)
- SMOOTH FLOOR (linoleum, ball court, or smooth concrete)

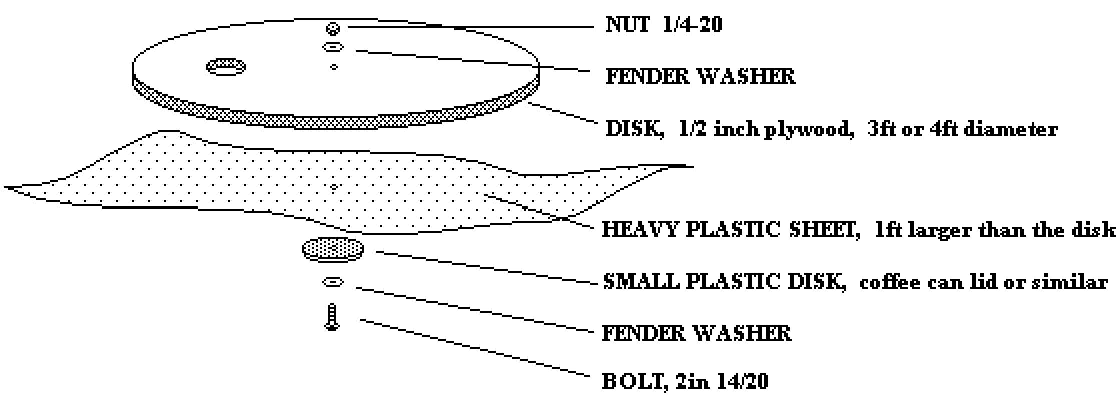

Figure 1: Assembly Diagram

Make the Wood Disk:

Cut the plywood disk to the correct size and shape. This can be square, or experiment with other shapes instead of round, but the sharp corners can hurt people. Round is best for safety. Drill a 5/16 in hole in the exact center, and make sure that the 2in bolt easily passes through it.

To avoid using a big bolt for safety reasons, follow these alternative instructions. Fasten the small plastic disk with several short wood screws. Kids sitting on the hovercraft won't get poked in the butt anymore by the big bolt in the original design. Make a hole in the plywood, which fits tightly with the end of your leaf blower or shopvac hose. This hole must be placed half way between the center of the disk and the edge, as shown below in Figure 2. It's a good idea to trace the hole in pencil on the wood (place the mouth of the leaf blower on the wood and trace around it.) It does not have to fit perfectly. Later you can seal any leaks with duct tape.

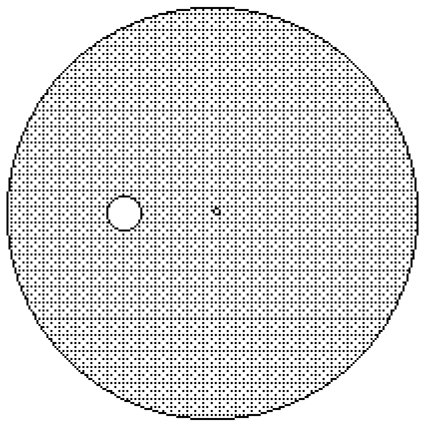

Figure 2: Hole Diagram

Next, lay the plywood disk on the center of the large plastic sheet. Fold the edges of the sheet up over the plywood, and then use the staple gun to staple it to the top of the plywood disk. Put a staple about every 4 inches. The plastic should be tight against the wood, but don't pull it too tight or the plastic will tear loose when inflated. When finished, cut off the excess plastic. Use duct tape to tape the edge of the plastic down to make it look nice.

Add the “Skirt Lifter”:

Poke a hole in the center of the coffee can lid. Attach it to the bottom of the hovercraft as shown below in Figure 3. It goes over the plastic sheet. It pins the plastic sheet firmly against the plywood. (The coffee can lid forms the "donut hole" when the leaf blower slightly inflates the plastic into a "donut" shape.)

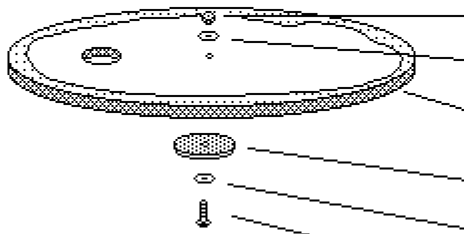

Figure 3: Skirt Lifter

Cut the Center Holes:

Use a razor knife to cut six vent holes in the plastic as shown below. They should be about 2" diameter. They must be placed within a few inches of the coffee can lid. Space them so that there is plenty of plastic between each of them. If they are too far away from the center, they will become plugged when the plastic sheet lays flat against the floor. If the plastic between the holes is too narrow, it will tear. Reinforce the thin necks of plastic between the holes using a couple of layers of duct tape. Flip the hovercraft over so the plastic sheet is on the bottom. Place it on a smooth floor. Stick the leaf blower into the hole and turn it on. The plastic on the bottom should inflate. If it does not, lift the plywood up a bit to let the air get in and inflate the skirt. The hovercraft will lift up slightly and start gliding around.

Safety:

Building this project has many safety hazards and should not be done without adult supervision. Another possibility would be to have the completed hovercraft built before class, and have the students test various weights on it. As an assignment, they could perform the necessary calculations. That is the route we have decided to take due to the complexity, time, and safety factors involved in this project. There is no negative effect with having the hovercraft constructed beforehand.

Cost:

This experiment is a little more expensive to complete, but the equipment may be used repeatedly. The total cost to build one hovercraft is approximately $71.61. The total cost to complete two is approximately $101.80. The breakdown of the expenses is displayed in Table 1.

Table 1: Hovercraft Cost Breakdown

Supplies	Cost	quantity or uses	Location
plywood	$ 19.97	2	Lowe's
plastic sheet	$ 6.98	2	Home Depot
leaf blower	$ 29.99	1	Home Depot
bolts	$ 0.20	1	www.stainless-fasteners.com
nuts	$ 6.99	100	Ace Hardware
fender washers	$ 6.31	100	Home Depot
duct tape	$ 1.17	2	Home Depot
Total Cost	**$ 71.61**	**1**	
Total Cost	**$ 101.80**	**2**	

Construction Problems:

Surprisingly few problems were encountered when constructing the hovercraft. The instructions were followed precisely and this allowed for minimal mistakes. A few construction changes needed to be made however. The directions recommend a circular shaped hovercraft and because we only had a jigsaw, we were forced to make a square with rounded edges. This was a minor setback, however. Upon testing the device, the force of the wind was so great that a few of the staples that were holding the plastic came loose. This was easily mended by adding extra staples to reinforce.

Static Electricity

Materials:

1. a hard rubber or plastic comb, or a balloon
2. spool of thread
3. small pieces of dry cereal (O-shapes, or puffed rice of wheat)

Procedure:

1. Tie a piece of the cereal to one end of a 12 inch piece of thread. Find a place to attach the other end so that the cereal does not hang close to anything else. (You can tape the thread to the edge of a table or desk)
2. Wash the comb to remove any oils and dry it well.
3. Charge the comb by running it through long, dry hair several times, or vigorously rub the comb on a wool sweater.
4. Slowly bring the comb near the cereal. It will swing to touch the comb. Hold it still until the cereal jumps away by itself.

5. Now try to touch the comb to the cereal again. It will move away as the comb approaches.
6. This project can also be done by substituting a balloon for the comb.

Explanation:

Combing your hair with the comb or rubbing the balloon with the sweater moved electrons from one object to another. The comb had a negative charge. The neutral cereal was attracted to it. When they touched, electrons slowly moved from the comb to the cereal. Now both objects had the same negative charge, and the cereal was repelled.

Pre-Experiment Information:

Everything we see is made up of tiny little parts called atoms. The atoms are made of even smaller parts called protons, neutrons and electrons. These three parts are very different from each other. One way they are different is their "charge". Protons have a positive charge, electrons have a negative charge, and neutrons have no charge (neutral).

Normally, atoms have the same number of protons and electrons. They have no charge and the atom is essentially neutral. When you rub things together, the electrons can rub from one atom and move to another. Some of the atoms will receive extra electrons and have a negative charge and some will lose electrons and have a positive charge. When charges are separated like this, it is called "static electricity".

If two things have different charges they are attracted and pull towards each other. If they have the same charge, they repel or push away from each other.

Think about when you walk across the carpet and then touch a doorknob and you get shocked. Or when you take off your hat in the winter and your hair sticks straight up. Electrons have moved from your hair to your hat and because the charge of your hair is all the same positive charge; they try to move away from each other and the furthest they can get is straight up. When you get shocked what happens is you have picked up extra electrons from walking across the rug and when you touch the doorknob the electrons jump from you to the door. Appendix B contains a lesson plan to complete this experiment.

Cost:

The total cost for approximately 25 students to complete this experiment is $6.98. This is very inexpensive for each student to complete. The breakdown of cost is displayed Table 2.

Table 2: Static Electricity Cost Breakdown

Supplies	quantity	Cost
Box of cereal	1	3.99
Spool of thread	2	1.00
25 Balloons	1	1.99
		Uses
Total Cost	6.98	20+

Assignment:

For this experiment it is not necessary to have a written assignment. Instead it is encouraged simply to ask questions to start discussion. Questions such as what is static electricity, what do you think we are going to do with these materials, and explanation of the structure of an atom is suggested. The written portion of the assignment can be found in Appendix E.

Construction Problems:

This experiment requires absolutely no construction. Because of this, there were no construction problems to encounter.

The Barometer

Build it:

First, clean an empty glass jar. Next, take one balloon of any color and cut off the top half. Then, take this top half of the balloon and stretch it over the top of the jar. Once this is complete, put a rubber band along the edge of the cover. Make sure that the rubber band is tight around the lid of the jar. There should be a drum like surface on the top of the jar. Next, flatten one corner of the straw (about an inch long). Flatten the end of the straw and make a one inch cut on the straw diagonally along the flattened portion and color the tip with a marker. Apply a strip of rubber cement glue to the drum like surface of the balloon and glue the unflattened portion of the straw to this. Hold the straw in place until the rubber cement dries. Make sure several inches (at least 5) of the straw sticks out over the edge of the bottle.

Assignment:

Creating the barometer is only the start of this experiment. To set the actual experiment up, minor preparation is necessary. First, take a piece of graph paper and divide it into seven equal columns. Label the columns Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. The purpose of this chart is to have a comparison for the barometric pressure for each day of the week. This graph paper can then be taped to the wall. Place the barometer next to the wall on a table or desk with the point of the straw pointing the correct day of the week. Each day the students should look at the position of the straw's point in the column and place a mark on the graph paper at the height of the straw for that day. After the measurement is taken, move the barometer to the next column on the graph paper and mark the location of the straw again the next day. Only one measurement is needed for a day, although multiple measurements spaced a few hours apart would do no harm. At the end of the week, replace the old paper with a new labeled graph sheet. Continue this for the next two weeks and discuss the results in class. This recording chart of the barometric pressure would be the written assignment required before the experiment begins. After the experiment has been built and created, the follow up would be to measure the position of the straw on a daily basis for a week or so and discuss the changes. It would also be possible to have the students do another written assignment after the week's time and predict why they think the readings changed.

How it works:

A barometer works using the surrounding weight of the air to determine whether a storm system or sunny weather is moving into an area. When a high pressure system moves into an area the weight of the air will change. The air will press down on the balloon and the pointer will rise. This is due to the fact that the balloon creates an air tight environment. The air inside the jar will remain the same regardless of the pressure of the air around the bottle. Thus, when a low pressure system enters the area, the air inside the jar will be heavier then the air on the outside. As a result of this, the pointer will point down.

Importance:

This experiment has two specific benefits. First, it gives students an idea of what some weather forecasts mean concerning low (or high) pressure systems moving into an area. Another benefit is that it allows students to grasp at the concept that air has substance, it has weight. After all, what else could cause the balloon to rise and plummet? Details for this lesson plan can be found in Appendix C.

Remember:

The two important concepts that students should take away is a hands-on experience of how weather works and what is used to predict whether tomorrow will be a dry day or a stormy day. In this, they will gain a better understanding of meteorology and how the weather is determined.

Cost:

The total cost for approximately 25 students to complete this experiment is $61.30. The breakdown of the materials, quantity, and cost are displayed in Table 3.

Table 3: Barometer Cost Breakdown

Supplies			**Size**	**Price**
Medium glass jar with small mouth			50 oz	$1.99
			46 oz	$2.49
			25 oz	$1.39
			24 oz	$1.59
Balloons			15/pkg	$1.99
			25/pkg	$1.99
			100/pkg	$4.99
			144/pkg	$5.99
Drinking straw (regular)			250/pkg	$1.99
			100/pkg	$1.09
4 pieces of graph paper			20/pkg	$1.99
Rubber cement				$1.49
Red marker with narrow point				
various colors perm marker (red,black,blue)			3/pkg	$1.99
permapak (red,black,blue)			3/pkg	$5.99
washable markers (various colors)				$3.99
		Uses		
Total Cost	**$ 61.30**	**25+**		

Construction Problems:

This experiment also had very few construction issues. Although construction is necessary to complete the experiment, it is fairly simple. The only issue we had was acquiring the materials, specifically the jars for the barometer. Beyond that, construction went smoothly for this project.

MI-CLiMB

Another important aspect of all of these experiments is their relevance to the Michigan Curriculum. MI-CLiMB clarifies the core area benchmarks and explains learning objectives and individual disciplines. It is broken down by education level into Elementary School, Middle School and High School. The fourth grade students we will be working with will fall into the Middle School category due to the fact that they are halfway through their fourth grade year.

The hovercraft satisfies Benchmarks 1 and 3, which are weight and electricity under Strand 4, Content Standard 1. Electricity is satisfied because of the use of the leaf blower and weight and gravity are explained through how the hovercraft works. It also covers Strand IV, Content Standard 3, Benchmarks 2 and 3, which include forces, pushing and pulling, gravity, speed, gravitational pull, and mass versus weight. All of these concepts were covered in the lecture material for the hovercraft.

The barometer material satisfies Strand I, Content Standard 1, Benchmarks 6 and 4. These are increases and decreases, data logging, and pressure units. It also teaches Strand V, Content Standard 3, Benchmark 1, which covers the concepts of weather and temperature. In our barometer experiment we also covered weather patterns, specifically warm and cold fronts. These are accounted for in Strand V, Content Standard 3, Benchmark 1.

The static electricity experiment satisfies Strand IV, Content Standard 1, Benchmark 3, which is static electricity, atoms, molecules, and energy. The lecture materials and questions associated with this experiment also draw from Strand IV, Content Standard 3, Benchmark 3 which focuses on positive and negative charges, electrical charging by rubbing, atoms, electrons, protons, neutrons, and electrical attraction and repulsion. All three of these contribute to the benchmark "Constructing New Scientific Knowledge" where they generate scientific questions about the world based on observation. The experiments will also teach how the common themes of science, math and technology apply in real world contexts. Electricity, weather and hovercrafts are all real world happenings.

Results from Classroom Testing

The classroom testing of our experiments made it possible to gauge the success of our efforts. In many cases, it is difficult to execute experiments exactly as they are planned on paper. To avoid any huge mistakes, we had another service learning project group test our experiments first before we brought them to the classroom. There was a minor preparation incident when we first arrived at the school because we didn't have all of the applesauce jars empty to make the barometers. This was quickly rectified though, and the experiment went smoothly.

The students highly favored the hovercraft experiment and wanted to spend most of the time doing that. It was beneficial that we had them complete their worksheets before they did the experiment, because they got extremely excited and had difficulty focusing during the experiment. Surprisingly, they were well aware of the concepts of force, gravity and mass.

The static electricity experiment also went well. The students liked that they were allowed the keep the balloons, so, as long as the teacher approves, this is recommended. The worksheet worked well to generate thought and ideas and the students enjoyed this experiment. The only issue here was that they constantly asked if they could eat the Cheerios.

For the barometer experiment we moved our group back into the classroom. This proved to be trying because the students in our group all wanted to see what the other group was doing. It would have been better if we had remained out in the hallway. To keep their attention we came up with some incentive. For every question they answered about the weather, they were able to choose a sticker to decorate their barometer. This refocused their attention on what we were doing and also helped us to teach some essential concepts. From this experiment the students enjoyed that they were able to keep their barometer. It seems to be a trend with children at this age; they want everything to be their own.

As a whole, the classroom testing was a success. We were able to observe the experiments in a real classroom setting and see that our objectives were met. It was rewarding to see that the students enjoyed what we have been planning for the past few months and actually learned something in the process.

Conclusion

These three experiments can teach students about important topics in science. The hovercraft teaches physical science, the static electricity experiment teaches about electricity, and finally, the barometer teaches about weather.

We recommend that each of these experiments should be completed in small groups with adult supervision. All lectures should be given just prior to the experiments.

Appendix A:
Hovercraft Lesson Plan

Hovercraft Lesson Plan

Grade Level: 4 and up

Subjects: Physical science/motion of objects

Duration: 2 hours

Description: Students will listen to lecture and watch some demonstrations. Then, students will conduct an experiment using several pre-constructed hovercraft. Following the experiment, students will be required to solve some math problems and answer some questions regarding what happened.

Goals: Students will work in groups to explore the motion of objects and be able to describe the motion of objects, explains the forces necessary for movement, and relate motion to unbalanced forces.

Objective: Students will be able to (all MICLIMB):

1) describe the motion of common objects in terms of speed and direction,
2) be able to explain how forces are needed to move an object,
3) qualitatively describe motion in two dimensions, and
4) relate motion to unbalanced forces.

Materials: (For experiment) several completed hovercraft, some leaf blowers, paper, pencils, calculators, and a scale (optional)

(For demonstrations) a tennis ball, string, and a brick (or large rock)

Vocabulary:

Gravity: a force that acts at a distance and draws bodies of matter towards each other

Force: a push or pull that causes an object at rest to move

Acceleration: the increase in velocity over a period of time

Velocity: measure of the speed in a given direction

Mass: the amount of material in an object, does not change with movement

Weight: the measure of the pull of gravity on an object

Speed: how fast an object is moving in regards to the object

Hovercraft: a vehicle that was patented in the 1950's that can move over any flat surface, it moves on a cushion of air

<u>Procedure</u>:

Intro: Begin with a demonstration: dropping the tennis ball. Drop the tennis ball and then ask students to explain what happened. Give them a few minutes to explain what happened. If no one mentions or brings up gravity then explain this term and how it pulls everything on earth down at a rate of 9.8 m/s^2. Next, you should do the next demonstration, involving the brick or large rock. Tie a string around the brick/rock and then have a student volunteer come up and move it using the string. The student should have to exert some force to move. After having a student (or students) tug on the rock/brick, and then ask the class why the brick/rock is harder to move compared to the tennis ball (you may also include the tennis ball in the second demonstration). Listen to the student responses and then discuss what mass, weight, and force are and the differences between them to the class. Finally, put up the force equation (force = mass x rate of acceleration) and explain what each part of the equation means.

CAUTION: Students may not understand some of these terms; feel free to substitute simpler language in for certain terms.

Lesson focus/setting up the experiment: To begin this part of the experiment it might be helpful to ask the class what is a hovercraft? It your question is answered with blank stares then here is some information that can help you out:

The term “hovercraft” is actually a commercial name patented in 1955 for an air-cushion vehicle. This refers to any vehicle that can travel above land and/or water. Air-cushion vehicles can use one several methods to “float,” but a hovercraft mainly relies on powerful cushion of air, directed downward by powerful fans, to levitate. The downward force of air is trapped in a flexible skirt that greatly increases its life capacity. When high pressure air pushes up on the hovercraft, it perfectly balances the pull of gravity from the earth. Thus, the hovercraft levitates over the surface. Hovercraft move via a propeller that can allow movement in any direction (something you might want to remember during the experiment).

Here is some specific material that you could focus on when explaining the experiment:

1) Force of gravity vs. force of air pressure – When lecturing over this material; teach students the differences between the force of gravity acting on the hovercraft and the force of the air pressure, exerted by the leaf blower, which is causing the hovercraft to levitate. A drawing on the board showing the direction that gravity is pulling on the hovercraft (down), the direction of force of air that is levitating the hovercraft (up), and the direction of the weight of the children when they get on the hovercraft (down) might be helpful.
2) Calculate how many kids it would take to make the hovercraft not be able to float over the ground – this is the mathematical aspect of the experiment where an average for the weight for the children will have to be used (if you wish, you might want to weigh several children in class and then average their results) in kg and the acceleration due to the gravity in terms of 10 m/s^2 (round to make calculations easier). They will use the force of the air pressure, which will have to be given to them as well. Next, they will calculate how many children it will take for the hovercraft not to work. The equation used for this experiment is: F=

(average mass of a child) x (number of children) x 10. They will check to see if their calculation is accurate during the experiment.

3) You could also perpetuate a conversation with the class that would discuss what it would take to make the hovercraft move side to side and what forces would have to be overcome in this degree (i.e. cause acceleration).

Evaluating the data: Collect the math portion of the experiment that was done by the students. Then, have the students write a short paragraph explaining what happened in the experiment, what they learned, what they didn't understand, and any questions that they might have. The next day, you should discuss the experiment with the students and address any questions they might have.

Assessment: This is an exercise for the students that will enable them to think about the horizontal forces on the hovercraft and what type of machine that could be used to move the hovercraft. In addition, this experiment will allow children to understand the forces of motion that we see in everyday life.

Suggested Internet Sites (References):

http://www.school-for-champions.com/science.htm

http://www.npl.co.uk/mass/faqs/massweight.html

Appendix B:
Static Electricity Lesson Plan

Static Electricity Lesson Plan

Grade Level: 4 and up

Subjects: Physical science/electricity
Forces of attraction

Duration: 45 minutes

Description: Students may listen to a short lecture that will detail static electricity. This lecture will discuss atomic level components, but will not go into extreme detail. In addition to static electricity, this might be a good opportunity to bring up electricity and possibly forms of energy.

Goals: Students will work individually to explore the world of static electricity. Using this experiment students will be confronted with the problem of what happened, which is what they will have to solve.

Objectives: It is hoped that students will be able to:

1) explain what static electricity is,
2) briefly explain how electricity is formed, and
3) be able to explain forces of attraction (MICLIMB).

Materials: Balloons (enough for each person)
12 in. piece of thread (one for each student)
Small pieces of dry cereal (O-shapes, or puffed rice of wheat)

Vocabulary:
Atoms: they are the basic building block of all matter

Neutrons: located in the nucleus of an atom and have no charge

Protons: located in the nucleus of an atom and have a positive charge

Electrons: located orbiting outside the nucleus and have a negative charge

Electricity: the movement of electrons between atoms

Static Electricity: occurs when there is no clear flow of electrons (i.e. wires to follow) and there is a buildup of electrons on the surface of a material, usually created by rubbing two or more materials together

Safety Hazard: Balloons may burst, caution should be exercised.

Procedure:

Intro: Ask students what keeps the lights on in the classroom. After you hear a response such as electricity then do a quick lecture on atoms (i.e. what they are, what they composed of, how do they relate to us). After discussing that then go onto talk about electricity, specifically how electricity is the movement of electrons from one place to another. This will set up the next part of the lecture: static electricity. Once you introduce static electricity, talk about what it is then introduce the experiment.

Lesson Focus: The focus of this lesson will be static electricity, but don't be afraid be thorough in extra things. Expect students not to fully grasp atoms and what they are made of, etc. This is a difficult concept for them. Be patient and work through their misunderstanding. You might want to spend the first day in lecture and then do the experiment the next day.

The following is something that you might want to consider using in you lecture:

Everything we see is made up of tiny little parts called atoms. The ancient Greeks viewed atoms as the smallest part of matter, one that no longer be divided into smaller pieces. However, we have since discovered otherwise. Atoms consist of smaller particles such as protons, electrons, and neutrons. These three parts of an atom differ in their charges and slightly differ in their location in the atom. Protons have a positive charge and are found in the nucleus of an atom, neutrons have no charge and with protons form the nucleus of any atom. Electrons have a negative charge and orbit outside the nucleus.

Normally, atoms have the same number of protons and electrons (there are special circumstances but don't go into detail unless directly asked by a student). They have no charge and thus the atom is essentially neutral. When you rub things together, the electrons can rub from one atom to another. Some of the atoms will receive extra electrons and have a negative charge, while other electrons will end up with a positive charge. When charges are separated like this, it is called static electricity. (Here you might want to bring a real life scenario such as lightning.)

If two things have different charges they are attracted to each other. If they have the same charge, then they repel each other. (Introduce the phrase, "likes repel, opposites attract."

Here are some examples of static electricity that students might have encountered:

1) walking across a carpet and then getting shocked when you touch a doorknob,
2) when you take off your hat in the winter and your hair stands straight up, and
3) thunder and lightning.

In each of these examples, the "shock" was the transfer of electrons from one place to another. When you walked across the rug, you picked up extra electrons and they jumped from you when you touched something.

The Experiment:

1. Tie a piece of the cereal to one end of a 12 inch piece of thread. Find a place to attach the other end so that the cereal does not hang close to anything else. (You can tape the thread to the edge of a table or desk)
2. Charge the balloon by vigorously rubbing it on your hair or a wool sweater.
3. Slowly bring the balloon near the cereal. It will swing to touch the balloon. Hold it still until the cereal jumps away by itself.
4. Now try to touch the balloon to the cereal again. It will move away as the balloon approaches.

How it works: When the balloon is charged, electrons move from the sweater or hair to the balloon. The balloon then has a negative charge. The neutral cereal was attracted to it. When they touched, electrons slowly moved from the balloon to the cereal. Now both objects had the same negative charge, and the cereal was repelled.

Evaluating the data: Have students answer the following questions:

1) What happened when the balloon touched the cereal? Before it was "charged" and after it was charged?
2) What is static electricity? How is it formed?
3) Was the balloon attracted to the cereal or repelled by it?
4) What part of the atom moved between the cereal and the balloon?
5) Was this experiment helpful in explaining static electricity? Why? (feedback for us and the teacher)

<u>Assessment</u>: Students will walk away from this experiment having an understanding of what static electricity is all about, they should be able to at least understand how electricity forms, and they should have an understanding of the forces of attraction.

Suggested Internet Websites (References):

http://education.jlab.org/atomtour/

http://www.energyquest.ca.gov/story/chapter02.html

http://www.school-for-champions.com/science/static.htm

Appendix C:
Barometer Lesson Plan

Barometer lesson plan

Grade Level: 3 and up

Subjects: Meteorology/ earth science
Atmosphere and weather

Description: Students will listen to a short lecture detailing various aspects of weather (i.e. air masses). Then, students will divide into groups to build a barometer. Over the course of a week students will observe the movement of the needle on the barometer and note these movements on a piece of graph paper. After a week, students will evaluate their data with what actually happened.

Goals: Students will work in teams to accomplish the experiment, and then explain what happened. They will have to draw on knowledge of weather to explain it.

Objectives: It is hoped that students will be able to:

1) explain patterns of changing weather and how they are measured (MICLIMB)
2) be able to grasp what barometric pressure is,
3) understand the concept that air has weight, and
4) have a brief understanding of what meteorology is.

Materials: medium-sized glass jar (one per group)
Balloons (one per group)
Drinking straw (one per group)
At least two pieces of graph paper per group
One bottle of rubber cement per group
Markers (red preferred but optional)

Vocabulary (feel free to elaborate on):
High pressure system: usually associated with fair, sunny weather; wind direction is clockwise, helps move air masses

Low pressure system: usually associated with stormy weather; wind direction is counterclockwise, helps to move air masses

Front: the leading edge of an air mass, the weather behind the front is always different; fronts can be either cold or warm, are connected to a pressure system, and help generate precipitation

Cold front: transition zone between a cold air mass and a warm air mass

Warm front: transition zone between a warm air mass and a cold air mass

Air mass: a large body of air that has a similar moisture content and temperature

Rain: generally come with warm fronts, (may come with cold fronts depending to the season) consist of falling drops of water

Fog: essentially a low level cloud, makes travel dangerous, may form due to temperature difference between the ground and the air

Snow: generally comes with cold fronts (may come with warm fronts depending on the season) consists of falling pieces of ice crystals

Barometer: a weather instrument used to measure the weight of the air in a given area

<u>Safety Hazards</u>: GLASS IS FRAGILE AND MAY BREAK. DO NOT INHALE THE RUBBER CEMENT FUMES.

<u>Procedure</u>:

Intro: Have students look outside and look at the sky. Ask them what's going on? (I recommend that if it is a nice day, take the class outside) Then ask the class if they know what the weather will be like tomorrow (look a response such as that the news said so, or the weatherman/woman predicted, or any reference to something someone said). Then tell the class that for a week or two, they get to take on the role of the weatherperson.

Lesson Focus: Introduce the barometer and explain to your students that barometers are a tool used by meteorologists to forecast the weather. I highly recommend that you bring out a pre-constructed version of the barometer and inform students that this is a homemade barometer. Explain that by using this instrument that they can make predictions about the next day's weather. From here, you should go into a lecture that will discuss air masses, warm/cold fronts, high/low pressure systems (place emphasis here since this will directly relate to the experiment), and the various forms of precipitation. Encourage note taking during the lecture.

The Experiment: Once you feel you have explained the above terms well enough, then you can go onto the experiment. For this experiment, divide the students into groups and then build the model according to the following directions:

To build the barometer;

1) Take the glass jar, clean it and make sure it is empty.
2) Take one balloon of any color and cut the top half off.
3) Take the top half of the balloon and stretch it over the top of the jar.
4) Once this is done, place a rubber band along the edge of the cover. Make sure the rubberband is tight around the lid of the jar. If you have done it correctly if you have a drum like surface on the top of the jar.
5) Take the straw, flatten one end of the straw (about an inch long portion). Cut the straw diagonally along the flattened portion and color the tip with a marker.
6) Apply a strip of rubber cement glue to the drum like surface of the balloon.
7) Glue the unflattened portion of the straw to the swab of rubber cement. Hold

the straw in place until the rubber cement dries. Make sure several inches (at least 5) of the straw sticks out from the bottle.

How it works: A barometer works using the surrounding weight of the air to determine whether a storm system or sunny weather is moving into an area. This barometer is no exception. When a high pressure system moves into an area the weight of the air will change. The air will press down on the balloon and the pointer will rise. This is due to the fact that the balloon creates an air tight environment. The air inside the jar will remain the same regardless of the pressure of the air around the bottle. Thus, when a low pressure system enters the area, the air inside the jar will be heavier then the air on the outside. As a result of this, the pointer will point down.

Recommendation: Have the piece of graph paper divided into the 5 days increments if time is short.

Setting up the experiment: Before students have built their barometers, feel free to let them decorate the glass jars if time allows. Creating the barometer is only the start of this experiment. To set the actual experiment up, minor preparation is necessary. First, take a piece of graph paper and divide it into seven equal columns. Label the columns Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. The purpose of this chart is to have a comparison for the barometric pressure for each day of the week. This graph paper can then be taped to the wall. Place the barometer next to the wall on a table or desk with the point of the straw pointing the correct day of the week. Each day the students should look at the position of the straw's point in the column and place a mark on the graph paper at the height of the straw for that day. After the measurement is taken, move the barometer to the next column on the graph paper and mark the location of the straw again the next day. Only one measurement is needed for a day, although multiple measurements spaced a few hours apart would do no harm. At the end of the week, replace the old paper with a new labeled graph sheet. Continue this for the next two weeks.

Evaluating the data: Have students connect the dots on the pieces of graph paper, so the day to day changes can be seen easily. (It might be wise to have a brief refresher of the weather lecture with special emphasis on high/low pressure systems.) Then have students write a paragraph or two explaining what happened each day in regard to the position of the needle and the weather that they observed the next day.

<u>Assessment</u>:   The four important concepts that students should take away is:

1) a hands-on experience of how weather works and what is used to predict whether tomorrow will be a good day or a stormy day,
2) a way to grasp at the concept that air has weight and not just something that we move through effortlessly, and
3) a brief understanding of what meteorology is.

Suggested Internet Sites (References):

http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/af/home.rxml

http://www.wxdude.com/parents.html

Appendix D:
Hovercraft Worksheet

Name________________________________ **Date:_______**

The Hovercraft Experiment

1) **What is the force of gravity and in what direction does gravity act?**

2) **What is air pressure and in what direction does air pressure act?**

3) **In what direction does the force of you standing on the hovercraft act?**

4) **If the force of the air pressure is 100 N and your friends weigh 20 kg each, how many of your friends would it take for the hovercraft not to float?**

1000=10 x 20 x friends friends=1000/(10 x 20)

5) **How would you make the hovercraft move side to side or forward or backward?**

Appendix E:
Static Electricity Worksheet

Name:______________
Date:______________

Static Electricity

Obtain the following from your teacher:

- One Balloon
- One 12 in. piece of thread
- One o-shaped piece of cereal

1. Tie a piece of the cereal to one end of a 12 inch piece of thread. Find a place to attach the other end so that the cereal does not hang close to anything else. (You can tape the thread to the edge of a table or desk)

2. Charge the balloon by rubbing it on your hair several times, or vigorously rub the balloon on a wool sweater.

3. Slowly bring the balloon near the cereal and watch carefully.

What happens?

4. Now try to touch the balloon to the cereal again.

Does the same thing happen?

5. Why do you think this happens?

Appendix F:
Barometer Worksheet

Student Experiment: The Barometer

Name:__________________________ Date:_______

Barometers are a type of weather instrument that meteorologists can use to help forecast the weather. For this experiment, you will build a barometer, take measurements with the aid of the graph paper and then using this information, try to forecast the weather for the next day.

Obtain the following from your teacher:

- One medium-sized glass jar
- One balloon
- One drinking straw
- Two pieces of graph paper
- One bottle of rubber cement
- A marker of your choice

Instructions:

1) Take the glass jar, clean it and make sure it is empty.
2) Take one balloon of any color and cut off the top half.
3) Take the top half of the balloon and stretch it over the top of the jar.
4) Once this is done, place a rubber band along the edge of the cover. Make sure the rubber band is tight. You have done it correctly if you have a drum like surface on the top of the jar.
5) Take the straw; flatten one corner of the straw (about an inch long portion). Cut the straw diagonally along the flattened portion and color the tip with a marker.
6) Apply a strip of rubber cement glue to the drum like surface of the balloon.
7) Glue the unflattened portion of the straw to the swab of rubber cement. Hold the straw in place until the rubber cement dries. Make sure several inches (at least 5) of the straw sticks out from the bottle opening.

Questions:

1) Write a paragraph or two explaining what happened each day in regard to the position of the needle and the weather that you observed the next day.

Here are some questions that you might find helpful when you are writing the paragraph(s):

What happened over the course of the experiment?
What caused the needle to drop and rise?
Where any of your predictions about the weather correct?