

April 1, 2011

**MAINE SCHOOL SCIENCE VOLUNTEERS
LIST AND BRIEF DESCRIPTION OF MODULES DEVELOPED
FOR AFTER SCHOOL SCIENCE CLUBS**

The following modules have been developed for use in after-school science clubs and similar after school activities. Most require about 90 minutes. Additional modules on other subjects can be developed on request.

1. ADHESIVES

To make a successful glue bond, an adhesive must wet the surfaces to be bonded and it must be strong enough to hold them together. This normally involves spreading a liquid adhesive over the surfaces and then letting it harden by drying, by cooling, or by chemical reaction. We will look at each type of hardening with a water-based wood glue, a hot melt, and a two-component epoxy. Each adhesive will be used to glue together a wood fixture and later these will be strung together in a chain and pulled apart to see which is the strongest. Each adhesive will also be used to glue together strips of paper and aluminum foil. Students will look at how quickly and firmly the paper and foil bonds form in order to predict which will produce the strongest and weakest wood fixtures.

For students 5th grade and above. Requires a minimum of 90 minutes

2. BEHAVIOR OF GASSES

The objective is to explore one of the simple Gas Law relationships, that between temperature and volume. The students use balloons inflated with air. The circumference of the balloon is measured at room temperature, at ice water temperature and at about 45° C. The measurement is made with waterproof nylon twine and a meter stick. The students use the relationship between circumference and volume of a sphere to calculate the gas volume and then plot the results on graph paper.

For students of 5th grade and above. Requires 90 minutes.

3. BRIDGES (WHY THEY ARE STRONGER THAN THE MATERIALS THEY ARE BUILT FROM ?)

Almost everyone has thrown a plank across from bank to bank to get over a small stream. Such a simple bridge will not carry much weight without sagging and finally breaking. When the same amount of lumber is built into a simple truss structure, it will carry much more weight safely and sag much less. We will try to demonstrate how this is possible. The students will build two simple bridges from soda straws held together with hot glue. The first bridge is a simple slab which will span the space between two stacks of books. The second bridge is a truss structure built from the same materials. The load carrying capacity of both structures will be tested by loading each with a stack of pennies placed at the center of the span until the structure fails.

For students of 6th grade and above. Requires a minimum of 90 minutes.

4. BUILDING A SMALL ELECTRIC MOTOR

The magnetic field surrounding a current-carrying conductor will be demonstrated using a large wire and a compass. Then the force on a current carrying conductor in a magnetic field will be demonstrated using a simple apparatus. After a brief review of the theory students will divide into groups to build a simple DC motor which usually runs well and embodies the principals discussed in the theory.

For students of 7th grade and above. Requires a minimum of 90 minutes.

5. DENSITY AND BUOYANCY

The objective is to connect the density of solids, liquids and gases to their molecular constituents. Students observe the behaviors of a variety of liquids (water, salad oil, rubbing alcohol, etc.) and solids (candles, rubber balls, Styrofoam balls, etc.) with special reference to the relationship of ice and water. Water displacement is used to determine the density of irregularly shaped objects. Buoyancy is explored by the construction of aluminum foil boats.

For students of 5th grade and above. Requires a minimum of 90 minutes.

6. DNA EXTRACTION FROM WHEAT GERM

DNA is a long, stringy biological molecule that can readily be extracted from cells like those of wheat germ using simple household items such as dish detergent and rubbing alcohol. Before beginning the experiment, DNA is introduced, its structure is described, as is a bit of the history of its discovery in the 1950s. Then, in a series of seven steps, the students will prepare their wheat germ samples and ultimately collect clumps of tangled DNA molecules that are easily visible to the naked eye. We finish by discussing what happened at each of the seven steps of our experiment that allowed us to extract the DNA from the cells and examine real-life applications of the science of DNA extraction.

For students of 5th grade and above. Requires 90 minutes.

7. LIGHT & COLOR

As a preface to the demonstrations the theory of light as a part of the electromagnetic spectrum will be introduced. The wave and particle properties of light will be explained. Simple ray tracing will be explained. Students will then construct a simple pin-hole camera. The camera will be converted into a simple lens imaging camera. The formation of an image by a convex lens will be explained. The concept of colors being due to various wavelengths of light will be explained as will be the concept of tri-color stimulus. The generation of colors by combining light of various pure colors will be demonstrated with tri-color flashlights. The separation of light into component colors will be demonstrated with both prisms and gratings. A simple grating spectrograph that the students can build themselves (at home) will be presented.

This module is for students of 7th grade and above. Requires a minimum 90 minutes.

8. MEASUREMENTS

We will introduce the parameters that will be measured: (length & mass) and discuss why even honest people don't always agree on size and mass (weight for this program). Students will make multiple measurements on small objects using various measuring devices. The results will be plotted on distribution curves and the shape of the distribution will be noted. The concept of averaging to improve the measurement will be demonstrated. Student groups will make repetitive measurement of the height of one student in both the standing and horizontal positions. The use of simple statistical techniques to draw conclusions from the data will be shown. If time permits, some precision measurement devices will be exhibited.

This module was developed for students of 6th grade and above. Requires a minimum of 90 minutes.

9. HOW BATTERIES WORK

The objective is to illustrate how a particular type of chemical reaction, the oxidation-reduction reaction, forms the basis of batteries by releasing electrons that can move into an external circuit. The students carry out a simple oxidation-reduction reaction with an aluminum/silver couple, observe the results and discuss how this does or does not form a battery. They then go on to prepare a battery with a different metal pair, measure the voltage produced and demonstrate the battery's ability to light a small LED.

Suitable for students of 7th grade and above. Requires every second of 50 minutes.

10. EXPLORING THE BEHAVIOR OF FLUIDS

The objectives are: (1) to identify and explore some behaviors of fluids and to relate them to the structure of molecules in the fluid and (2) to react two liquids to form a polymer (glue) and observe its anomalous fluid-like properties. The pourability, shapelessness and cutability of water are compared to that behavior of cardboard and modeling clay. The polymer is made of Elmer's Glue and liquid starch and its behavior is compared to that of water, cardboard and modeling clay.

For students of 5th grade and above. Requires a minimum of 90 minutes.

11. ROCKETS

This module uses rockets to demonstrate Newton's Laws of Motion and interest students in rocketry and NASA. It can be adjusted to one or three sessions. Stomp, bottle rockets, and/or water bottle rockets are used out of doors. Balloon rocket races are used for single sessions indoors.

This module can be adapted to elementary or junior high students.

12. SEPARATIONS (simple physical and chromatographic)

The objective is to illustrate the utility of separations to studying a physical system. Students begin with a plastic bag filled with a mixture of different kinds of beans. They separate the different beans manually and characterize each group in as many ways as time and equipment permit: size, shape, color, weight, etc. Following this, they carry out a separation that can not be done manually, separating the liquid colors in marker pens using paper chromatography. Comparison is made of different solvents and different brands of marker pens. The importance of the polarity of the solvents to the end result, as well as the mixtures of some colors to form

Suitable for students of 5th grade and above. Requires 90 minutes.

13. SIMPLE CHEMICAL REACTIONS - PENNY CLEANING RACE

The objective is to show chemical reactions using simple readily available reactants and to explore how the reactants influence the reaction rate. Multiple measurements with each reaction system allow students to learn about averages and the variability of data. Using discolored pennies and restoring them to a bright shiny condition in the course of the reaction provides a convenient endpoint for a time of reaction measurement. Comparisons are made of the rates (hence races) of reaction of the pennies with cola, vinegar and lemon juice, all weak acids.

For students of 5th grade and above. Requires 90 minutes.

14. SOUND & WAVES

The general nature of waves will be introduced along with the defining characteristics: media, mechanism, velocity of propagation, and wavelength or frequency. Several well known examples of waves will be discussed in terms of the defining characteristics. The peculiar characteristics of electromagnetic waves will be discussed.

The remainder of the time will be devoted to sound waves with examples on musical instruments including but not limited to: home made one-string violin, tin can telephone, whistles, bells, voices, and whatever instruments the students bring to the session.

The characteristic sound of various frequencies in the sound spectrum will be demonstrated using a signal generator. The concept of waveform determining the character of sound will be demonstrated using a storage scope which allows the students to see the waveform of various sounds including those of musical instruments and voices.

Designed for students of 7th grade and above. Requires a minimum of 90 minutes. Request students to bring examples of instrument they can play (even a little bit).

15. DATA ANALYSIS / STATISTICS USING BAGS OF M&Ms OR COLORED BLOCKS

The objective of this exercise is to introduce students to the use of statistics and to learn something about averages, graphs, data, and sampling techniques. Each student or team is given a sample (M&Ms or colored blocks). Have them guess the number of items in the sample without counting. After they estimate the sample size, have them count their sample and see if the original estimate was reasonable. Then have them sort the sample by color and draw a bar graph to show the distribution starting with the color with the largest number. The individual results are then combined, and each group prepares another graph of the overall data. Students will determine if the sequence of colors changed when going from individual data to the larger sample of the overall data. Have the students calculate the average number for each color in the pooled sample. Determine the range of the data.

All the samples can be pooled into a bowl, and have the students reach in and select one without looking. Discuss which color is most likely to be selected and least likely to be selected. Then reveal which color was actually selected. Discuss lotteries, raffles, and the computation of odds.

For students of 6th grade and above. Requires 90 minutes.

16. WEIGHING THE PLANETS

We will discuss how the mass of a planet (or the sun) can be determined by observing how it affects other objects. The simplest (and earliest) method is to equate the gravitational attraction [between an orbiting object (moon/planet) and the object (planet/sun) it is orbiting], to the centripetal force acting on that object due to its orbital motion. The resulting equation for the mass of the object being orbited depends only on the mass of the orbited object and the orbital distance and the time to complete one orbit.

Depending on the age (mathematical background) of the students, this relationship can be shown using elementary algebra, or just by a brief description on the concepts without using mathematical formulas.

A brief discussion of how humans have trouble understanding both very small and very large numbers. Two hands-on demonstrations are performed. The first shows a time line encompassing the age of the earth, with event markers placed at various milestones in the development of life. When it is done on a standard 400 sheet roll of toilet paper that has been laid out in a school corridor, it stretches almost 150

feet, with homo sapiens appearing 0.040 inches from the end. The second is a scale model of the solar system, also laid out on a corridor floor. When the distance between the Sun and Mercury is one foot, Earth and Venus and Mars are each also spaced about one foot further away. At the other end, Neptune is placed at 80 feet and Pluto at 106 feet. (At this scale the nearest star is about 137 miles away.)

The next discussion is about the number of stars in our galaxy, and the number of galaxies. The total number of stars in the universe is greater than the total number of grains of sand on all of the beaches on earth.

The last discussion is about the fact that only a few of the elements necessary for human life are created in the furnaces of normal stars. The others are only created when a super-nova occurs, and the resulting gigantic explosion strews the heavier elements throughout space, only to eventually coalesce into second generation stars and their planets. In fact, we contain elements that were born in the stars.

For students of 5th grade and above. Requires a minimum of 90 minutes.

17. HEAT, HEAT FLOW, AND HOW TO STAY WARM IN A COLD CLIMATE

We first describe what heat is and then talk about how heat flows from one place to another. This leads to a description of the units of heat and energy and the concept of insulation. We then have a hands-on experiment in which students measure the relative insulating properties of several different kinds of cloth and clothing liners. This is done by measuring, and recording, the rate of temperature fall of cans of hot water insulated by samples of the material being investigated. If time permits, the effect of air flow (wind chill) is demonstrated. This experiment can actually be used to evaluate insulating materials.

For students of 6th grade and above. Requires about 90 minutes.

18. UNDERSTANDING BLOOD PRESSURE AND BLOOD FLOW.

The mechanism of the human heart and circulatory system is described and the reason for the periodic changes in pressure in the arteries is explained. The definition of the terms "Systolic" and "Diastolic" is explained and the common method for measuring blood pressure is demonstrated and explained. Students are taught how to measure blood pressure on each other. We have enough equipment for about 5 student groups. The effect of blood circulation loss is demonstrated by using the blood pressure cuffs to constrict circulation in the arm while the students are working to compress a sponge with the hand.

The functions of blood circulation are reviewed and the mechanisms of various failures of that system are explained. This leads to a discussion of heart attacks, what can be done to make them less likely and the best course of action, should one encounter a person having a heart attack.

This module is led by an MSSV volunteer who is a practicing MD and scheduling must be coordinated with his availability.

For students of 5th grade and above. Requires 60 minutes. 90 minutes would be better, if possible.

MODULES DEVELOPED FOR CLASS PERIOD PRESENTATION

From time to time MSSV volunteers have presented special content modules in classes as requested by teachers. Some of these modules appear to be of general interest and are available to teachers who may want to include them in their class schedules. In each case the modules have been used by a particular volunteer who has expressed a willingness to travel a reasonable distance in order to present the particular module in a location different from his/her home area.

For each of these modules, MSSV has the equipment and reproducible class notes so that all the teacher needs to provide are the students and a scheduled time and location.

On request we, will consider other modules requested by teachers provided we have or can recruit the necessary talent. If there is something you need, just ask.

1. Buoyancy and Density.

This module was prepared for Lisbon middle school and was presented to about 6 classes in 2007. The module was presented by two volunteers working as a team and requires a full class period.

2. Battery Chemistry and theory.

This module was prepared and presented by a team consisting of a chemist and a physicist. In the presentation the theory of the oxidation reduction reaction that produces the electrons was presented. Following this the class was divided into groups of 4 or 5 students and each group was given instructions and material for the construction of a battery. The battery design was an MSSV original and was chosen to be safe and to produce a large enough current to brightly illuminate an LED. This module requires every second of a 45 minute class period. It would be better to give it two class periods.

3. How do you Weigh the Planets ?

We were asked to prepare a program on how the weight of the planets in the solar system are determined. While the method is not too difficult for one who has a little knowledge of classical mechanics, the problem facing us was how to explain this to 7th graders. One of our volunteers spent some time figuring out how to explain this to students and made a successful presentation to several classes. He would be willing to do this again for anyone who needs the program. It was complete in one class period.

4. Small Electric Motors a Student can Build.

For several years one of our volunteers who is an electrical engineer has presented a program in which the students are divided into small teams, each of which builds a small motor which runs from a standard 1.5 Volt battery. To do this, the volunteer pre-fabs some of the parts that the students would have trouble with. The motors each require about \$1.00 worth of materials (not including batteries or battery holders). We can supply the materials on a limited basis, but it would be better if the school paid for this, particularly if they want to allow the students to keep the motors they have built. The program requires 2 or 3 class periods and so far all of the motors constructed have run. We would be happy to present this program to other schools which include electricity and magnetism in their science curriculum.

5. Van de Graaff Generator.

Many schools have one of these high voltage generators in their supply room. The generators are truly impressive. They are inherently safe for humans (not so safe for electronic devices) but the static discharge can be surprising if the students are not properly instructed. Every year we are requested to handle the demonstration of these things for teachers who are not comfortable with the generators and the high voltage effects they produce. One of our volunteers will come to a classroom that has or can borrow a Van de Graaff generator. We will carry out the demonstration so that everyone has fun and no one gets hurt. We will also explain how the generators work and explain why they produce the effects that are observed.

The generators are notoriously delicate and require occasional repair to keep them working. We know how to do this and will repair the generators as necessary as a part of a scheduled presentation. If your school owns one of these generators you should budget about \$20.00 for a replacement belt every year, and about \$100 for other replacement parts every five years.

6. Mechanics. (Special subjects and entire program).
MSSV has prepared a complete program on the subject of Mechanics. We have also written a series of notes that can be reproduced as needed. These notes form a mini textbook that can be distributed to all students for the cost of reproduction. The entire program is intended to guide the presentation of the subject for schools that wish to include it in their curriculum. MSSV volunteers who are trained in this subject are available to assist with any or all parts of this program.

The titles of the individual sections of the notes and hence the sections of the program are:

- A. Units of measure
- B. Vectors and Scalars and description of forces
- C. Newton's laws (all three)
- D. Momentum and conservation of momentum
- E. Gravity (Newton again)
- F. Energy potential energy and kinetic energy and conservation of energy
- G. Power
- H. Friction
- I. Efficiency.
- J. Density and buoyancy.
- K. Introduction and teacher's notes.

These notes are written at 7th and 8th grade level and have been used in a number of classes, so we think that most students of those grades can understand them.

On request we can convert any of the above topics into a stand-alone one-class presentation.

7. Electricity & Magnetism. Special subjects and entire program.
MSSV has prepared a complete program on the subject of Electricity and Magnetism. We have also written a series of notes that can be reproduced as needed. These notes form a mini textbook that can be distributed to all students for the cost of reproduction. The entire program is intended to guide the presentation of the subject for schools that wish to include it in their curriculum. MSSV volunteers who are trained in this subject are available to assist with any or all parts of this program.

The titles of the individual sections of the notes and hence the sections of the program are:

- A. Static Electricity
- B. Magnetism
- C. Electrical Units
- D. Circuits & Schematics
- E. Simple Circuits
- F. Ohm's Law
- G. Power in Electric Circuits
- H. Batteries
- I. Current-carrying Conductors in Magnetic Fields (motors and generators)
- J. Electrical Safety
- K. Lightning Safety
- L. Introduction and teacher's notes.

These notes are written at 7th and 8th grade level and have been used in a number of classes, so we think that most students of those grades can understand them. MSSV owns and maintain a great deal of the equipment used in these class programs.

On request, we can convert any of the above topics into a stand-alone, one class presentation.

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