THE UNIVERSITY OF ARIZONA

Girls in the SYSTEM

A Handbook of Science, Mathematics, and Engineering Activities for 8-12 Year Olds

Compiled by Jennifer Rickard

A Collaboration between the University of Arizona and the Sahuaro Girl Scout Council

Girls in the SYSTEM

(Sustaining Youth in Science, Technology, Engineering and Mathematics)

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Introduction

Introduction

This is a guide to doing fun and meaningful science in the classroom, after school program, home or Girl Scout troop. Our hope is that doing enjoyable science, technology, engineering and mathematics activities will foster enthusiasm for these subjects and that girls will consider careers in related fields. It is one of the products of a three-year project funded by the National Science Foundation called Girls in the SYSTEM whose aim was to improve science, technology, engineering and mathematics (STEM) education for girls aged 8-12. It brought together the Sahuaro Girl Scout Council and five departments of the University of Arizona (Ecology and Evolutionary Biology, Materials Science and Engineering, Mathematics, Mining and Geological Engineering, and the Southwest Institute for Research on Women in the Women's Studies Department). This partnership linked **formal** and **informal educators** in its effort to reach girls, especially those from low-income and ethnic minority communities. **(Throughout this book any adults working with children are referred to as educators.)** By including parents, teachers and troop leaders, it connected the educational system with the community. The components of the program were: STEM Academies, Girl Scout troop programs, summer day camps, parent workshops, and mini-grants for leadership development.

In STEM Academies experienced teachers, pre-service teachers, Girl Scout troop leaders, and parents received training in science, technology, engineering, mathematics, and gender equity. These workshops provided opportunities to work with innovative educational resources that increased their knowledge and confidence in STEM, and provided instructional ideas for their work with youth, placing emphasis on issues of gender equity.

In Girl Scout troop programs, STEM Academy participants facilitated the incorporation of STEM activities into Girl Scout troop meetings during six-week sessions at selected sites. The program was designed to stimulate and nurture girls' interest in using methods of inquiry to enhance their understanding of STEM. Facilitators used challenging hands-on STEM activities that supported and expanded girls' abilities to solve problems using the tools of scientific investigation and their natural curiosity about how things work.

During the one-week summer day camps, participating adults provided engaging activities that motivated children's interest in STEM. In addition, the camps served as teaching laboratories in which teachers and leaders implemented new teaching strategies with small groups of children. Some of the weeks included boys in order to enable educators to analyze and refine their own practices with regard to gender equity.

Parent workshops were incorporated into the Girl Scout troop setting and the summer camps, as well as STEM Academies. The goal of reaching the parents was to inform them of available resources to strengthen their children's interest and engagement in STEM.The workshops involved family members in STEM activities and provided information about women in science careers. Parents were reminded of their significance in the academic preparation of their children.

Mini-grants were awarded as leadership development opportunities to allow adult participants to take initiative in extending the impact of the project. Some of the activities funded were a field trip to the Pima Air and Space Museum, trips by a Tohono O'odham troop to gather grasses used in traditional basket-making, and a suspension bridge construction day for a troop in an outlying area.

Using This Guide

You can use this guide to encourage your children to investigate the world and to ask why and how things work. Maybe they can find the answers on their own, which is the most satisfying thing of all. As adults, some of us tend to jump in with the answer in our own enthusiasm and curiosity. But when we can restrain ourselves, it is much more satisfying to see the looks on young people's faces when they make their own discoveries. Most of these activities can be done at home, in the classroom, or the after school setting. Elementary school teachers were a big part of this collaboration, and we are sure many took the ideas straight from (or back to) the classroom. They would love for you to do the same.

If you are a troop leader reading this, it may be your first year as a Girl Scout leader, or you may have been leading girls for years. If you are new, this guide will be useful when you realize your next meeting is TONIGHT and you have not prepared an activity. If you already have plenty of ideas on arts and crafts, songs, and games, this could encourage you to work on some badges you may have shied away from in the past. You may be a camp director looking for new themes for summer camp. Whatever the case may be, you will have some fun with this guide, as you explore new subject areas with your children. Most of the activities take 45 minutes to an hour and a half. Be sure to use safety goggles where necessary and give instructions on the safe use of tools prior to beginning any activity.

From Jennifer Rickard As A Troop Leader:
"But I Was Never Good In Science Or Math"

Please don't be intimidated by the subject area. Personally, I took as little math and science as possible to get through high school, went to college for a year, took eleven years off and then graduated from college with a degree in "multi-disciplinary studies." After I took Algebra 1(both my freshman and sophomore years in high school), I took a year of Geometry and was done with formal training in math forever. I took the science courses necessary to get through college, taking mainly Anthropology, Art History and language courses, which I thought at the time were more interesting. It's funny; you never know what you will end up doing if you keep an open mind!

I am now learning that science is great fun, and kids love it, because it means trying new things, getting messy, and YES, sometimes burning things up or launching them great distances into the air!

It's Too Much Work

Science activities require no more planning than other activities. Don't be concerned with having everything set up ahead of time. Use the kid power in front of you. They want to do something useful! My first year as an adult counselor at a Girl Scout summer camp, I was watching an old pro. I think she was all of seventeen, but had been in Girl Scouts forever and had probably spent a good deal of time watching her mom who had been a leader for years. I was wondering how to keep about 10 kids (aged 6-8) occupied, while at the same time cooking lunch for them in a solar oven. She gave every girl something to carry, and marched them outside to a table near the solar oven. Each one had a job to do. Open this, pour that, sprinkle this; it was great to watch. Then they put the creation in the oven and off they went to play a game while lunch baked in the sun. Thus having a vested interest in the meal, they all at least tried it when it was ready to eat! So, put the kids to work; they feel needed which is important, they aren't baked bored, which is also important, and the job or experiment gets done, by the kids, which is very important!!

What if the Experiment Fails or I Don't Know the Answer?

The next thing to keep in mind, which dovetails nicely with point one (no science training), is that you need not have all the answers. In fact, if you don't have the answers, you can't jump in with them, thereby ruining the surprises and discoveries for the kids! However this book will give you some background and definitions regarding the science content in the activities, for your own peace of mind. If you happen to have a science or engineering background yourself, these definitions may bring things to a layperson's level for you.

But if you know you read it, and can't remember, and some sweet, trusting child looks up at you with those liquid, brown eyes, and says, "WHY does the boat sink when it's full of pennies," just smile and say, "What do YOU think?"

The main point of this informal science education is to get the kids thinking and enjoying the process. We want kids to see that exploration and experimentation are fun and exciting.

Another great aspect of working with kids and science is this: Not all science experiments turn out the way you expect. Some teachers tend to find this distressing, but it doesn't bother some of us at all. One time we had about 30 girls outside in 100-degree heat trying to make sun prints on specially coated blue paper. The instructions were pretty basic: Go outside. Put some object on the paper for five minutes or less. Rinse the paper in water. Let it dry. What could go wrong? Well, we're still not sure what did go wrong, but almost all the prints disappeared and the paper just looked wavy and faded. We suspect that the Arizona sun in summer was just a little bit too much for this paper. But, the point is this: the kids didn't mind, and the kids and adults all got to keep trying variations on the theme to see if we could get it to work. Less time in the sun, less tme in the water, more time in the water, no water, dry them inside, etc., etc., etc. This sort of experimentation teaches us not to give up, not to expect perfection and to enjoy the journey as much as the destination.

So, science is not like spelling, where the word is either spelled right or wrong. The experiment can have the desired end result or not, but it has still been valuable in teaching us methods in science, questions to ask, and love of trying new things.

How the Book is Organized

This book is divided into sections by subject theme. Each section has six or more activities listed on a single theme such as solar energy, so that you can put together either a six-week format or a one-week camp on a particular theme. If the actual activities are not here, for lack of copyright permission, we have included names of web sites where you can find the same or similar activities. In some cases, we have included original activities that we may have modified for our use. For example, we included all the pages of the NASA activities and the

GEMS[1] activities even though in many cases, we did less than what was suggested. If we considered something too “schooly”, we often left out written portions of activities and just discussed findings aloud.

We also tell you how we organized and planned our six-week sessions and one-week camps. The clusters of activities by subject are valuable for the person who wants to pull together a meaningful sequence of activities on a particular subject theme, or toward a Girl Scout badge. However, the most essential and vital part of the book, in my opinion, is the Criteria and Indicators for Successful Science, Technology, Engineering, and Mathematics Activities for Girls developed by the project staff (see pp. 9-11). By using these as a guideline, you will choose the best activities to interest your particular group of kids and present them in such a way as to captivate your young participants. In about six camps, boys participated, and just for the record, these criteria and indicators work just as well for doing science with boys!

Materials

Most of the materials we used can be easily bought, donated, or found at home. Because we used such large quantities of some things, wood was bought through a catalog and some of the solar items were purchased over the Internet. But if you just keep some basic materials on hand, you can pick up a couple of things specific to an activity and look like a magician, pulling great activities out of your hat at a moment’s notice. Some good, basic items for your kit are glue, scissors, rulers or measuring tape, felt-tipped markers, masking tape, eyedroppers, pennies, paper, pencils, clay and basic tools (like screwdrivers, wire cutters and hammers). It’s also essential to have a first aid kit and a roll of paper towels.

[1] *Information on NASA activities can be found at the Space Educators’ Handbook homepage, http://vesuvius.jsc nasa.gov/er/seh. Details of GEMS materials may be found at http://www.lhsgems.org.*

Doing Science, Technology, Engineering, and Math With 8-12 Year Olds

As the project progressed, the SYSTEM staff came up with a set of criteria and indicators for successful STEM activities for girls. As you read them, you will see that not all activities can contain all of the indicators. However, refer often to this list of criteria and indicators. Keep them in mind when choosing and facilitating activities. If you see that many of the indicators are being incorporated into each activity, we believe you will see success in the faces of the children. When teaching adults at STEM Academies, we modeled the leadership behaviors we tried to promote, and asked participants to evaluate the session by the criteria and indicators. Leaders were delighted with this teaching model and often stated they would be taking it back to the classroom or troop.

Vital methods of this model of teaching are found throughout the **criteria and indicators.** Here is a quick overview of the basics:

1) Foster an environment in which children are encouraged to take risks without fear of judgement or failure.

2) Explore with them, asking questions more often than telling answers.

3) Help them or show them how to do something, but don't do it for them.

4) Keep the tools and materials in the hands of the children, not in your hands.

5) Practice patience, giving children time to explore and rebuild, or to think about a problem before answering. If there is silence after you ask a question, it is often because there is thinking going on.

6) End an activity while there is still enthusiasm for it.

It's a fine line between giving them enough time to explore a project and giving them too long, but enthusiasm remains high if you keep things moving at a good pace. Tell them it's time to do the next activity, but let them know if you will make time at the next meeting or during free choice or snack for those who want to revisit or finish an activity.

Suggestions for Doing Science With Elementary to Middle School Age Kids

We have worked successfully with groups of kids who ranged in age from seven to fourteen. Some activities can be done on various levels and still be effective. However, generally speaking, we found that some eight year olds (third graders) were a little too young for our projects. I say "generally" because we did have seven year olds who participated successfully. So, if you have prior knowledge of the group, use it when planning activities. Choose activities they can succeed in. Perhaps match up an eleven year old with good coordination with an eight year old. On the other end of the scale, twelve to fourteen year olds may feel too old to participate with elementary school kids, though our activities are absolutely appropriate for them. Socially, they are just in another world at that age. If you work with a diverse group, you may want to separate them for some activities so the older kids feel special and don't just mentally check out!

We include a lot of team work since girls generally enjoy working in a group, and we don't emphasize competition. If we give out awards when we do compete, we give them in several categories, such as Lightest Boat, Best Design, Team with the Most Stick-to-it-iveness, Fastest Car, etc., but we award them in no particular order, everyone claps and laughs, and for the most part, it is all good-natured. I did hear of some parts-theft before one boat race, but those incidents were few and far between. Boys and girls alike seemed to appreciate our relaxed style of learning combined with fun. It honors their intelligence and encourages them to use their minds while not being afraid to ask a passing adult for advice **or input.**

Criteria and Indicators for Successful Science, Technology, Engineering, and Mathematics Activities for Girls

1. Activities reflect significant content and process in science, technology, engineering and/or mathematics.

- Activities reflect the content of physical science including such topics as properties and changes of properties of matter; motions and forces; transfer of energy.
- Activities reflect the content of life science including such topics as the structure and function of living systems, reproduction and heredity, regulations and behavior, populations and ecosystems, diversity and adaptations of organisms.
- Activities reflect the content of earth and space science including such topics as the structure of the earth system, earth's history, and the earth in the solar system.
- Activities reflect the content of technology and computer science including such topics as web page design, computers as tools for communication and problem solving, electronic components of computer systems.
- Activities reflect the content of engineering including such topics as architecture, chemical engineering, structural engineering, electrical engineering, environmental engineering.
- Activities reflect the content of mathematics including such topics as ratio and proportion, logical reasoning, measurement, geometry, and problem solving.

2. Activities are active and engaging.

- Activities encourage exploration, investigation, creativity and risk-taking.
- Activities encourage a playful, friendly, adventuresome climate.
- Activities offer opportunities to use tools to build, take apart, and measure.
- Activities encourage participation of all girls.
- Activities are interconnected and may culminate with a special event or public display of girls' work.
- Activities include science experiments in which girls test hypotheses by manipulating variables.
- Activities use simple materials in order to promote girls' further exploration of STEM ideas at home.
- Activities relate to phenomena and/or objects that occur in a girl's everyday life.
- Activities include games and/or puzzles.

3. Structure of the session is flexible.

- Girls choose materials and/or tools for a particular task.
- Girls choose the topic of study or an area within a topic.
- Girls choose which activities they want to do and how long to spend with each.
- Sessions offer opportunities for girls to work individually, in pairs, in small groups, in large groups.
- Activities offer opportunities for competition and for cooperation.

4. Activities promote conversation.

- Girls talk about STEM with each other.
- Girls talk about STEM with educators.
- Girls talk about STEM careers.
- Educators pose good questions that ask, "How?" "Why?" and "What if?"
- Girls pose good questions that ask, "How?" "Why?" and "What if?"
- Girls interact with women who work in STEM fields.

5. Activities promote positive attitudes about STEM.

- Girls show enthusiasm about trying activities.
- Girls talk about activities at home and school afterwards.
- Activities provide positive female role models and career examples.
- Activities provide information about the contributions women scientists have made to their fields.
- Activities provide opportunities for success with STEM.
- Activities require perseverance and persistence.
- Girls discuss feelings about STEM and possible STEM careers.
- Educators facilitate discussions about the important contributions people in STEM careers make towards solving social, environmental and ecological concerns.

6. All girls participate fully in STEM activities. The voice of each girl is heard.

- Educators do more asking than telling.
- Educators and girls provide encouragement for all.
- Educators practice appropriate wait-time.
- Educators make a deliberate effort to engage each girl in each activity.
- Educators guard against any individual or group dominating the conversation during an activity.
- Educators acknowledge and respect diversity among girls including cultural diversity, maturity/age differences, multiple learning styles, and personality differences.
- Educators promote participation by keeping activity materials in the hands of girls rather than in their own.

Organizing, Planning and Implementing a One-week Science Camp

Over the three summers of the project, we conducted 14 one-week camps. The themes are listed elsewhere in this text, and according to child and parent comments, all the camps were a success. It was at times an organizational feat for the adults in charge, but we got really good at it! We hope you can learn from our experience. Start planning at least three months before the first day of camp.

Step one: Find a location for the camp(s) and obtain written permission from the school district, community organization, or owners of the building. Keep in mind that you will require running water, a large central location for whole group activity, perhaps two adjoining rooms for small group activities, bathrooms, and a place where it is okay to eat and drink.

Step two: For us, the next step was assembling a team of teachers, pre-service teachers, University staff and troop leaders for each week of camp. Whenever possible, we chose from the participants of STEM Academy. You could provide the written criteria and indicators of successful STEM activities to the team members prior to the first meeting, so they have an idea of the objectives of the camp.

Step three: If you are recruiting for the camp, you will also prepare flyers or advertise the camps in some way, very early on. Remember that if you are mailing, people need time to reply, and then if you are mailing confirmation packets, those need time to arrive and if that requires a response....so clearly you need a couple of months! Have someone register the children as they sign up, so you can keep track of registration, permission forms and health histories.

Step four: Send out notice of a **mandatory meeting** for the educators, and have it at a time when most everyone can make it (like Friday at 5 p.m.). At this meeting, have snacks or a light meal, name tags and any handouts ready as people come in. It saves time if you provide some themes for the team(s) to choose. In addition have resources available for these themes. Books, copies of good activities, and lists of good science web sites help to get the ball rolling. After about half an hour, get everyone's attention, greet them, and outline an agenda for the evening. We sometimes started with an icebreaker game, such as, "Startling Statements" (www.lawrencehallofscience.org/equals). As the evening went on, we divided according to camp, and began preliminary planning. If you are planning only one camp, you may adjust time frames accordingly and have a shorter meeting, or you may just get a lot done the first night! By the close of the first meeting, the camps' themes should be chosen or narrowed down. Have each team choose their next meeting time and location before they leave. Teams can now meet on their own, and meetings will run about an hour and a half.

Step five: At the next meeting, clarify what the major theme of the camp is to be. From there you can decide what supporting topics would be useful to cover in separate centers. Decide who will be responsible for each center and what the science content will be. Plan the next meeting. It should take 3-4 meetings to be ready for the first day of camp.

Step six: You also need to start shopping for supplies as soon as possible. That's why centers and free choice activities should be firm by the second or third meeting. That will allow ample time to buy supplies.

The rationale, structure and components of a SYSTEM camp week:

Pre and post assessment: Evaluation was an integral part of the project, so we always recorded what the children knew about the subject before the sessions, and then asked them the same questions after the sessions had ended. If camp, that would be on the first and last day. If in a Girl Scout troop, we would assess during or before the first meeting on science and during or after the sixth meeting. In addition, students, teachers, parents, and troop leaders filled out program evaluations. By doing these assessments, you can monitor the effectiveness of your program.

Puzzles and Games: Educators and children alike loved the array of puzzles and games we brought to each camp. We began each morning and ended each afternoon with some free time to try and solve the puzzles and games. If there was down time during the day, it was where people went! We were fortunate to have on our staff a wonderful math teacher who made several sets of the puzzles for the project. It was a nice time to get to know each other, and to relax, while being challenged and stumped by the math patterns and logic hidden in the puzzles. **The paper versions of the puzzles are included in this book.**

Setting the stage: This was a time on the first day to introduce the children to the week's theme through a short discussion, presentation, or video. It provided continuity and flow: where we are, where we're going, and how we will get there.

Make invitations for the parents to join us the last day: By doing this early in the week, it encourages children and parents to begin planning to attend. During the week, when we are in the large group, we ask the children if they have a confirmation yet, or if they think someone from their family will attend. We also make it clear that we understand many parents work and may not be able to get away early. We tell them that anyone who has no family member attending can show a staff member around that day. We have had great success getting parents to attend. We think it's a combination of genuine excitement from the children, peer pressure, and a positive, friendly environment at the camp. Also, since our camps end at two p.m., and someone has to pick up the child at that time, it's safe to assume that someone could come an hour early on the last day.

Parent attendance is key to our program for several reasons. If the parents believe that science, technology, engineering and math are important for girls, this camp re-affirms that. If they don't necessarily agree, or have never really thought about it, we provide some education in that area. If children see that their parents value something, it becomes more important to them. (At least up to a certain age!) Having the parents visit also provides an important learning opportunity for their children. Usually on Thursday, we ask the kids to think about what their favorite activities and centers have been. Then they can choose one or two of those to recreate and share with their parents on Friday. Concepts they have learned during the week are reinforced when they explain an idea or show someone else how to make, build or operate something. In addition, getting input from parents gives us an opportunity to evaluate the program from another perspective.

Centers: By organizing the camp into centers, several things are accomplished.

1) The theme of the week can be broken down into many facets that fit together into a cohesive whole. For example, one of our themes was simple machines (*see sample schedule p. 17*). Each center taught what a different machine was and the basic concepts behind it, such as friction, gravity and acceleration. By the time the final challenge is posed, children can infer that to move something high, you will choose either a pulley system or a lever used as a catapult. To move something far or fast you will probably combine wheels and inclined planes. For our week on water, the concepts or areas covered in the centers included surface tension, propulsion, density, buoyancy, and for local application - aquifers, since Tucson is built on an aquifer. By the final challenge, kids knew the science behind choosing fairly light, buoyant materials to build their boats, and using motors or sails for a power source.

2) Having two days with a total of four centers provides an effective format. Everyone knows they will get to do each center on Tuesday and Wednesday and that Monday, Thursday and Friday will be different.

3) Leaders do the same center four times over the course of the two days, enabling them to refine techniques and pay attention to different details, such as science content, interest level of the children, and gender and cultural equity.

Free Choice Centers: Especially fun are the free choice centers we incorporated into several of the camps on Thursday afternoons. During the pre-camp planning sessions, team members often came up with more activities than we could use, or activities that were applicable, but which were shorter than an hour and a half. This was a good way to use them. For it to be truly a free choice, have about eight activities for a camp of 40-50 kids. Depending on the nature of the activity, different numbers of kids may be accommodated in each center. You also don't want their first choice to be full. Let leaders know that if no one chooses their activity, they can use that time to help or observe at another center. We set it up so that they could choose two 45-minute sessions to attend. You can put sign-up sheets on the wall with the center's title and the lines numbered as to how many kids can sign up. After each leader does an ad for her center, the kids can then sign up at the centers that interest them. Another fun way we've done it is by handing out a playing card to each child. Have the leaders do their ads, and then while everyone is seated on the floor draw from another deck of cards, calling out each one, so the person with the corresponding card can come up and choose her two centers.

Culminating Challenge: This gave the week a focus but often was not decided upon during initial planning meetings. Once the centers were chosen, there was more of an idea of what the challenge should be. Sometimes it was changed or decided upon after camp started. For instance, suppose you are doing a camp on bridges. Each center may cover a different type of bridge, including application, or in what context a particular bridge may be used. Once the content of the centers is established, it is easier to decide what sort of challenge or culminating activity would best demonstrate the children's newfound knowledge. You may decide that to build a bridge that can hold a live load of 50 pennies and span at least twelve inches is appropriate for your purposes.

Photo Gallery: All during the week we took pictures. On Thursday night someone would get all the film developed and bring the photos in on Friday. Before parents arrived we set aside a half hour or forty-five minutes for all campers to choose any two pictures, mount them on brightly colored paper and in large letters, describe what was happening in the picture. As these were finished, they were posted on the walls for everyone to enjoy. It was fun, informative, and festive as well!

Video: We also took video footage throughout the week and it was fun to have that playing on Friday.

SYSTEM Summer Camp Format

This format worked very well for us. It gave enough structure to keep everyone occupied, and yet was flexible enough to allow for impromptu games or large group activities and also to give guest speakers a choice of days and times. Each small group visited two centers a day (each 1 ½ hours long). You could schedule three 1 hour centers if desired. A typical camp week looked like this one we did on simple machines:

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
9:00-9:30	Arrive, welcome, puzzles	Arrive, welcome, puzzles	Arrive, welcome, puzzles	Arrive, welcome, puzzles	Arrive, welcome, puzzles
9:30-11:00	Make nametags Preassess by round robin Interview Ice breaker game	Centers: 1) Pulleys 2) Levers/Inclined Planes 3) Gears/Screws 4) Wheels	Centers: 1) Pulleys 2) Levers/Inclined Planes 3) Gears/Screws 4) Wheels	Pose culminating challenge: Design and construct a device that can move a 2 liter soda bottle high, far, and/or fast. Kids self-select groups (no larger than 4) and begin working on challenge.	Finish/test challenge. "Machine Show at the Ramada" Survey of attitude towards math/science (in challenge groups)
11:00-11:30	Lunch	Lunch	Lunch	Lunch	Lunch
11:30-1:00	Set the stage for the week with a video or intro of some kind. Take things apart Make invitations to send home using scraps from take-apart activity	Centers: 1) Pulleys 2) Levers/Inclined Planes 3) Gears/Screws 4) Wheels	Centers: 1) Pulleys 2) Levers/Inclined Planes 3) Gears/Screws 4) Wheels	Guest speaker (45 min.) Discuss in small groups how to measure how high, how far, how fast liter bottles go.	Build a scrapbook/gallery for parents to view Prepare "Tell and Show" "I Can Do That" video
1:00-1:30	Snack	Snack	Snack	Snack	Snack-parents arrive, "tell and show" for parents, show video of week.
1:30-2:00	Wrap-up, closing, puzzles	Wrap-up, closing, puzzles	Wrap-up, closing, puzzles	Wrap-up, closing, puzzles	Wrap-up, closing, puzzles

Most of the activities in this book, whether we used them at troop meetings or summer camp, can be plugged into this format. Unless otherwise noted in the text, each one was used in a time slot of an hour to an hour and a half. However, we suggest having two activities ready, or something else to do since it's always better to have more prepared than you need. Someone always finishes early! Note that the time frame includes clean-up if necessary.

Organizing, Planning and Implementing a Six-week Program

These programs consist of six weekly meetings, each of which can be one to two hours, depending on your situation. They can be used as part of an in-school Girl Scouting program, an after school program (of same or mixed gender), during regular Girl Scout troop meetings, or any other way that suits your needs.

The planning time is less than for one-week camps, because you only have to plan activities for 6-12 hours as opposed to 20 hours. Basically we did the same activities or types of activities as at a camp, but we didn't always have a culminating activity. Sometimes we worked in depth on a particular topic, such as electricity. Other times we earned Girl Scout badges, which meant exploring two or three topics, but in greater depth than required for the badge work.

Guest speakers are an integral part of encouraging girls in science, whether in the classroom, after school program or one week summer camp. Be sure that guest speakers and videos that you show reflect the girls represented in your groups. A troop of Native American girls will more likely be able to picture themselves as future doctors if you have a Native American woman telling them that she too grew up on the Reservation, and became a doctor despite many obstacles.

It is also powerful to have college students speak to the girls. Elementary and middle school kids can relate to a young woman in blue jeans telling them she is in college to become an engineer. She can tell them what she enjoyed doing at their age, and what subjects she took later in school. Most university departments will either have, or be able to direct you to groups who do public outreach, such as WISE (Women in Science and Engineering). Remember they are students; work around their schedules, and if at all possible, feed them! When you invite people to speak to your group, be sure they know the ages they'll be addressing. Suggest a hands-on activity, or encourage the speaker to use a video or samples of her work. Keep the presentation time to a half hour if it will be lecture only. Otherwise, an hour is appropriate.

Another way to be ever so subtle about role modeling is to have everyone wear tags with their name and a title derived from the associated subject matter imprinted on it. This can easily be made on a computer and worn around the neck or pinned on.

Ashley Ramirez

Chemical Engineer

Associated adults can use the subject theme, or their job title or major in college, if scientific or mathematical.

At the end of the six weeks (or one week camp), you can award prizes or certificates for completion of the project.

In a six-week program, your goal is to introduce a topic or series of activities that the girls may never have had any hands-on experience with. It is a taste of something new, and your desire is that someone's appetite will be whetted for further exploration, or just that the children will enjoy science or technology or math, maybe for the first time! If you do your job right, they will walk away with some new terminology and concepts. Later in school, when they hear some of the terminology again, they will already have experience and be somewhat familiar with the words. But again, the overriding hope is that the kids will mainly remember this as a good experience when they begin to choose a career path. Learning what women and men do in their careers helps put a more human face on an otherwise sterile word. In other words, the experience brings engineering or computer science or mathematics home to them.

Getting Started

By browsing through the clusters of activities in this book, you will find enough to put together 6 weeks of activities on the topics of your choice. By using the glossary, you can familiarize yourself with the scientific terms and concepts that you will be using. Have one or two meetings prior to the start to determine topic and sequence of activities. Allow enough time to shop for needed supplies.

Be Flexible!

Depending on the team of educators (preferably two or more people), the participants, and the topic, you may need to reevaluate or meet again one or two weeks into the program. Something may not be working, and you have to be willing to shift gears, rather than struggling on with a topic that's too hard or too easy for the group or is not successful in some way. You may have a great program underway and discover that it would have been perfect for 5^{th} and 6^{th} graders, but is not so great for your 3^{rd} graders who lack the hand-eye coordination, or concentration skills necessary for the tasks. It's okay and even preferable to make children stretch, but always be on the lookout for signs of boredom, and don't just ignore them! Don't be afraid to ask the children what would improve the activity for them. Sometimes it may be a minor adjustment that you can make. However, if the kids just aren't responding to the entire theme, take a break, play a game, and make new plans for the subsequent weeks. The activities included here have all been used with success, so the chances are good that they'll work for you too, but it's best to be prepared for any eventuality!

Links Between Activities and Girl Scout Badges

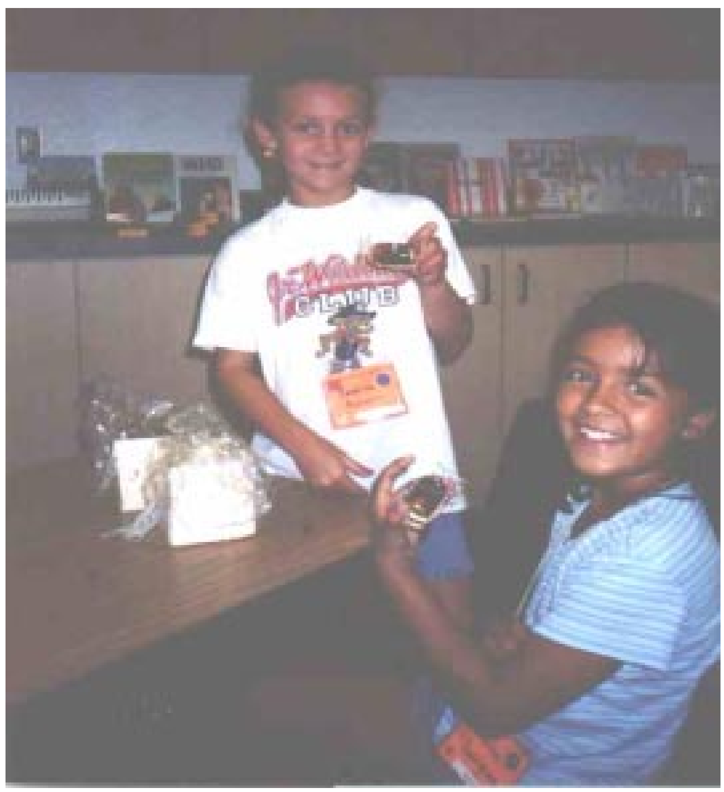
Science Themes and Activities linked with Junior Girl Scout Badges	Aerospace	Careers	Computer Fun	Creative Solutions	Discovering Technology	Finding Your Way	Making It Matter	Math Whiz	Outdoor Cook	Puzzlers	Science in Everyday Life	Science Discovery	Science Sleuth
CHEMICAL ENGINEERING													
Super Absorbers (p. 26)												X	
Gurch (p. 26)												X	
Slime (p. 26)							X						
Silver Polish (p. 27)												X	X
Playdough Playground (p. 28)				X									
Oobleck (p. 30)							X						
Ice Cream and Freezing Point Depression (p. 49)												X	
FLIGHT/AEROSPACE ENGINEERING													
Rocket Glyph (p. 54)				X									
The Fantastic Garbage Bag Blow Up! (p. 56)												X	
Become a Paper Helicopter Engineer (p. 57)	X												
Simple Parachute (p. 59)	X												
Balloons Aloft (p. 61)	X												
Balloon Rocket (p. 62)	X												
3-2-1 Pop! (p. 64)	X												
Paper Rockets (p. 68)	X												
Rocket Car (p. 71)	X												
Altitude Tracking (p. 79)	X												
Bottle Rocket Launcher (p. 87)	X												
MATHEMATICS													
Scaling Down: Proportional Reasoning (p. 96)								X					
Tangram Puzzles (p. 99)								X					
Optical Art (p. 100)										X		X	
Salsa Making (p. 100)								X					
Body Proportions. Are You a Square? (p. 101)								X					
Body Proportions. Scaling Down Your Foot (p. 102)								X					
M.C. Escher-Style Tesselations (p. 102)												X	
Making and Solving Puzzles (p. 103)								X		X			
Math Games (p. 144)								X		X			

Science Themes and Activities linked with Junior Girl Scout Badges

	Aerospace	Careers	Computer Fun	Creative Solutions	Discovering Technology	Finding Your Way	Making It Matter	Math Whiz	Outdoor Cook	Puzzlers	Science in Everyday Life	Science Discovery	Science Sleuth
SIMPLE MACHINES													
Machine Detectives (p. 169)							X						X
Pulleys (p. 172)							X						
Wheels (p. 173)							X					X	X
Inclined Planes (p. 174)							X						X
Gears (p. 175)													X
SOLAR ENERGY													
Sun Prints (p. 181)											X		
Sun and Earth (p. 182)								X					
Solar Oven (p. 184)									X				
Solar Homes (p. 187)											X		
Solar-Powered Cars (p. 200)					X								
Solar Still (p. 202)									X				
Wood Burning (p. 203)											X		
Viking Bearing Dial (p. 204)						X							
STRUCTURES													
Exploring Structures (p. 207)								X					X
Building 3-D Shapes (p. 209)								X					
Newspaper Engineer (p. 216)							X						
The Yolk's On You (p. 217)							X						
Adobe Bricks (p. 218)							X				X		
TECHNOLOGY													
Web Surfing (p. 223)			X		X								
Logo, Computers (p. 227)			X		X			X					
PROPERTIES OF WATER													
Sink or Float (p. 237)													X
Convection (p. 238)													X
Hot and Cold (p. 240)													X
Plankton Race (p. 242)												X	
Discovering Density (p. 245)												X	X
Build Your Own Aquifer (p. 253)											X	X	
Edible Earth Parfaits (p. 255)												X	
Water Drops on a Penny (p. 257)												X	X

Themes and Activities

Chemical Engineering



Chemical Engineering

A Six-week or One-week Format

Absorption, density, freezing point, heat, liquids, polymers, and solids are the concepts covered. (*See glossary for some definitions*.) At each meeting, or at each center, the children make something or conduct experiments in which the original substances change in some way. These activities can each probably be wrapped up in under an hour, except for paper-making, so if your meeting or center is 45 minutes to an hour, great! If you have an hour and a half, I suggest doing two activities, in rotation. Remember to ask lots of questions by way of introduction, and let the kids participate in all the preparation, mixing, and clean-up.

Career options for those who enjoy chemistry include pharmacist, chemical engineer, chemistry teacher, doctor, nurse and many more. Can you think of some?

Week one: Silver polish* and Glurch or Slime.
For Glurch, see http://student.biology.arizona.edu/sciconn.
For Slime, see http://www.plastics.com/slime.php.

Week two: Make paper. See http://www.beakman.com/paper/paper.html

Week three: play dough* and model playground* (May take an hour or more)

Week four: Super absorbers - see how much water two brands of disposable diapers can hold. http://www.projectlabs.com/htmldocs/superdiaper.html

Week five: Oobleck*

Week six: Ice cubes and salt, and "Make and Eat coffee can ice cream"*!

For ice cubes and salt see same web site as listed for Glurch.

***Items with asterisks are included on the following pages.** The other experiments we used are readily available on the internet, so are not reprinted here. The web sites are also listed on the page of Science Sites in this book. Also just type in "kids' chemistry" and see what you can find.

Comments: These activities were used during at least two Girl Scout troop programs in various combinations with other types of engineering activities. (*See structural engineering section*.) At camps with a water theme, we also made ice cream. Any excuse for a tasty treat!

Caution: When working with sodium polyacrylate (the substance inside disposable diapers), KEEP IT AWAY FROM YOUR EYES! We didn't have any trouble, but I saw a warning on the Internet. It does rapidly soak up moisture, so it can't be good for your eyes. As with all chemistry experiments, remind the girls of common sense safety. Use goggles if you have them. Don't eat anything but the ic*e cream! Wash hands after handling the slime, Glurch, and sodium polyacrylate.*

SILVER POLISH

Category:
Chemical Engineering

Objective*:*
Get the kids to polish all the family heirloom silver in time for that big dinner party!

Introduction:
Seriously, there are two interesting phenomena that take place here. First, what happens when you mix cream of tartar with lemon juice? What is cream of tartar? Then how does it remove tarnish? What is tarnish? After consulting my trusty dictionary, I find that cream of tartar is also known as potassium bitartrate, used in baking powder, as a component of laxatives, and in the tinning of metals (aha!), We know lemon juice is very acidic. Tarnish is the discoloring or dulling of the luster, especially by exposure to air (oxidation) or dirt. So I can only surmise that there is a chemical reaction between the cream of tartar and the tarnish. The lemon juice (or acid) is a catalyst, allowing the reaction to happen more easily, and voila! If you really want to know, one molecule of potassium bitartrate reacts with two molecules of silver oxide, making four atoms of silver, two molecules of water, and whatever the oxidized tartrate product would be, but what you get is shiny silver again! It's very dramatic and the kids are enthusiastic about shining things up.

Materials:
- bucket of clean water or sink in the room
- soft rags or old wash cloths
- some tarnished silver
- cream of tartar (available in spice or baking section of grocery store)
- one or two lemons (or bottled lemon juice)
- non-metallic stirrer to mix paste

Procedure: Make silver polish by adding a small amount of lemon juice to cream of tartar. Mix together with a plastic spoon or wooden stirrer until you have a paste. Then put a little of this paste on a cloth, and clean tarnished silver by rubbing it gently. After the tarnish is gone, rinse the piece of silver in water and shine it with a soft towel or cloth. If you don't have any silver to clean, test your polish on a piece of scrap metal.

Recipe from *Girl Scout Badges and Signs* 1990 by Girl Scouts of the United States of America (now out of print).

PLAY DOUGH PLAYGROUND

Category:
Chemical and Structural Engineering

Objective:
To see how simple household ingredients can combine to make a new (and fun!) substance. To begin thinking about design and the imagination engineers use as they plan and build.

Concepts:
Chemical change, shape and materials strength, design

Materials: As listed in recipes (p. 29)

- graph paper (with large grid if possible)
- pencils
- rulers
- toothpicks
- gumdrops or raisins
- plastic baggies to take clay home

Procedure: Make any version of the play dough or clay. Set it aside. Pass out graph paper and pencils. Tell the group they are playground engineers and have been hired to design a new sort of playground for children with various disabilities. Some use a wheelchair, some cannot see, etc. Their first job is to plan the playground on paper.

You can bring in math at various levels. One inch equals one foot is an easy scale to use, but adjust as needed. Once they have drawn a plan, they can build right on the paper, or double the size and build elsewhere.

If you are near a real playground, go inspect it for equipment size, layout, pathways to water and restrooms, landscaping and variety of design. Talk about how playgrounds have changed over the years, and what new ideas they, as designers, might have in the future.

Comment: The play dough is rather flimsy for building certain shapes, so you could use toothpicks and gumdrops for some geometric shapes and use the play dough for other parts, for people, or for wheelchairs. But just give out the materials and the “assignment” and see where they go with it. You may just see typical slides and swing sets but you may just be surprised!

Recipe for Cooked Playdough

2 cups flour
1 cup salt
4 tsp cream of tartar
2 cups water
2 tsp food coloring
4 tsp oil

Combine flour, salt, and cream of tartar in large saucepan. Add oil and food coloring to water and stir into flour mixture. Cook over medium heat, stirring constantly until mixture forms a ball. Remove from heat and knead a few minutes. This playdough should be stored in a plastic bag and refrigerated.

Recipe for Uncooked Playdough

½ cup salt
5 cups flour
1 ½ cups water
½ cup oil

Mix flour and salt together. Add food coloring and oil to water, and gradually add to flour mixture. Knead until smooth.

Recipe for Homemade Clay

1 cup flour
2 cup salt
1 tsp. oil
water to desired consistency
(add Kool-Aid for color)

Recipes vary in amount, but the first two will be enough for at least 4 kids. The clay will probably be enough for 2-3. You can always supplement the supply with store-bought for a larger group.

OOBLECK

Introduction

Oobleck—even the name of this mysterious substance conjures up strange sensations. Oobleck is always a surprise. Watch it flow like a liquid, then feel its surface resist your pressing fingers like a solid!

This can be condensed. We included all pages for a good overview, but you can combine and shorten sessions as needed, or only do session one, for example.

Experimenting with Oobleck is much more than having fun with a weird substance. As you follow the activities outlined in this booklet, your students develop important skills in the art of scientific investigation.

During the first activity session, students form small laboratory teams to investigate Oobleck, said to be an unknown substance from another planet. They learn how scientists describe the “properties” of a substance. During the lab session, they observe, hypothesize, and experiment with Oobleck to determine its unique properties.

In the second activity session, the lab teams hold a scientific convention to discuss and analyze their findings. Discussions about the behavior of Oobleck are always animated, because its unusual nature generates controversy. Students challenge each other to define the properties of Oobleck more accurately and refine their communications skills.

During the third session, your students become engineers, attempting to design a spacecraft that can land successfully on an ocean of Oobleck and then take off again without getting stuck.

In the last session, the methods students used to analyze Oobleck are compared to those of professional scientists. Students learn how scientists on the Mars Viking Project also explored the properties of an unknown substance—the red soil of the planet. Scientists discussed their results in scientific conventions and designed a spacecraft to land on Mars.

The “Oobleck experience” is appropriate for a wide range of age Ievels. Younger students tend to respond more positively to the open-ended, creative activities, while older students may become more involved in discussions. Shorten discussions if it seems appropriate and, in any case, try to provide extra time for suggested follow-up activities to capture your students’ imaginations. In this way, the energy and enthusiasm generated by this mysterious substance will help bring out the feelings of wonder, curiosity, and discovery that are at the heart of scientific investigation.

Time Frame

Teacher Preparation	45 minutes
Session 1: Lab Investigation	45 minutes
Session 2: Scientific Convention	25-45 minutes
Session 3: Spacecraft Design	60-90 minutes
Session 4: Scientific Methods	20 minutes

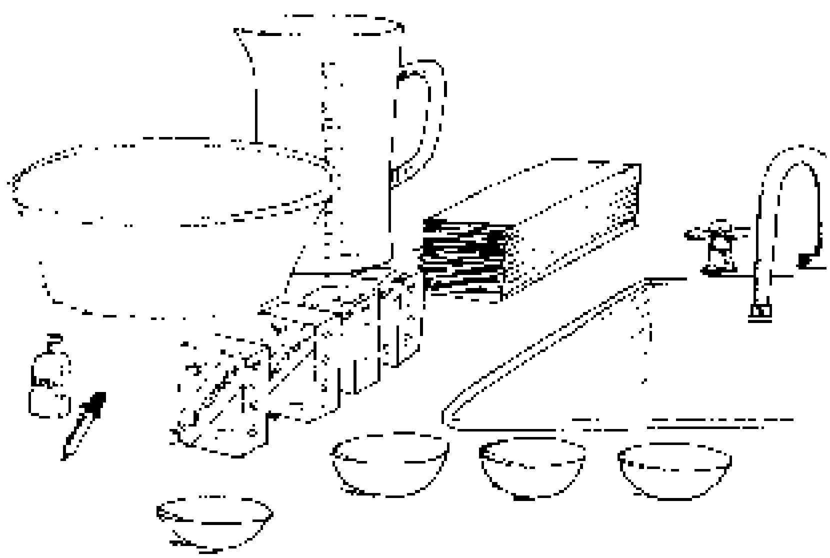
What You Need (for Sessions 1-4)

For the class:

☐ lots of old newspapers
☐ 1 roll of masking tape
☐ 1 small bottle of green **food coloring**
☐ 1 extra 16-oz. box of cornstarch
☐ 1 large mixing bowl or small bucket (6-8 liters)
☐ water
☐ paper towels
☐ chalk
☐ chalkboard
☐ poster of Viking Mission
☐ (optional) selection of small wood, paper, plastic, and metal items (e.g. toothpicks, popsicle sticks, plastic silverware, small paper cups, paper clips, straws, etc.)
☐ (optional) hot plate and saucepan

For each team of 4-6 students:

☐ 1 8" aluminum pie pan or deep plastic bowl
☐ 1 16-oz. box of cornstarch
☐ 1 felt-tipped marker or crayon
☐ 2 large sheets of paper (at least 16" x 20")



Session 1: Lab Investigation

What You Need

For each team of 4-6 students:

- ☐ 1 bowl of Oobleck
- ☐ 1 work station covered with old newspapers
- ☐ 1 large sheet of paper
- ☐ 1 felt-tipped marker or crayon

For the class:

- ☐ *1 equipment station*
- ☐ *water*
- ☐ *paper towels*

Getting Ready

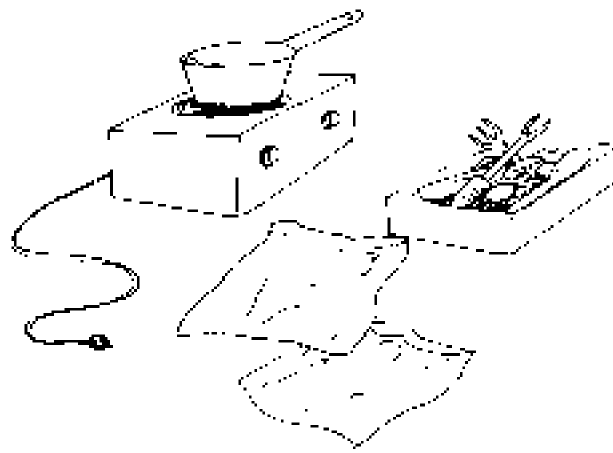
1. Preparation time. If possible, start mixing the Oobleck about two hours before class. Although it is possible to mix the Oobleck shortly before class, you can make any necessary adjustments more easily if you allow yourself more time. In any case, you should allow at least 45 minutes to prepare the Oobleck, and to set up the work stations and the equipment station for the lab investigation.

2. Prepare the Oobleck. The proportions used here—4 boxes cornstarch, 6¾ cups (1600 ml) water, and about 15 drops of food coloring—will make enough for six teams of students to have about 1½ cups of Oobleck each. Keep an additional box of cornstarch on the side to thicken the mixture in case it becomes too soupy.

To prepare the Oobleck, add 15 drops of green food coloring to 4¼ cups (1 liter) of water. Pour the light green water into a mixing bowl and add four boxes of cornstarch and another 2½ cups (600 ml) of water. Swirl and tip the bowl to level the contents, then place the bowl aside.

About 15 minutes before you plan to start the activity, mix the Oobleck by hand to ensure an even consistency. PLEASE NOTE: Some brands of cornstarch may require slightly different amounts of water, so you should always test the Oobleck as follows: the Oobleck should flow when you tip the bowl but feel like a solid when you hit it or rub your finger across the surface. If it is too thick to flow, add a little water. If it is too soupy, add a little more cornstarch. It is better to err slightly on the soupy side since some water will evaporate during the class. Pour about 1½ cups (350 ml) of Oobleck into each team's bowl. Then set the bowls aside until after you set the scene.

***3*. Prepare work areas.** Spread several sheets of newspaper on each table where a group of students will work. If there is a rug, you may wish to spread newspaper on the floor under the edge of each table. (Oobleck can be swept easily or vacuumed when it is dry, but the newspaper will make cleanup a little faster.)



***4*. Establish an equipment station (optional).** Students will discover the most important qualities of Oobleck by handling it, or by observing it in its container or while it dries on newspaper. If you wish, you can enrich and extend the testing phase by providing an assortment of materials at an equipment station. The station might contain a hot plate, a saucepan, plastic bags, and a selection of wood, metal, and plastic implements.

GO!

Setting the Scene

1. Tell your students that a space probe has just returned from a planet in another star system. The planet is covered with large, green oceans, and a sample of the ocean material was collected by space probe. Ask the students to imagine they are a group of space scientists gathering to investigate the properties of the ocean sample from outer space.

2. Explain that the material has been named "Oobleck" since it looks a bit like the green rain Dr. Seuss describes in his book Bartholomew and the Oobleck. *Show your students the containers of Oobleck.*

3. Mention that preliminary studies have shown that: (a) Oobleck is safe to handle; and (b) although we don't know for certain what it is made of, Oobleck seems to have a lot in common with some sort of starch mixed with water. Tell your students there is a team of chemists trying to find out its exact composition, and their results will be revealed when their research is completed.

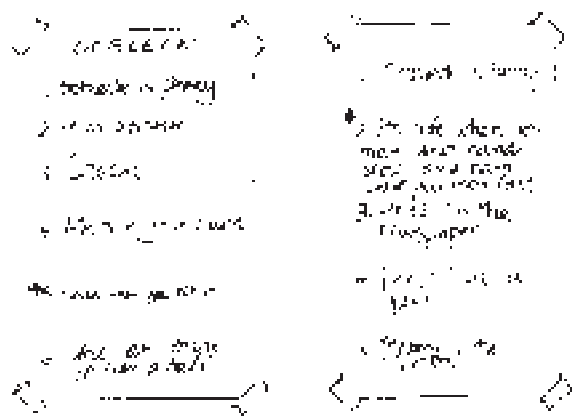
4. Explain to your students that their job is to investigate the properties of Oobleck. Use the following example to explain what is meant by "property of a substance" and to demonstrate the process of recording these properties. Do not spend longer than five minutes on this exercise, so your students will have most of the session to conduct their investigations of Oobleck.

a. Hold up a piece of chalk, and tell the students; "Raise your hand if you can describe this chalk from what you observe, or from what you have learned by using chalk." Common responses include: "It is white," "It is hard," "It leaves dust on your fingers," "You can write with it."

b. List the responses on the board, and number each one. If the students come up with statements based only on the appearance of chalk, say: "Let's do an experiment." (Drop a long piece of chalk so it breaks.) Ask: "What can we say about chalk based on this experiment?" Add their statements to the list.

c. Explain that the list on the board describes some of the properties of chalk. A *property* of a substance is something that can be seen, heard, smelled, felt by the senses, or detected by instruments—such as microscopes, telescopes, and thermometers—that are extensions of our senses. The color, size, shape, texture, weight, hardness, odor, and sound of a substance are examples of its properties.

5. When the group has listed at least five properties of chalk, remind them that their job is to determine the properties of Oobleck. Tell them to explore the Oobleck by observing and touching it, and (if you have set up the equipment station) by using the various materials at the equipment station. Urge them to use all of their senses **except taste.**



6. Organize the students into laboratory teams of four or five students each. Have each team sit around a table or desk covered with newspapers. Tell them that after they've had a chance to investigate the Oobleck for a few minutes with just their senses, you will bring around sheets of paper on which each team can record properties of Oobleck. At that time (if you have set up an equipment station), they may also choose various instruments to aid their investigation. Tell them to number the properties and to write using large, clear letters. One person from each team will need to wash his hands and be the Recorder. You may wish to have the teams designate their Recorders at this point.

7. Give each lab team one container of Oobleck, placing it on the newspapers to aid in cleanup. As the students investigate Oobleck, circulate from group to group encouraging them to touch the Oobleck with their fingers.

Experimenting with Oobleck is so engaging that the only way to get the attention of the entire class after they have begun exploring is to remove the containers. If you'd rather not collect the containers each time you have something to say to the entire class, going from group to group also provides an effective way to communicate with the class during this laboratory phase.

8. After the students have investigated Oobleck for about five minutes and discovered some of its weird properties, give each lab group a large sheet of paper and a felt-tipped marker or crayon. Help the students start recording the properties of Oobleck by circulating among the groups asking questions such as: "How does Oobleck behave when you press on it?" "When does Oobleck behave like a solid?" "When does Oobleck behave like a liquid?" Suggest that the students test their ideas by experimenting. For example, many students think that Oobleck turns to liquid because of the heat from their hands. Point to nearby pieces of wood or plastic, or containers they might use to test that idea. Help students learn to resolve disagreements by performing experiments or by discussing ways to describe a property so everyone on the team agrees.

9. Ask each laboratory team to put a star on their list next to the property of Oobleck they believe to be most important in explaining under what circumstances Oobleck acts as a solid or as a liquid.

10. You may want to end the investigation ten minutes before the bell rings so your students can help you clean up.

CLEANUP HINTS: Put the bowls of Oobleck aside until the next day so your students can see what it looks like when it dries. Reconstitute one or more of the bowls of Oobleck (by adding a little water) for use during the scientific convention. Dry Oobleck can be dumped into the wastebasket. **Do NOT pour Oobleck into the sink, as it is likely to clog the drain.** Do not attempt to mop up a large spill; scoop up most of it first, then wipe up the remaining Oobleck with a sponge.

Session 2: Scientific Convention

What You Need

For each team of 4-6 students:

☐ 1 bowl of Oobleck

For the class:

☐ lots of old newspapers
☐ water
☐ paper towels
☐ list of properties from Session 1
☐ chalkboard
☐ felt-ripped marker or crayon
☐ 1 roll of tape

Getting Ready

1. Use tape to post the lists of properties on the wall or chalkboard. Arrange the students' chairs in a semicircle so everyone can see the lists and each other.

2. Keep the bowls of Oobleck and newspapers on hand in case they are needed.

Setting the Scene

1. Explain to your students that professional scientists in most fields come from all over the world to attend meetings called ***scientific conventions***. The topic of one meeting might be "Heart Disease," while another meeting might concern "The Planet Mars" or "Earthquake Prediction." During a convention, scientists listen to each other's experimental results and critically discuss them. The goal of the convention is not to prove each other right or wrong, but to *find the truth and to state it as clearly and completely as possible.*

2. Tell the students that they are about to hold a scientific convention on Oobleck. The starred properties listed on the board are the scientific results they will discuss, according to the following rules:

a. Only one property of Oobleck will be discussed at a time. First, one lab team explains or demonstrates the experiments that led to the property they starred.

b. Students who wish to agree or disagree with the property being discussed are invited to raise their hands to explain why.

c. Encourage students to find ways to change the wording of a property so everyone can agree on it.

d. After fully discussing a property, vote on whether or not it is really a property of Oobleck. If three-quarters of the class votes for a property, it is called a "Law of Oobleck." To Illustrate what is meant by a law, tell the students that most scientists would agree that "water turns from liquid to solid below 32 degrees Fahrenheit," so that could be called a "law" of water.

Facilitating the Discussion

The scientific convention is one of the most exciting parts of the Qobleck experience because students are scientists when they debate their views and refine their statements of properties in order to seek the truth. Your role as facilitator of the discussion is critical to its success. Following are some suggestions for moderating a successful discussion:

• The process used to arrive at a "Law of Oobleck" can be lengthy. Some groups start squirming in **their** seats after 20 minutes. Other groups are still going strong after 45 minutes, If your students are deeply involved in the discussion, you may want to continue the discussion the following day so they can further refine their communication skills. Above all, be aware of the interest level of your class, and end the discussion when you think it is appropriate. While the ideal is for each group to present their starred property to the class, discussing and voting on one or two laws may be sufficient to highlight the importance of debate and communication in science.

• One way to maintain interest in the discussion is to break for five or ten minutes to allow all of the teams to test a particular property of Oobleck, then reconvene and share the results.

• Disagreements are starting points for fruitful discussions. After the first group has read their starred property and explained their choice, ask if anyone disagrees with that property. If no one challenges it, ask if anyone can think of a case where that property would ***not*** *be true.*

• Once you have provoked disagreement, challenge students to find ways of changing the wording so everyone can agree on the property. Following are some common ways of resolving problems you might suggest to students:

1. **Add a phrase.** For example, in one class one team listed this property: “Oobleck dries out when left on paper.” A student objected, saying that this is not true when Oobleck is put on paper for just a few seconds. The teacher resolved the disagreement by suggesting the students add the phrase, “for more than ten minutes.” Adding such qualifiers is the essence of good scientific reporting.

2. **Define terms.** One team listed the property: “Oobleck is sticky.” When challenged to define sticky, the students realized there are several different kinds of “stickiness.” After a brief debate, they changed the property to read: “Your finger will get stuck if you try to pull it out fast.” A discussion like this highlights the importance of using precise terms that are agreed on by every scientist who works in a given field.

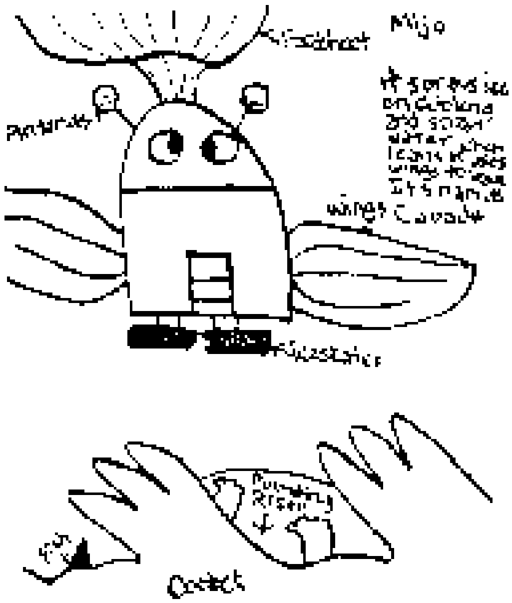
In some cases, further experiments can best resolve disagreements. By keeping bowls of Oobleck on hand during the convention, you can have two or three students do the experiment, or have all of the laboratory teams try it. For example, one team proposed that contact with air made Oobleck "liquidy." Another student suggested putting Oobleck into a plastic bag where it could not touch the air. It turned out to be just as "liquidy" in the bag as it was in the bowl. After the experiment the students voted not to make that particular property a law of Oobleck. Similarly, professional scientists sometimes report initial findings that later experiments show to be erroneous.

• Following is an excerpt from the scientific convention of one class (T = teacher, S = student).

T: Will someone from the first lab group read their most important property (the one with the star in front)?
S1: It's hard when you hit it.
T: Please explain why your group thinks that is true.
S1: Well, at first it's runny, but then when you hit it; it feels hard...your hand doesn't go in.
T: Does anyone have a comment on this statement?
S2: What if you hit it lightly? See (getting a bowl to demonstrate), if I hit it slowly, my hand goes in.
S1: Slowly isn't hitting, it's something else, like just touching.
S3: It gets hard when you rub your hand over the top. You don't even have to hit it.
S4: And when you try to pick it up.
T: Can anyone suggest a word that is better than hitting?
S5: What about pressing?
S6: You'd have to say "pressing hard" or "pressing fast."
T: (to S1) Is it okay with your lab group if we change the property to read, "Oobleck feels solid when you press it hard and fast?"
S1: (after consulting with classmates) Okay, I guess that's what we meant by hitting it.

T: All those who agree that "Oobleck feels solid when you press it hard and fast," raise your hands... Opposed?... Abstentions?... Okay, that's 18 in favor and two opposed, so we'll call it a "Law of Oobleck." (Teacher makes change on list and circles it.) Those of you who disagree may want to think of an experiment to try tomorrow that may convince the rest of the class.

T: Will someone from the second group please read their most important property?...



Session 3: Spacecraft Design

What You Need

For each student:

- ☐ 1 8 ½” x 11" sheet of white paper
- ☐ felt-tipped markers, crayons, or colored pencils

For the class:

- ☐ 1 roll of masking tape

Getting Ready

On the board, write out the “Laws of Oobleck” that the students agreed upon in Session 2.

Setting the Scene

1. Tell the students that their next assignment is to design a spacecraft that is able to land on an ocean of Oobleck, explore the whole planet, and take off again, with all passengers aboard.

2. Explain that the planet has conditions very much like those on Earth, except that the oceans are made of Oobleck and the sky is green. Review the “Laws of Oobleck” that resulted from the scientific convention. Tell the students that their designs must take these laws into account. Emphasize that the most important part of the assignment is to figure out how to build the spaceships so they can land safely on the Oobleck and take off again.

3. Tell the students to label those parts or features of their spacecraft that allow it to land and take off without sinking or getting stuck in the Oobleck.

4. Hand out paper and felt-tipped markers, crayons, or colored pencils so the students can draw, color, and label their designs.

To foster creativity and diversity, ***do not give specific hints about how to design the spacecraft.*** *With only the suggestions given here, elementary-school students have come up with very creative solutions to the Oobleck spacecraft problem. Some have built flying machines with thousands of little feet that continuously press on the Oobleck so it stays solid. Others have used a hovercraft concept, high speed cars, Oobleck dryers, or landing platforms with a detachable return shuttle.*

Designing and Discussing Spacecraft

1. Circulate among the students as they work, asking them how their spacecraft will land on the Oobleck and take off again. Remind them to label their drawings.

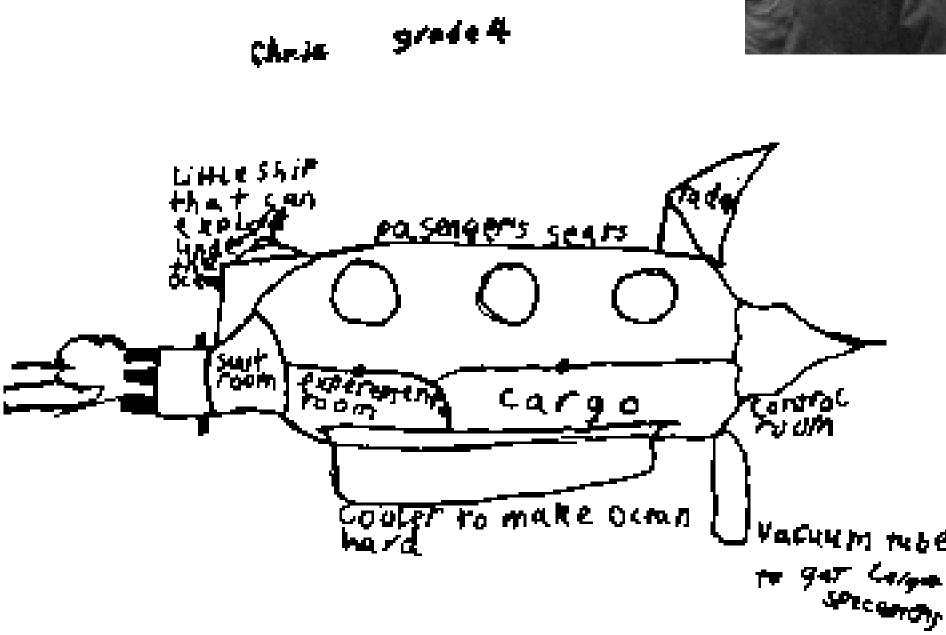
2. Some classes finish their drawings in one 45-minute session. However, many classes require additional time during the second 45-minute session to complete their drawings.

3. When the students are finished, allow five or ten minutes for them to circulate around the room to view each other's drawings.

4. Tell everyone to be seated and ask for volunteers to explain their drawings to the class. Invite one volunteer at a time to stand in front of the class, hold up her drawing, and explain how it will land on the Oobleck and take off again. Give every student who wants to a chance to present her design to the group.

5. Wrap up the presentations by asking the students which designs they think are most likely to survive the trip to and from the Oobleck ocean.

Students often get carried away creating their spacecrafts, including elaborate features that have little or nothing to do with landing the craft, such as laser cannons, force fields, and convertible roofs. These features are okay, but you may have to remind your students several times that the object is to create a spacecraft that can land on and take off from an ocean of Oobleck without sinking or getting stuck. This design challenge should be their first priority.



Session 4: Scientific Methods

What You Need

- ☐ poster from the Viking Mission
- ☐ (optional) opaque projector or slide projector
- ☐ (optional) slides or pictures from the Resources list (page 48)

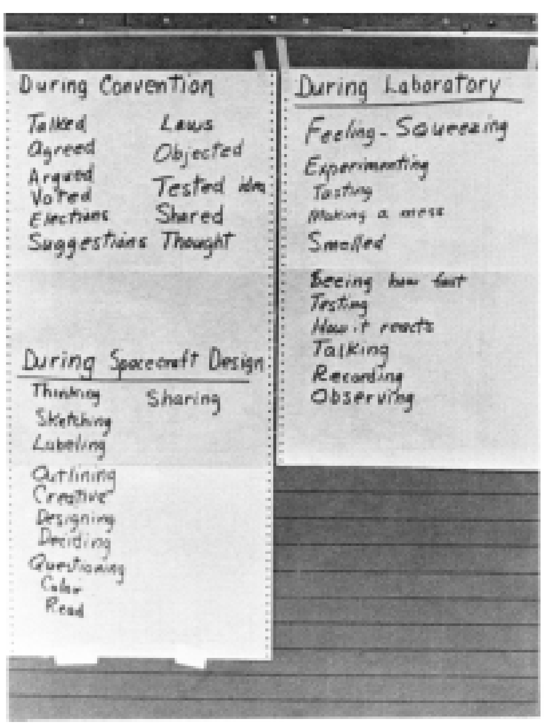
Getting Ready

At the top of the chalkboard write three headings: **LABORATORY**, **CONVENTION**, and **SPACECRAFT DESIGN**. Put the Viking Mission poster up where all the students can see it.

Setting the Scene

1. At this point you can announce that the team of chemists mentioned earlier has reported its findings on the exact composition of Oobleck. The scientists have revealed that Oobleck is made up of cornstarch, water, and green food coloring.

2. Remind your students that there were three parts to the Oobleck activity: a laboratory session, the scientific convention, and spacecraft design. Explain to them that during all of these activities they did many things that scientists also do.



Students as Scientists

1. Ask your students to describe some of the ways they behaved like scientists during the laboratory session. List their ideas on the chalkboard under the “LABORATORY” heading. Following is a typical list: looked, touched, smelled, wrote ideas, experimented, tested ideas, talked, used instruments (plastic spoons, etc.), compared Oobleck with things we know about.

2. Ask the students to list the ways they acted like scientists during the scientific convention. List their ideas under the “CONVENTION” heading. Here is what one class listed: talked, disagreed, argued, explained our experiments, changed words, defined words, criticized, did more experiments, voted, decided if we thought something was true.

The purpose of this part of the activity is to draw a parallel between what scientists and engineers do and what your students have done in investigating Oobleck, conducting a scientific convention, and designing spacecrafts. Sometimes groups have a hard time generating lists of ways they acted like scientists or engineers. In these situations, rather than trying to pull these responses out of them, go ahead and list haw you noticed them acting as scientists and engineers.

3. Ask the students to list the ways they acted like engineers when they designed spacecrafts to land on the ocean of Oobleck. List their ideas under the “SPACECRAFT DESIGN” heading. They might come up with a list like this: drew pictures, thought about laws of Oobleck, invented machines, imagined walking on Oobleck, changed ideas.

4. Explain that these ***scientific methods*** are used by professional scientists. As an example, show the poster with the photo of Mars taken from the Viking Spacecraft. Here’s how you can explain to your students how scientific work on Viking was similar to their work with Oobleck:

a. Viking was a robot space probe sent to Mars to explore its surface. The first thing that Viking did was to use its camera to *look* at Mars just as you looked at Oobleck. This is what the camera saw. The large rock is about seven feet long. You can also see that there are sand dunes on Mars, and that the color of the rocks, soil, and atmosphere is reddish-pink. This television picture was transmitted back to Earth, where scientists could study it and learn about the properties of the Martian surface, just as you learned about the properties of Oobleck.

b. The first small drawing on the poster shows the Viking spacecraft. Notice the long robot arm in front, used to “touch” the surface and pick up a soil sample. The arm put the soil into the spacecraft where remote-control experiments were done to find out if there were any Martian life forms. No life forms were found. One instrument “smelled” the gases given off, by analyzing their chemical content. Another instrument “listened” for vibrations that would incidate a “marsquake.” The “dish” at the top of the spacecraft is an antenna used to send information about Mars back to Earth. So, the Viking robot used all of its senses and communicated its findings just like you did when you first explored Oobleck.

c. The second small drawing shows the scientists in charge of the project voting on where the second Viking spacecraft should land. What part of the Oobleck experience does this remind you of? You may want to add that, on most issues, scientists do not actually vote by raising their hands, but rather by continuing to discuss and experiment. Even if most scientists agree on the correctness of an idea, one scientist can always come up with a new experiment or argument that will change the opinions of nearly all the others.

d. The third small drawing shows a spaceship designed to land people on Mars. The engineers who designed this spaceship used information about the properties of the Martian surface gained from Project Viking. What part of the Oobleck experience does this remind you of?

Going Further

1. One fascinating way to deepen this unit is to ask your students to pretend that they have “microscope” eyes and to imagine that they can see what Oobleck molecules look like. Can they imagine how the structure of Oobleck’s molecules can explain why it behaves as it does? Suggest that students draw what they visualize and share their ideas with the class.

2. Following Session 3, Spacecraft Design, provide students with an array of materials and fresh bowls of Oobleck to test their ideas about how to keep a spacecraft from getting stuck. You might provide different substances such as wood, metal, glass, plastic, and cardboard to see which ones float on the surface and which ones stick to it. You could also provide springs for bouncing on the Oobleck, or rubber bands to see how much force is needed to pull a spacecraft off the surface. If your students become deeply involved in this activity, you might invite them to bring in materials from home.

Many teachers have extended and built upon “the Oobleck experience” by having students actually construct landing crafts from various materials, such as straws, toothpicks, balloons, meat traps, paper/ styrofoam cups, packing materials, etc. The crafts must be able to land on and sit upon a large tray/pan of Oobleck for five seconds, and then be able to “take off” (be lifted off) without sinking or getting stuck in the Oobleck.

3. Explain to the students how they can make Oobleck at home for additional experiments. Tell them to get one box of cornstarch, put most of it into a bowl, then add water, little by little, mixing until it feels like the substance they used in class. Then they can add food coloring, any color they want. If it is too soupy, they should add a little more cornstarch. Of course, remind them about cleanup precautions and methods.

3. Ask your students to make up stories about creatures who live on the planet with the green Oobleck oceans. How do these creatures survive if they fall into the ocean? What do they eat? What do they look like? What are some of their social customs? How would they respond to visitors from Earth?

4. Ask your students to make up stories about creatures who live on the planet with the green Oobleck oceans. How do these creatures survive if they fall into the ocean? What do they eat? What do they look like? What are some of their social customs? How might they respond to visitors from Earth?

RESOURCES

The following sources can provide pictures and other materials about Project Viking:

- **Slides** can be purchased from:

  MMI Space Science Corporation
  2950 Wyman Parkway
  Baltimore, MD 21211

  Phone: (301) 366-1222

  Viking I and II
  1012-B 20 slides (14 color, 6 b/w)
  1012-C 40 slides with cassette

  NASA
  300 “E” Street SW
  Washington, D.C. 20546
  (202) 358-0000

  Ask for photo index book and price list.

- **Films:**

  National Aeronautics and Space Administration (NASA) films may be ordered for the cost of return postage and insurance from your NASA branch office. For a film catalogue and the address of your local office, write or call:

  NASA
  300 “E” Street SW
  Washington, D.C. 20546
  (202) 358-0000

  If you have a computer and modem, you may be interested in Space-link, a computerized information service offered to teachers by NASA. Current and historical material, as well as lesson plans and classroom activities, can be accessed. To access Space-link, call (via modem) (205) 895-0028.

  The NASA/Goddard Space Flight Center has a Teacher Resource Laboratory (TRL).
  Call (301) 286-8570 or (301) 286-7205.
  The office is closed Sunday and Monday.

- **Articles** are featured in National Geographic magazine, January 1977.

- **Books** on this topic are available from:
  Superintendent of Documents
  U.S. Government Printing Office
  Washington, D.C. 20402

  These books include:

  Viking Orbiter View of Mars (catalog no. 033-000-00-795-7), $11.00.

  Mars: The Viking Discoveries (catalog no. 033-000-00-703-5), $2.75.

- A wide variety of related materials on astronomy is available from:

  Astronomical Society of the Pacific
  1290 24th Avenue
  San Francisco, CA 94122
  Write to ask for the current catalogue.

ICE CREAM AND FREEZING POINT DEPRESSION

Category:
Chemical Engineering or Properties of Water

Concepts:
States of matter, freezing point depression

Objective:
To explore change in matter (solid, liquid, gas) and understand freezing point depression by making ice cream appear! (and quickly disappear.)

Materials per team of two:
Recipe posted on wall or handed out
1 large and 1 small coffee can with plastic lids
Measuring cups and spoons
½ cup half and half
4 tsp. sugar
½ tsp. vanilla
2 spoons
paper towels

Materials for whole group:
ice (3-4 bags for a group of 30)
rock salt - 1 bag (available at grocery stores)

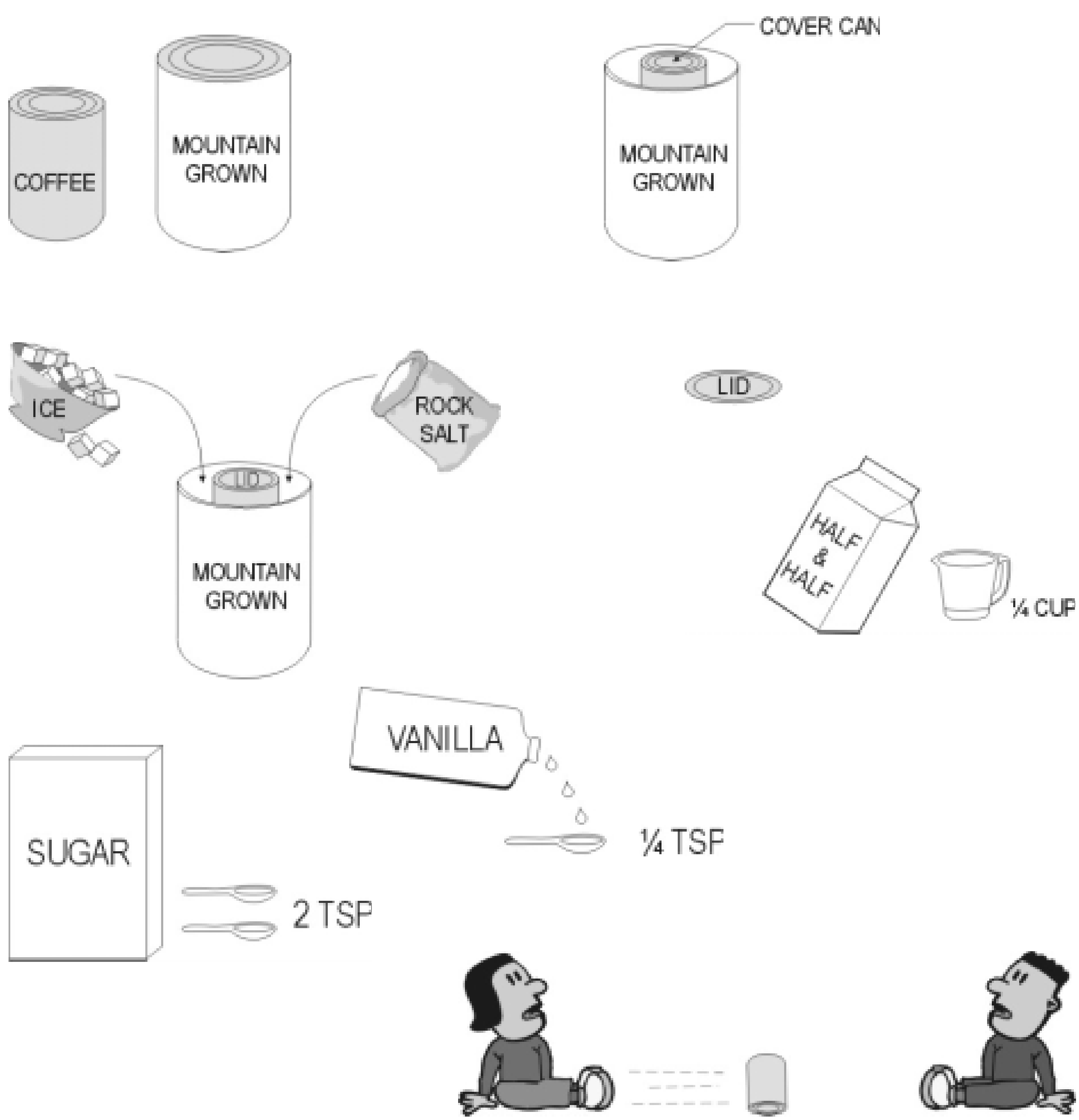
Introduction: A good introduction is the ice cube, salt and string demonstration found at http://student.biology.arizona.edu/sciconn, and also listed on our page of science web sites. Ask what the three states of water are. Ask for some examples of water going back and forth from one phase to another. What happens when water gets very cold? (It turns into ice - a solid). What is condensation, evaporation, freezing, melting?

Freezing point (or melting point) depression is the difference in temperature between the freezing point of a solution (when the solid and liquid states are in equilibrium) and the freezing point of the solvent.

Procedure:
1) Have each team measure the half and half, sugar, and vanilla into their small can. Replace lid tightly
2) Place small can inside the large can.
3) Fill in around the small can with 4 parts ice to 1 part rock salt. Put in a little ice, then rock salt; then more ice, more rock salt, more ice and the rest of the rock salt.
4) Put large can's lid on, and sit on the floor with your partner.
5) Roll can back and forth to each other and watch the frost form on the outer can.

6) In about 5-6 minutes, wipe off the inner lid and check to see if the solution has become ice cream yet. When it's firm, dig in! *Be sure to clean lid off well before removing it so you don't get salt in the small, inner can where the ice cream is. Yuck!

Explanation: As the ice in the outer can melts, the ice cream freezes. Since salt has a higher melting point, adding salt absorbs heat, cooling off the ice in the outer can. The ice and salt mixture melts at a lower temperature because the salt depresses or lowers the freezing point of the water. With the lowered temperature in the can, the ice cream quickly freezes. Ice alone will not freeze the cream solution.



Flight/Aerospace Engineering

Flight/Aerospace Engineering

A Six-week or One-week Format

Concepts: aerodynamics, buoyancy, drag, energy, friction, gravity, lift, and thrust are terms that you can toss around and become familiar with during this unit! See glossary for definitions. As the weeks go by, weave these words into casual discussion during the projects, as well as career possibilities in related fields.

At each meeting or center, the children make a different vehicle. They test it, then have opportunity to adjust and refine it to improve performance. There are almost countless vehicles to choose from, some of which are included here. Search the internet and see our recommendations for web sites offering many wonderful paper airplanes, helicopters, rockets, and more.

Career options include jet engine mechanic, air traffic controller, aerospace and mechanical engineers, defense weapons developers, and all kinds of pilots, including commercial, bush, border patrol, and search and rescue. There are undoubtedly many more jobs related to this field as well. Can you think of some other jobs related to this field?

Week one: Rocket Glyph, Fantastic Garbage Bag Blow Up! and Paper Helicopters or Airplanes

Week two: Parachutes or Balloons Aloft

Week three: Balloon Rockets or Paper Rockets

Week four: 3-2-1-Pop Rockets or *Bottle Rockets (*need wide open outdoor space and launcher). May require 2 sessions, but well worth it! We borrowed a launcher.

Week five: Rocket Racers or Bottle Rockets (make altitude trackers for next week)

Week six: Have several competitions - paper airplanes (longest flight, most loops, fastest), highest bottle rocket, longest distance for rocket racer, etc.)

Comments: We did these activities at several sites, both as six-week programs and one-week camps. The activities are engaging and allow for adjustments to the original designs. Each takes about 45 minutes to an hour and a half, depending on how much time you allow for redesign and testing. Set a tone of scientific experimentation at the first meeting. (They are design engineers trying to perfect that particular vehicle). Each week the girls make the prescribed vehicle, test it, and then make adjustments and refinements at their own pace, retesting as they go, for speed, height, accuracy, or whatever the case may be. It creates the atmosphere of a testing lab, rather than a craft or toy project. In later projects, girls will be quick to redesign something that isn't working, as we saw when we later made kaleidoscopes with the same troop of girls!

Encourage the girls to think about the science behind the activity. Ask leading questions to get the girls to consider and verbalize concepts such as friction and gravity, and to begin thinking about ideas such as lift and drag. For example: What things fly? (Birds, planes, jets, mosquitos). What do they have in common? (Wings, fuel source). What makes something fly? (*Hmmmm*) What causes something to fall from the air? (Out of fuel, gravity, broken wing) Why do some things fall more slowly than others? (Like a feather vs. a rock.) Why would you want something to fall more slowly? They may come up with the concepts or words friction, gravity, energy, etc.

ROCKET GLYPH

We often used “glyphs” as an ice breaker when first meeting with a group, or introducing a new set of activities. A glyph always contains information about the individual making it. The information you request can vary according to the group, or the purpose of the gathering. The glyph can also be used as the invitation to the parents for the culminating event.

For one of our water camps, the glyphs were made out of water bottles, with a certain amount and color of water in it, according to favorite color and favorite subject in school, gummy fish (one for each family member), stickers for grade in school, etc.

The rocket glyph on the next page is pretty self-explanatory. If you want it to double as a name tag, simply cut it out, punch a hole near the top and thread some yarn through it so it can go around the neck.

Graphing with Glyphs

Sounds like one of those do it yourself TV shows, but trust me - this is a sneaky and entertaining way to introduce graphs! Just have the kids gather round an open floor space with their completed glyphs and you can graph any information you’ve collected on the glyph.

For example, “Everyone who chose ‘chocolate’ for their favorite ice cream, put their glyph in this column.” (Just lay them out on the floor in columns and rows.) “ Everyone who chose ‘vanilla’, place theirs in this column. Those who picked ‘other’, put your glyph in this column.” Guess what? You are looking at a bar graph! Then you can make observations about the statistics in the group. “Oh, I see that six out of nine like chocolate best.” Let them count how many like vanilla best, and so on.

Now let them choose another item from the glyph to graph. Line up all those whose favorite animal is the horse, cat, dog, etc.

Try grouping them together as you would see on a pie chart or some other kind of graph.

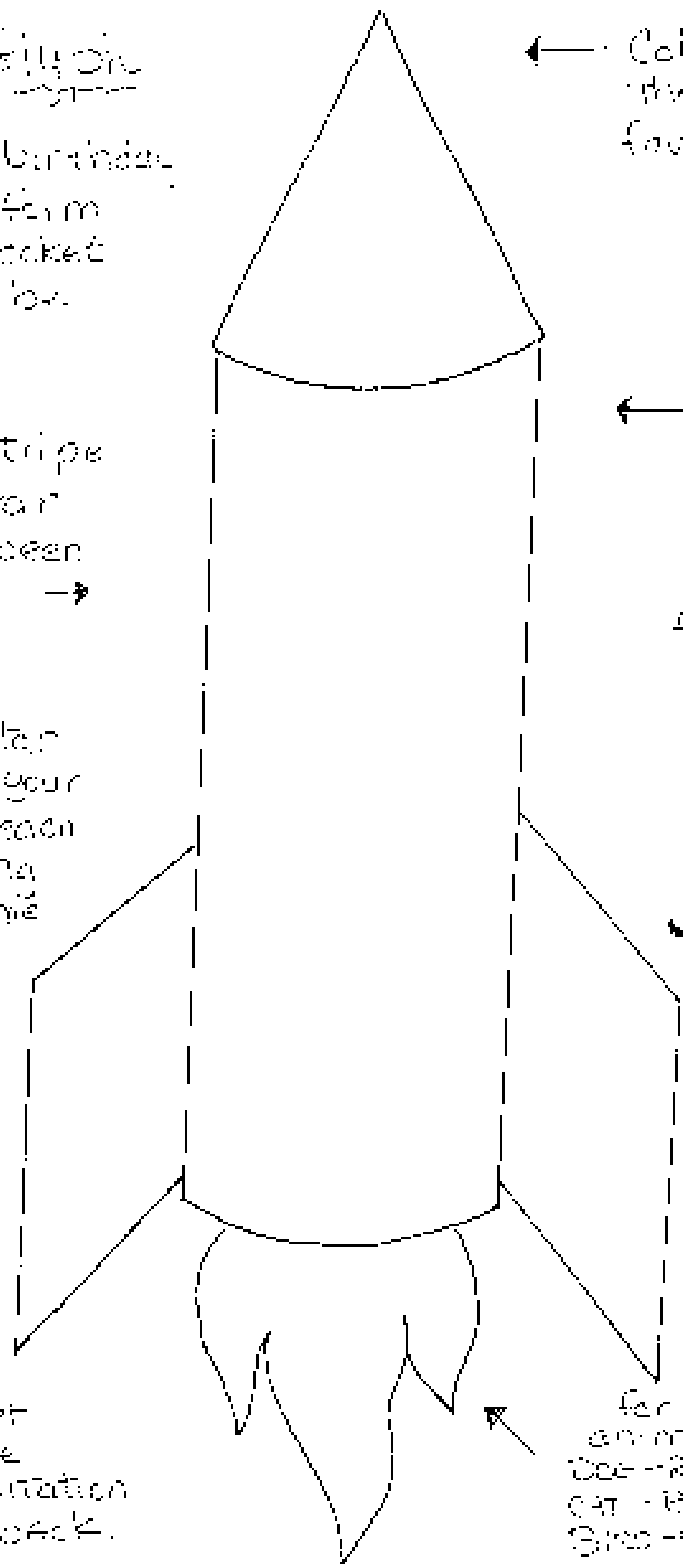
Very fun, and when they see charts and graphs in school, they will have a better understanding of how they work and what their purpose is.

Rocket Glyph

Write your birthday in number form on your rocket (729 would be July 29).

Draw one stripe for each year you have been in school. →

Place one star sticker on your rocket for each person living in your home.



← Color the cone the color of your favorite ice cream

← - Write your name on the body, then color it your favorite color

← Color the fins green if you would like to travel in space, red if you would not.

Color the flames for your favorite animal:
Dog - RED
Horse - orange
Cat - Blue
Whale - pink
Bird - yellow
other - purple

LAST - cut out the rocket and write your invitation on the back.

THE FANTASTIC GARBAGE BAG BLOW-UP! [1]

Category: Flight

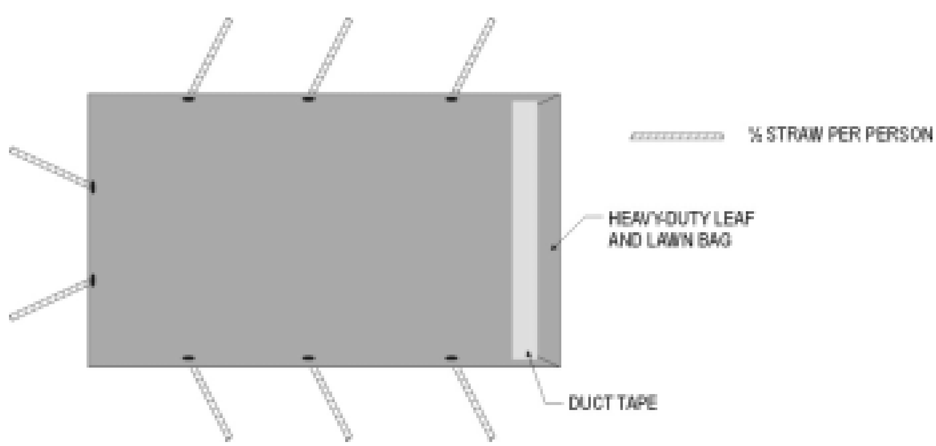
Objective: To challenge your thinking about air, force, energy
Compressed air: Air under greater than atmospheric pressure can exert force on an object.

Materials:
- Roll of duct tape
- Package of drinking straws
- Several heavy-duty leaf and lawn bags

Introduction:
Begin by gathering the girls and asking if they think it is possible for a group of girls to lift another girl off the ground by blowing air into a garbage bag on which she is sitting. You can even lead up to this by first asking if they think it's possible to raise a book off a table by blowing air into a bag under the book.

Procedure:
1) Cut some straws in half at an angle.
2) Have each of about 6-8 girls press a straw through one layer of the bag at even intervals around the edge. At the open edge go several inches in so you have room to duct tape it closed. **Hint:** Do this before sealing the bag; it will be **much** easier.
3) Then have them wrap pieces of duct tape around the straw where it enters the bag, so no air can escape around the straw.
4) Fold the open end of the bag over and seal it with duct tape.
5) Next, have a girl remove her shoes, (optional, but it saves wear and tear on the bag) and sit cross-legged on the bag.
6) Have the other girls position themselves around the bag and blow into the straws. When they are not blowing into a straw, pinch that straw closed so air will not escape.
(If you want to start with lifting a book, use a small plastic bag on a table.)

Insert 2 - 3 straws to a side and 2 at each end depending on the number of kids you have.



[1] *Adapted from the National Science Partnership for Girl Scouts and Sciences Museums, http://sln.fi.edu/tfi/programs/nsp.html.*

BECOME A PAPER HELICOPTER ENGINEER

Category:
Flight

Objective:
To make and modify a model helicopter

Procedure:

1) Use the Paper Helicopters sheet. Cut on solid lines, fold on dotted lines and add two paper clips to create the prototype paper helicopter shown on the page.

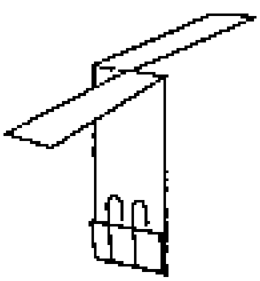
2) Explore the effect of changing some or all of these variables:

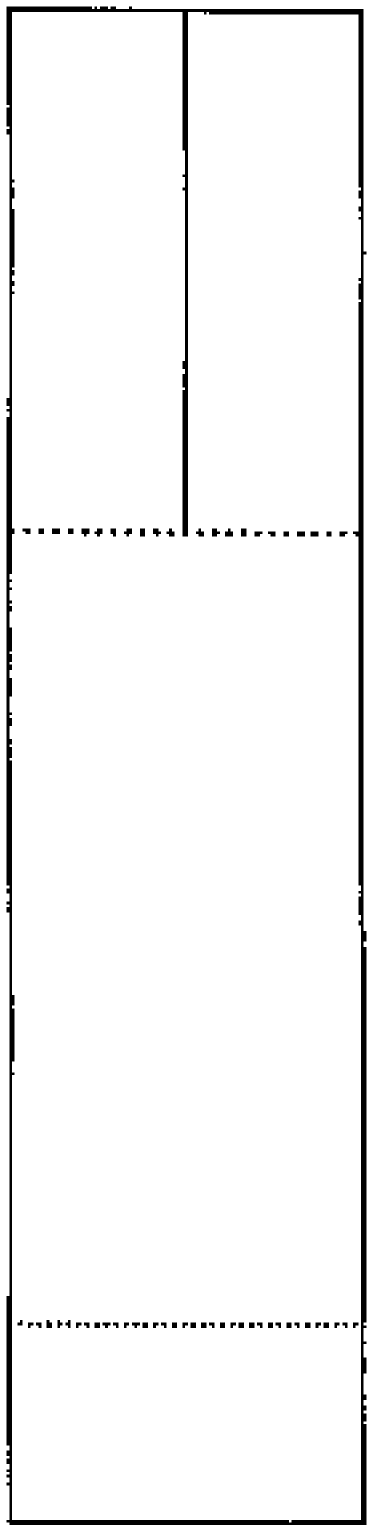
- **Material:** Use construction paper, card stock, tissue paper, foil, waxed paper, or ...
- **Rotor blades:** Change the length, width, number, shape, or ...
- **Helicopter body:** Change the length, width, shape, or ...
- **Weighting system:** Use more or fewer paper clips, place paper clips in other locations, or use smaller or larger paper clips, use something else as a weight, or ...

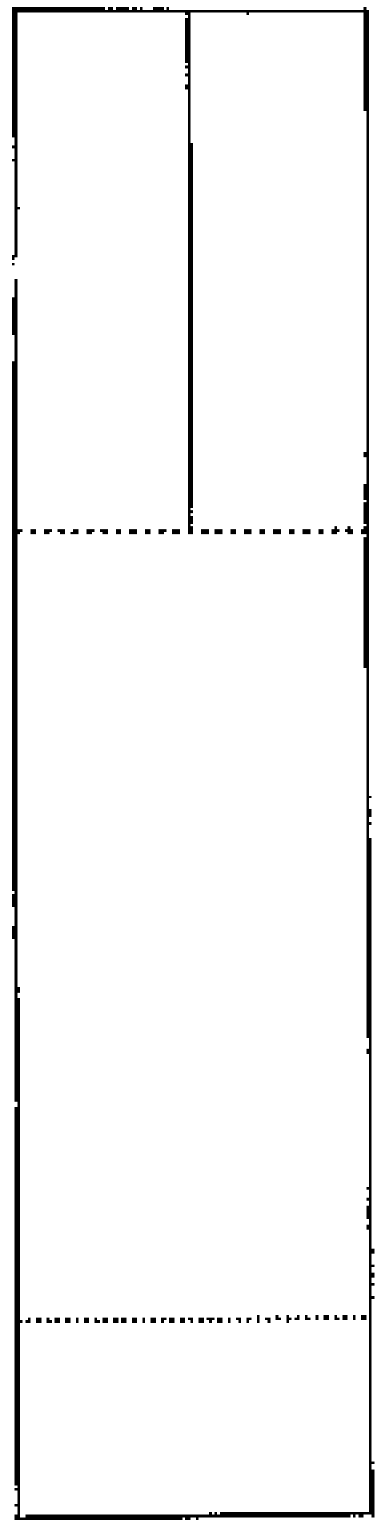
3) Determine your definition of a "GOOD" paper helicopter. Be prepared to demonstrate your best design and to explain its features.

This activity has been adapted from "Nosebag Science: Quick and Easy Activities", Bridging the Gap,a collaboration between Discovery Place, Inc. and Hornet's Nest Girl Scout Council, http://www.discoveryplace.org.

Paper Helicopters







SIMPLE PARACHUTE

Category:
Flight

Objective:
Make and modify parachutes and time their descent. The slower, the better.

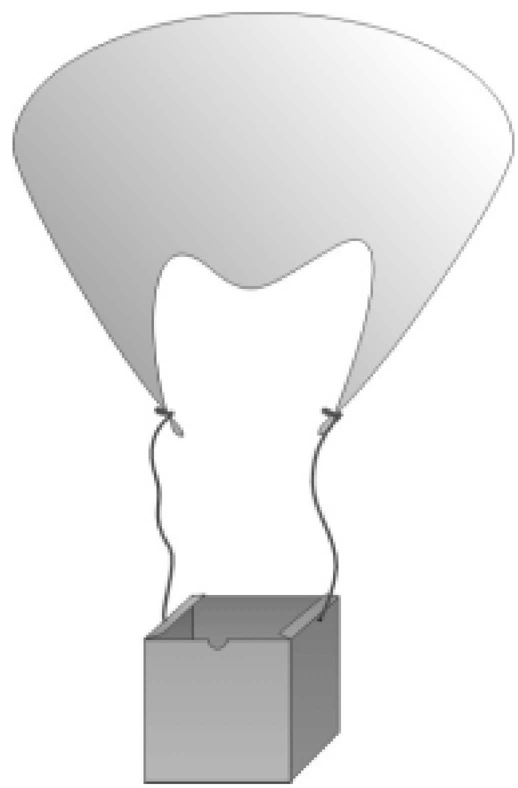
Concepts:
Drag, gravity

Materials:
Thread, scissors, tape, paper towels, plastic wrap, handkerchiefs, tin foil, pencils, markers, construction paper or thin cardboard (like cereal box), box template (included on next page), paper clips or pennies, stop watch or watch with second hand.

Introduction: What happens when a rock falls or is thrown from a great height? Why might you want something to fall more slowly? What's the purpose of a parachute? How does it work? What are some materials we might try for the chute?

Create a story line for the exercise. For example, ask the girls to become aeronautical engineers or design engineers who have been hired to make a parachute that will fall as slowly as possible because it is carrying weather equipment, or fragile supplies to people who need food or medicine.

Procedures: 1) Tie thread to each corner of whatever you have chosen for your parachute material. (The thread should be about 1and ½ times the length of the parachute material. Ten inches square is a good approximate size for the chute so the thread should be about 15 inches long.)

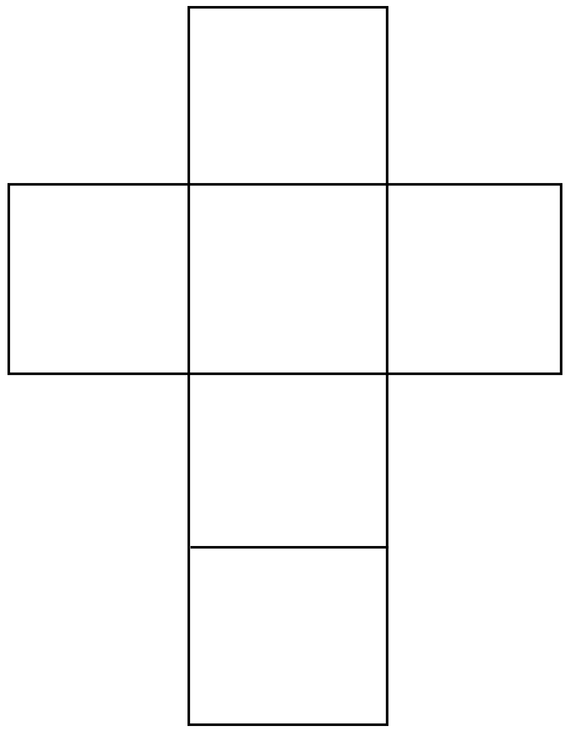


2) Next, attach the loose ends of the thread to the object you want to carry. A lightweight toy, a person cut out of cardboard, or a box all work well. There's a template for the box in this book; just fold it on the lines, and tape it closed. If you use a box or cardboard person, use a paper clip or penny for weight.

3) You are now ready to stand on something high and test your parachute. Be careful! Another person can time the descent and a third person can record the results.

Variables: If you want to try for a better time, you may want to change one variable at a time and see what works. Things to consider: thread length, weight, chute material.

Wrap up: What do you think makes the parachute fall more slowly/ What do you think of the tin foil? What other materials might you use for a parachute? If the word "gravity" has come up, ask "What is gravity?"



Box Template

BALLOONS ALOFT

Category:
Rockets and Flight

Objective:
To lift an object into the air and have it hover, using helium-filled balloons

Concepts:
Buoyancy, density, gravity. Helium's density is less than air density, so it rises. Gravity wants to pull down on the objects, and so you need to get just the right balance for it to hover.

Materials:
These quantities were used for a group of about 30, working in groups of 4-5.

- helium tank (can be rented from party store)
- 75-80 helium-quality balloons (or number that the tank can fill)
- a roll of string or ribbon (should be supplied when you buy the balloons and helium)
- scissors for each group
- tape
- hole punchers
- small, lightweight boxes such as tea bags or butter come in, tiny baskets, or plastic tubs
- ballast (small objects to use as weights) or passengers - tiny stuffed animals, action figures, pennies

Procedure: This activity is best accomplished indoors for obvious reasons!
If you have more than one adult, one can take a few kids and inflate balloons while the other starts the meeting, plays a game, or does another activity. If you work alone with a small group, have the kids help you inflate and tie the balloons. One can hand you balloons, one can cut string (3 foot lengths), one can tie them onto the knotted balloons. Another can secure them in bunches of eight or ten to chair backs until they are needed.

When the balloons are all inflated and bundled, present the challenge. The task is to make the bunch of balloons and its basket hover in midair. Have a variety of supplies to choose from. Let them explore on their own - very little direction is needed. If the contraption begins to take off, it's easy to think of adding weight. However, it is more apt to be too heavy and sink to the ground. Let them work it out on their own. Tell them they can make any modifications necessary to get it to hover. If they need hints on lightening the load, mention that you wonder what they might do with the scissors. (If even the paper box is too heavy, they could start cutting parts of it out to lighten the load.) They could also make the strings or ribbons shorter. If they started with a butter tub, they may change to a basket or paper box. Anything goes. After a decent interval (half an hour or so), and if you have extra balloons inflated, they could add more balloons.

That's it. A short discussion on buoyancy could follow. Nothing too weighty. (Buoyancy is the tendency or capacity to float or rise through liquid, air or gas and it depends on the difference between the density of the object and, in this case, the air.)

BALLOON ROCKET

Category:
Flight

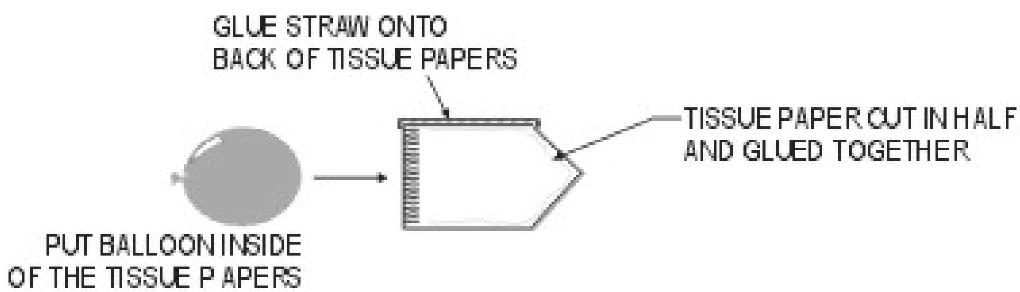
Objective:
To race a balloon along a string.

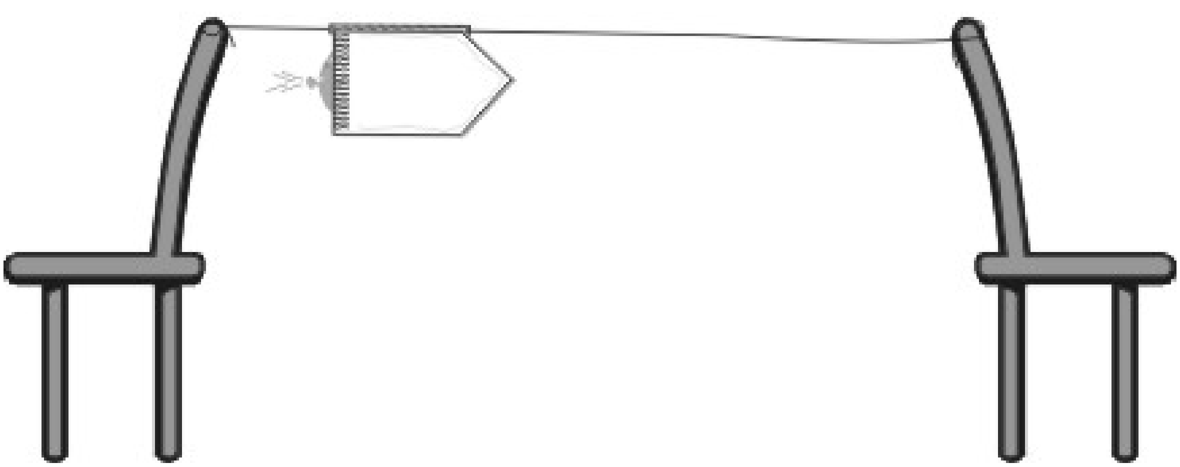
Concepts:
Energy source, friction, drag

Materials:
Two chairs, string, tissue paper, different sized balloons, straws, tape, colored markers, light-weight decorations like sequins, measuring tape.

Procedure:
Dress up an old-fashioned balloon rocket for the 21st century.

1) Blow up the balloon and measure around the fattest part.





2) Cut two pieces of tissue paper about the same length as the balloon and a little more than half as wide. Cut the front ends to a point.

3) Glue them together on the sides and front so it's like an envelope. Decorate it with a few lightweight sequins or magic marker designs.

4)Tape the straw to it (the long way). Fringe the (back end) opening.

5) Blow up your balloon and see if it fits into it. Let the air out.

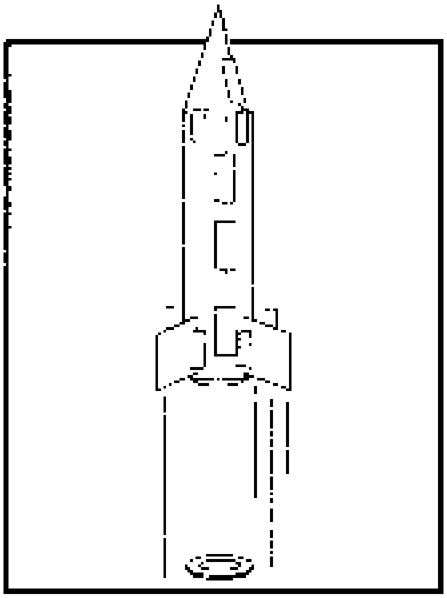
6) Put the string through the straw (which is now taped to the balloon envelope) and attach one end of the string to the back of a chair. Place the other chair about twenty feet away, pull the line tight and tie it to that chair. Now your rocket is suspended from a tight line or track.

7) Blow up the balloon again and pinch it closed until you're ready to race. When you're ready, let go! See how far along the string your rocket blasts! To race someone else, simply set up another string between the two chairs and have two people go at once.

You may find some other instructions at: http://www.planetary.org/learn/activities/BalloonRocket.html.

Variables

Experiment with:
Materials for the track: string, wire, monofilament fishing line, etc.
Different sized balloon
Different shaped balloon
Length of the straw
Material for the envelope: tissue paper, plastic bag, plastic wrap, paper bag



Teacher Information

3-2-1 POP!

Objective:
To demonstrate how rocket liftoff is an application of Newton's Laws of Motion.

Description:
Students construct a rocket powered by the pressure generated from an effervescing antacid tablet reacting with water.

Science Standards:
Physical Science - Position and motion of objects
Science and Technology - Abilities of technological design - Understanding about science and technology

Process Skills:
Observing
Communicating
Making Models
Inferring

Management:
For best results, students should work in pairs. It will take approximately 40 to 45 minutes to complete the activity. Make samples of rockets in various stages of completion available for students to study. This will help some students visualize the construction steps.

A single sheet of paper is sufficient to make a rocket. Be sure to tell the students to plan how they are going to use the paper. Let the students decide whether to cut the paper the short or long direction to make the body tube of the rocket. This will lead to rockets of different lengths for flight comparison.

The most common mistakes in constructing the rocket are: forgetting to tape the film canister to the rocket body, failing to mount the canister with the lid end down, and not extending the canister far enough from the paper tube to make snapping the lid easy. Some students may have difficulty in forming the cone. To make a cone, cut out a "Pacman" shape from a circle and curl it into a cone. See the pattern on the next page. Cones can be any size.

Materials and Tools:
- Heavy paper (60-110 index stock or construction paper)
- Plastic 35 mm film canister*
- Student sheets
- Cellophane tape
- Scissors
- Effervescing antacid tablet
- Paper towels
- Water
- Eye protection

* The film canister must have an internal-sealing lid. See management section for more details.

Film canisters are available from camera shops and stores where photographic processing takes place. These businesses recycle the canisters and are often willing to donate them for educational use. Be sure to obtain canisters with the internal sealing lid. These are usually translucent canisters. Canisters with the external lid (lid that wraps around the canister rim) will not work. These are usually opaque canisters.

Background Information:
This activity is a simple but exciting demonstration of Newton's Laws of Motion. The rocket lifts off because it is acted upon by an unbalanced force (First Law). This is the force produced when the lid blows off by the gas formed in the canister. The rocket travels upward with a force that is equal and opposite to the downward force propelling the water, gas, and lid (Third Law). The amount of force is directly proportional to the mass of water and gas expelled from the canister and how fast it accelerates (Second Law). For a more complete discussion of Newton's Laws of Motion, see pages 13-17 in this guide.

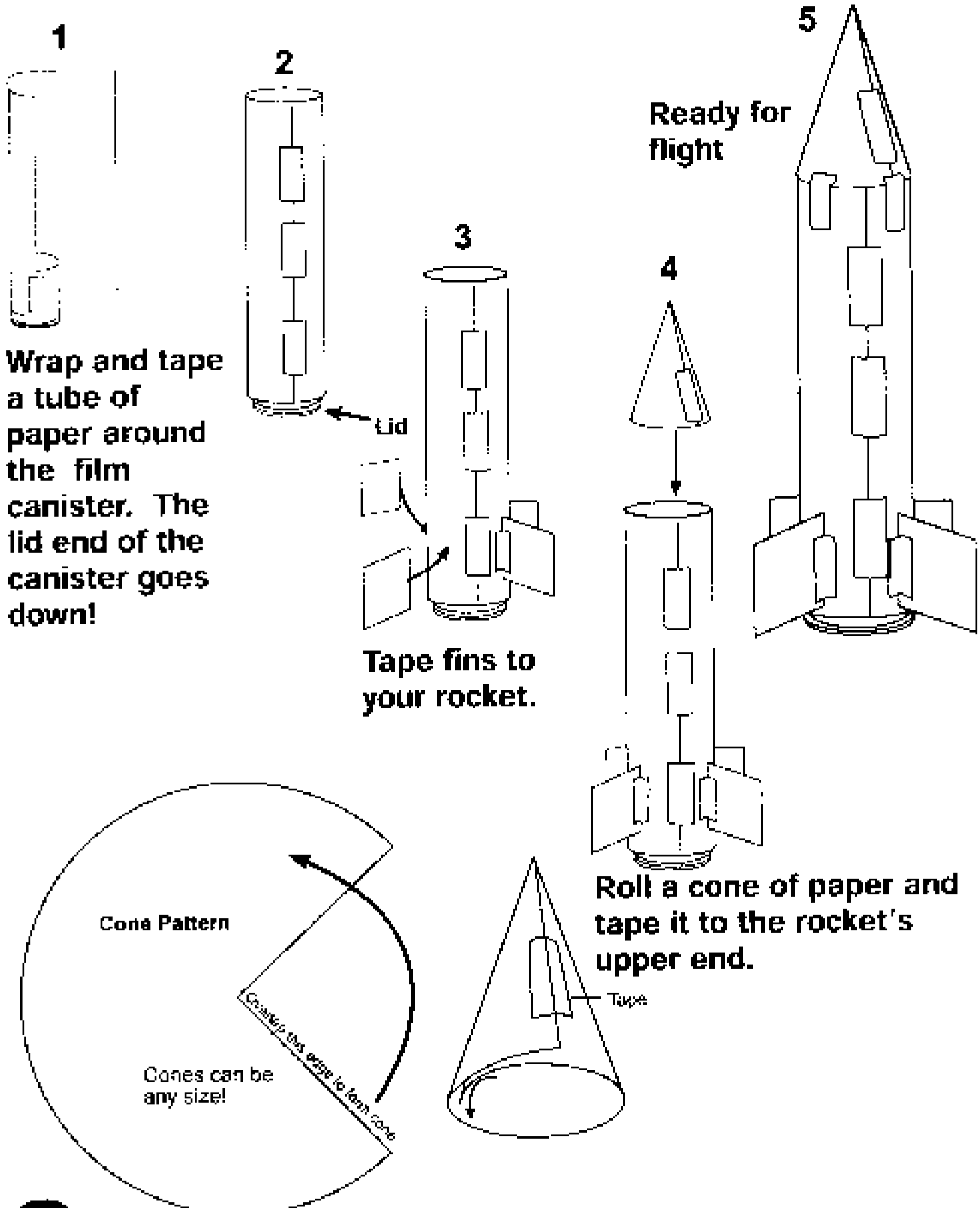
Procedure:
Refer to the Student Sheet.

Discussion:
- How does the amount of water placed in the cylinder affect how high the rocket will fly?
- How does the temperature of the water affect how high the rocket will fly?
- How does the amount of the tablet used affect how high the rocket will fly?
- How does the length or empty weight of the rocket affect how high the rocket will fly?
- How would it be possible to create a two-stage rocket?

Assessment:
Ask students to explain how Newton's Laws of Motion apply to this rocket. Compare the rockets for skill in construction. Rockets that use excessive paper and tape are likely to be less efficient fliers because they carry additional weight.

Extensions:
- Hold an altitude contest to see which rockets fly the highest. Launch the rockets near a wall in a room with a high ceiling. Tape a tape measure to the wall. Stand back and observe how high the rockets travel upward along the wall. Let all students take turns measuring rocket altitudes
- What geometric shapes are present in a rocket?
- Use the discussion questions to design experiments with the rockets. Graph your results.

3-2-1 POP!


1
2
3
4
5
Ready for flight
Wrap and tape a tube of paper around the film canister. The lid end of the canister goes down!
Lid
Tape fins to your rocket.
Roll a cone of paper and tape it to the rocket's upper end.
Cone Pattern
Overlap this edge to form cone
Cones can be any size!
Tape

ROCKETEER NAMES

____

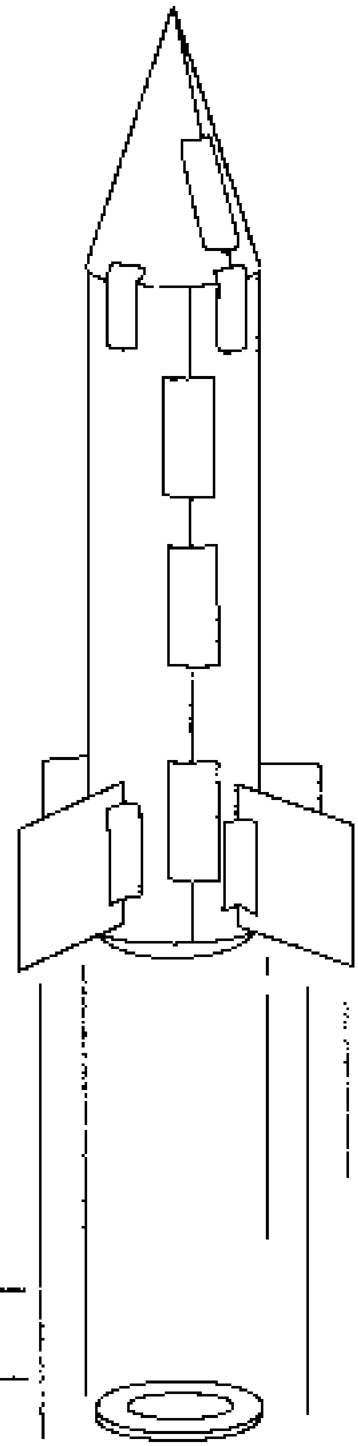
____

COUNTDOWN:

1. Put on your eye protection.
2. Turn the rocket upside down and fill the canister one-third full of water.

<u>Work quickly on the next steps!</u>

3. Drop in 1/2 tablet.
4. Snap lid on tight.
5. Stand rocket on launch platform.
6. Stand back.



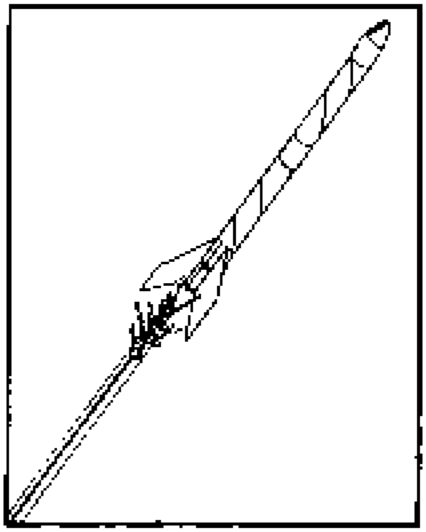
LIFTOFF!

What three ways can you improve your rocket?

1. ______________________________________

2. ______________________________________

3. ______________________________________



Teacher Information

PAPER ROCKETS

Objective:
To design, construct, and fly paper rockets that will travel the greatest distance possible across a floor model of the solar system.

Description:
In this activity, students construct small flying rockets out of paper and propel them by blowing air through a straw.

Science Standards:
- Science as Inquiry
- Physical Science - Position and motion of objects
- Science and Technology - Abilities of technological design
- Unifying Concepts and Processes - Evidence, models, and explanation

Science Process Skills:
- Observing
- Communicating
- Measuring
- Collecting Data
- Inferring
- Predicting
- Making Models
- Interpreting Data
- Controlling Variables
- Defining Operationally
- Investigating

Mathematics Standards:
- Mathematics as Problem Solving
- Mathematics as Reasoning
- Mathematical Connections
- Geometry and Spatial Sense
- Statistics and Probability

Management:
After demonstrating a completed paper rocket to the students, have them construct their own paper rockets and decorate them. Students may work individually or in pairs.
★ Because the rockets are projectiles, make sure students wear eye protection.

Materials and Tools:
- Scrap bond paper
- Cellophane tape
- Scissors
- Sharpened fat pencil
- Milkshake straw (slightly thinner than pencil)
- Eye protection
- Metric ruler
- Masking tape or Altitude trackers
- Pictures of the Sun and planets

When students complete the rockets, distribute straws. Select a location for flying the rockets. A room with open floor space or a hallway is preferable. Prepare the floor by marking a 10-meter test range with tape measures or meter sticks laid end to end. As an alternative, lay out the planetary target range as shown on the next page. Have students launch from planet Earth, and tell them to determine the farthest planet they are able to reach with their rocket. Use the planetary arrangement shown on the next page for laying out the launch range. Pictures for the planets are found on page 63.[1] Enlarge these pictures as desired.

Record data from each launch on the Paper Rocket Launch Record Report form. The form includes spaces for data from three different rockets. After the first launches,

[1] See page 70 in this handbook.

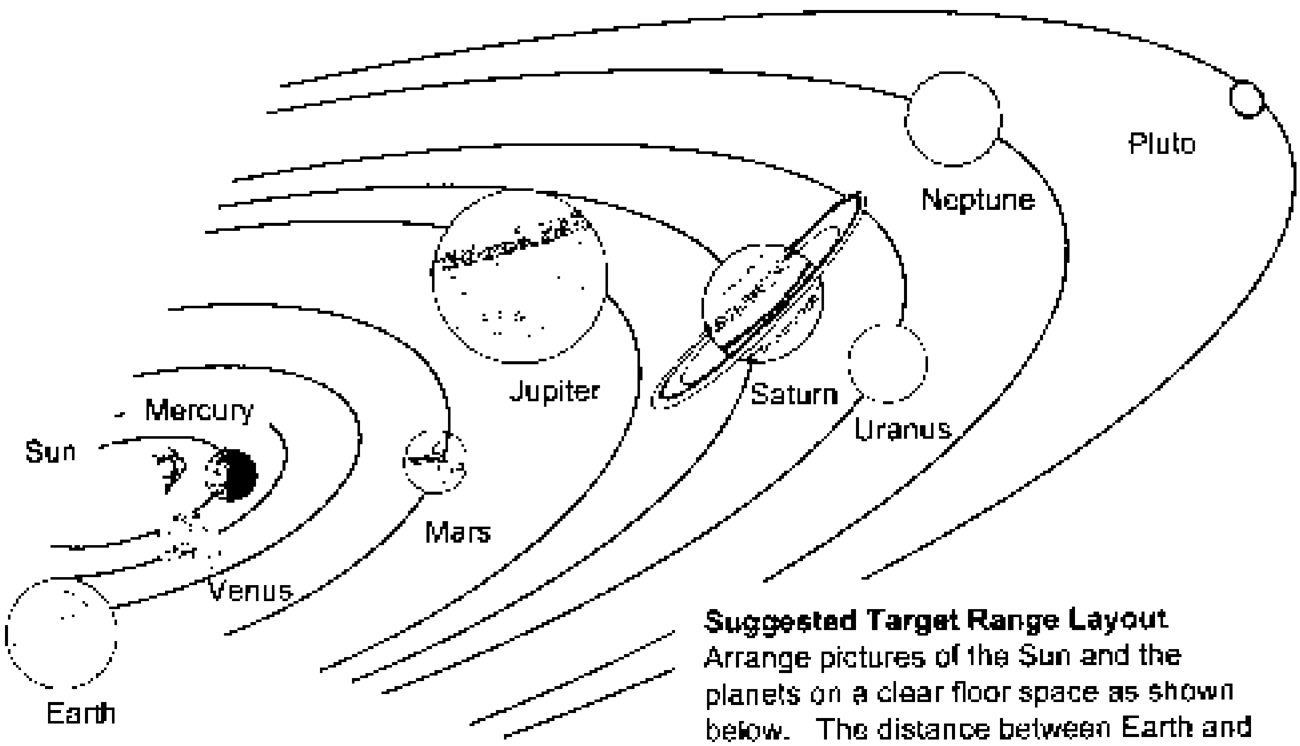
students should construct new and "improved" paper rockets and attempt a longer journey through the solar system. Encourage the students to try different sized rockets and different shapes and number of fins. For younger students, create a chart listing how far each planet target is from Earth. Older students can measure these distances for themselves.

Background Information:

Although the activity uses a solar system target range, the Paper Rockets activity demonstrates how rockets fly through the atmosphere. A rocket with no fins is much more difficult to control than a rocket with fins. The placement and size of the fins is critical to achieve adequate stability while not adding too much weight. More information on rocket fins can be found on pages 22-23 of this guide.

Making and Launching Paper Rockets:

1. Distribute the materials and construction tools to each student.
2. Students should each construct a rocket as shown in the instructions on the student sheet.
3. Tell students to predict how far their rocket will fly and record their estimates in the test report sheet. After test flying the rocket and measuring the distance it reached, students should record the actual distance and the difference between predicted and actual distances on the Paper Rockets Test Report.
4. Following the flight of the first rocket, students should construct and test two additional rockets of different sizes and fin designs.

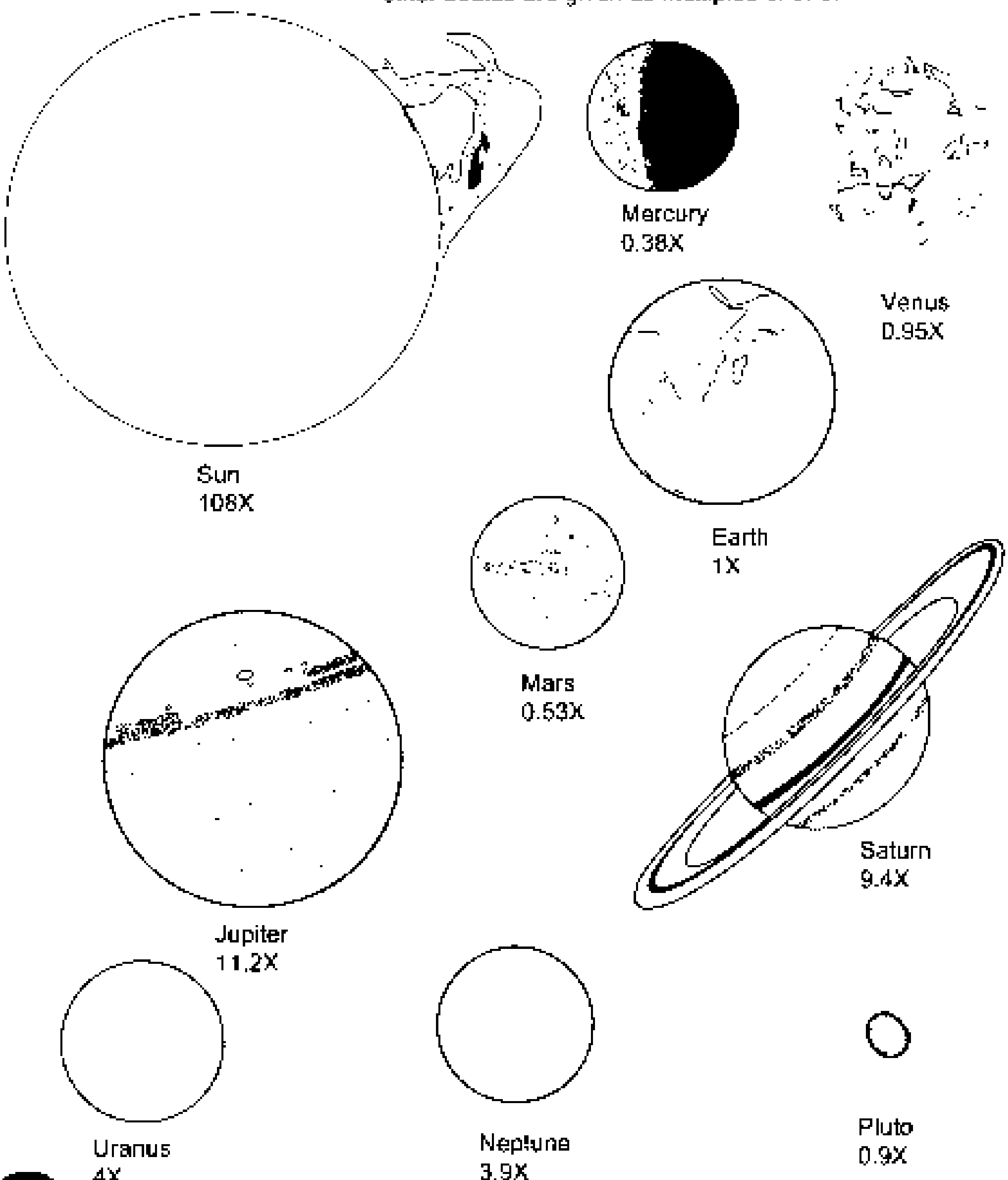


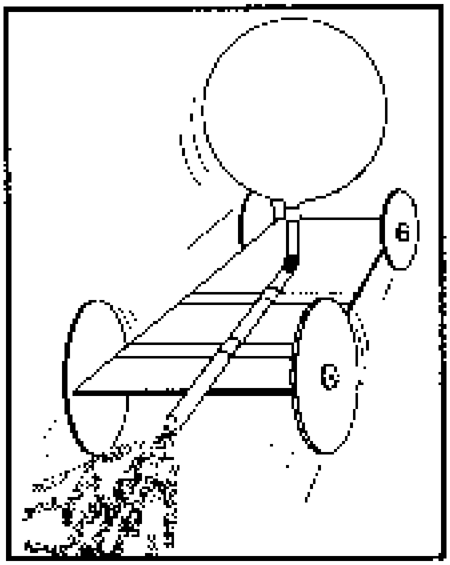
Suggested Target Range Layout
Arrange pictures of the Sun and the planets on a clear floor space as shown below. The distance between Earth and Pluto should be about 8 meters. Refer to an encyclopedia or other reference for a chart on the actual distances to each planet.

Planet Targets

(Not Drawn To Scale)

Enlarge these pictures on a copy machine or sketch copies of the pictures on separate paper. Place these pictures on the floor according to the arrangement on the previous page. If you wish to make the planets to scale, refer to the numbers beside the names indicating the relative sizes of each body. Earth's diameter is given as one and all the other bodies are given as multiples of one.





Teacher Information

ROCKET CAR

Objectives:
- To construct a rocket propelled vehicle.
- To experiment with ways of increasing the distance the rocket car travels.

Description:
Students construct a balloon-powered rocket car from a styrofoam tray, pins, tape, and a flexible straw, and test it along a measured track on the floor.

Science Standards:
Science as Inquiry
Physical Science - Position and motion of objects
Science and Technology - Abilities of technological design
Unifying Concepts and Processes - Change, constancy, and measurement

Science Process Skills:
Observing
Communicating
Measuring
Collecting Data
Inferring
Making Models
Interpreting Data
Making Graphs
Controlling Variables
Defining Operationally
Investigating

Mathematics Standards:
Mathematics as Problem Solving
Mathematics as Communication
Mathematics as Reasoning
Mathematical Connections
Measurement
Statistics and Probability
Patterns and Relationships

Management:
This activity can be done individually or with students working in pairs. Allow 40 to 45 minutes to complete the first part of the activity. The activity stresses technology education and provides students with the opportunity to modify their car designs to increase performance. The optional second part of the activity directs students to design, construct, and test a new rocket car based on the results of the first car. Refer to the materials list and provide what is needed for making one rocket car for each group of two students. Styrofoam food trays are available from butchers in supermarkets. They are usually sold for a few cents each or you may be able to get them donated. Students can also save trays at home and bring them to class.

Materials and Tools:
- 4 Pins
- Styrofoam meat tray
- Masking tape
- Flexible straw
- Scissors
- Drawing compass
- Marker pen
- Small round party balloon
- Ruler
- Student Sheets (one set per group)
- 10 Meter tape measure or other measuring markers for track (one for the whole class)

If compasses are not available, students can trace circular objects to make the wheels or use the wheel and hubcap patterns printed on page 38.[1]

If using the second part of the activity, provide each group with an extra set of materials. Save scraps from the first styrofoam tray to build the second car. You may wish to hold drag or distance races with the cars. The cars will work very well on tile floors and carpeted floors with a short nap. Several tables stretched end to end will also work, but cars may roll off the edges.

Although this activity provides one car design, students can try any car shape and any number, size, and placement of wheels they wish. Long cars often work differently than short cars.

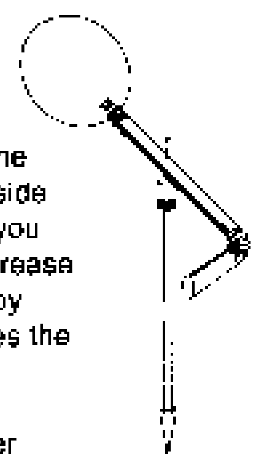
Background Information:

The rocket car is a simple way to observe Newton's Third Law of Motion. (Please refer to pages 15-16 of the rocket principles section of this guide for a complete description.) While it is possible to demonstrate Newton's Law with just a balloon, constructing a car provides students with the opportunity to put the action/reaction force to practical use. In this case, the payload of the balloon rocket is the car. Wheels reduce friction with the floor to help cars move. Because of individual variations in the student cars, they will travel different distances and often in unplanned directions. Through modifications, the students can correct for undesirable results and improve their cars' efficiency.

Making a Rocket Car:

1. Distribute the materials and construction tools to each student group. If you are going to have them construct a second car, tell them to save styrofoam tray scraps for later. Hold back the additional materials for the second car until students need them
2. Students should plan the arrangement of parts on the tray before cutting them out. If you do not wish to use scissors, students can trace the pattern pieces with the sharp point of a pencil or a pen. The pieces will snap out of the styrofoam if the lines are pressed deeply.
3. Lay out a track on the floor approximately 10 meters long. Several metric tape measures joined together can be placed on the floor for determining how far the cars travel. The students should measure in 10 centimeter intervals.
4. Test cars as they are completed. Students should fill in the data sheets and create a report cover with a drawing of the car they constructed.
5. If a second car will be constructed, distribute design pages so that the students can design their cars before starting construction.

Extensions:



- Tie a loop of string around the inflated balloon before releasing the car. Inflate the balloon inside the string loop each time you test the cars. This will increase the accuracy of the tests by insuring the balloon inflates the same amount each time.
- Make a balloon-powered pinwheel by taping another balloon to a flexible straw. Push a pin through the straw and into the eraser of a pencil. Inflate the balloon and watch it go.

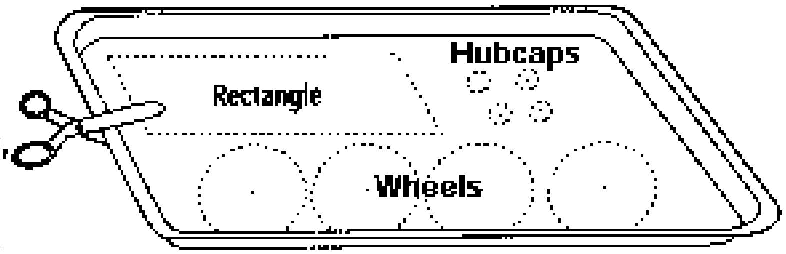
Assessment:

Students will create "Rocket Car Test Reports" to describe test runs and modifications that improved their car's efficiency. Use these reports for assessment along with the design sheet and new car, should you choose to use the second part of this activity.

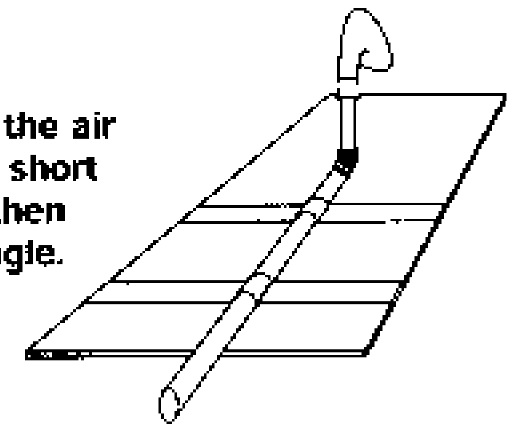
[1] See page 74 in this handbook.

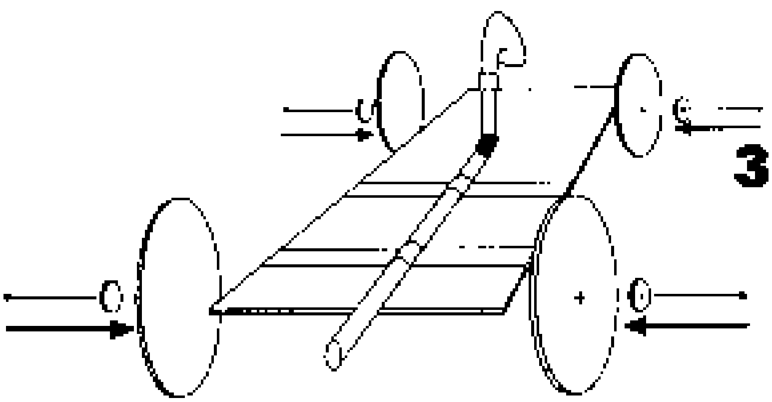
How To Build A Rocket Car

1. Lay out your pattern on a styrofoam tray. You need 1 rectangle, 4 wheels, and 4 hubcaps. Use a compass to draw the wheels.

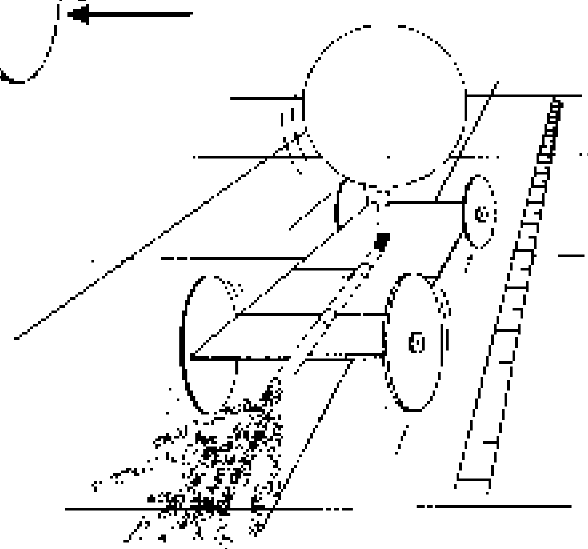


2. Blow up the balloon and let the air out. Tape the balloon to the short end of a flexible straw and then tape the straw to the rectangle.





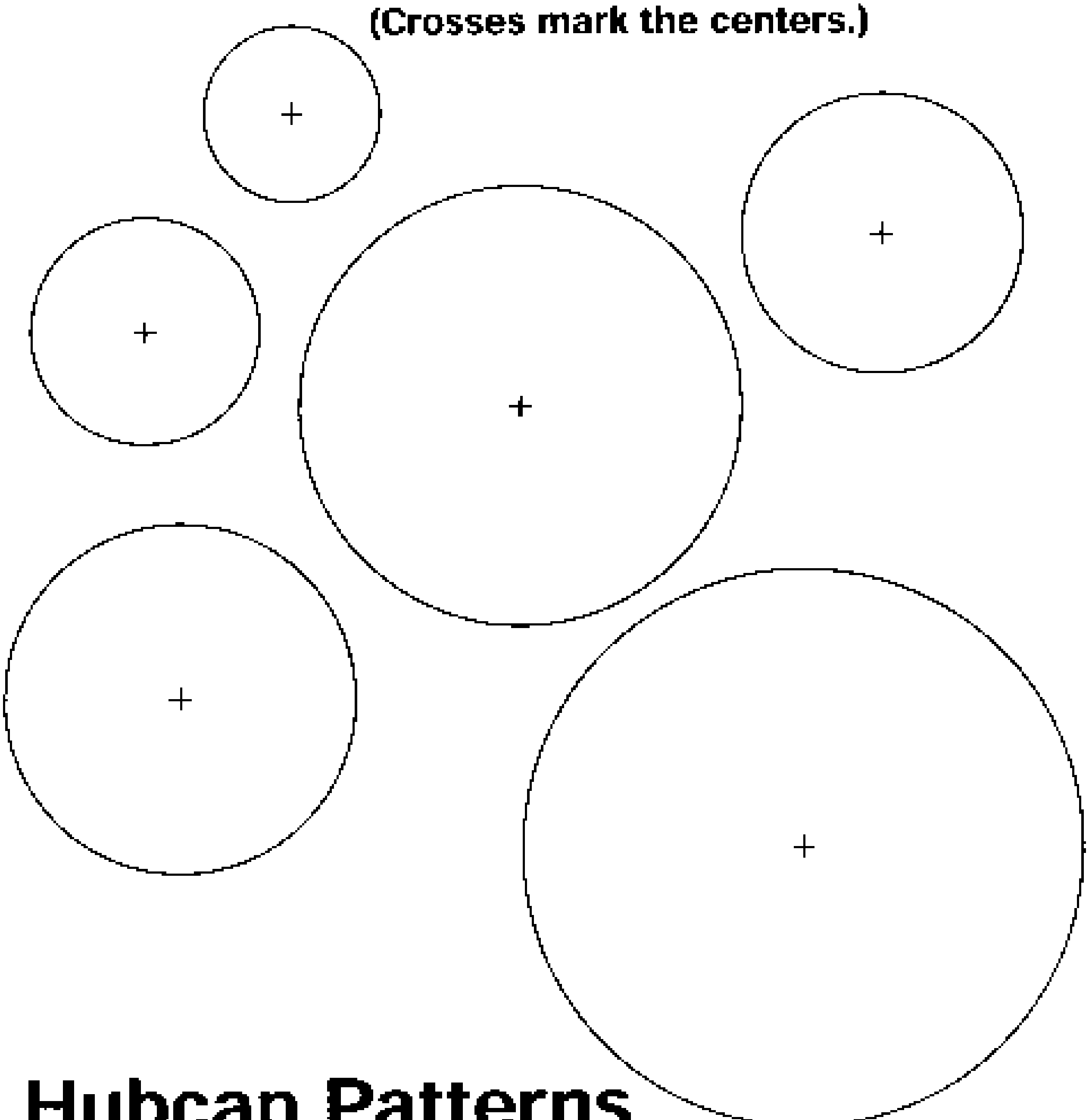
3. Push pins through the hubcaps into the wheels and then into the edges of the rectangle.



4. Blow up the balloon through the straw. Squeeze the end of the straw. Place the car on floor and let it go!

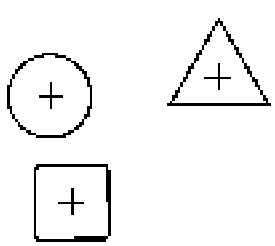
Wheel Patterns

(Crosses mark the centers.)



Hubcap Patterns

(Crosses mark the centers.)



Rocket Car Test Report

Draw a picture of your rocket car.

BY

____

____

DATE: __________________________

Rocket Car Test Report

Place your rocket car on the test track and measure how far it travels.

1. Describe how your rocket car ran during the first trial run.
   (Did it run on a straight or curved path?)

   ____

   How far did it go? ____________ centimeters

   Color in one block on the graph for each 10 centimeters your car traveled.

2. Find a way to change and improve your rocket car and test it again.

   What did you do to improve the rocket car for the second trial run?

   ____

   ____

   How far did it go? ____________ centimeters

   Color in one block on the graph for each 10 centimeters your car traveled.

3. Find a way to change and improve your rocket car and test it again.

   What did you do to improve the rocket car for the third trial run?

   ____

   ____

   How far did it go? ____________ centimeters

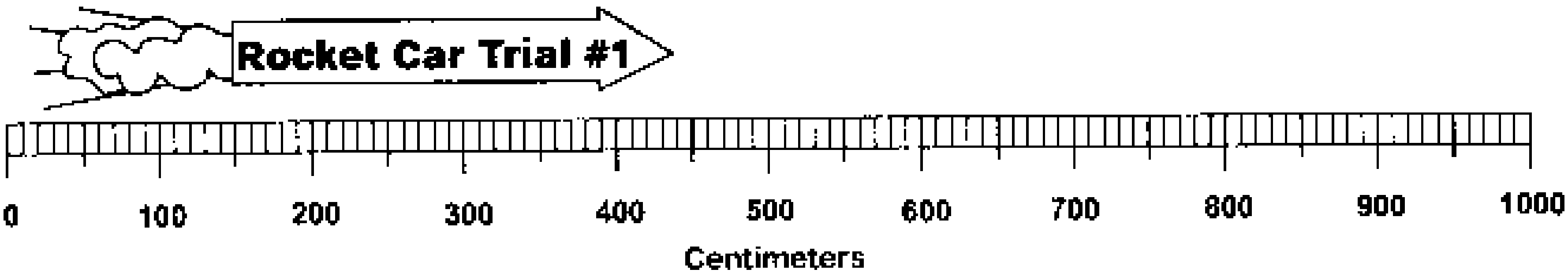
   Color in one block on the graph for each 10 centimeters your car traveled.

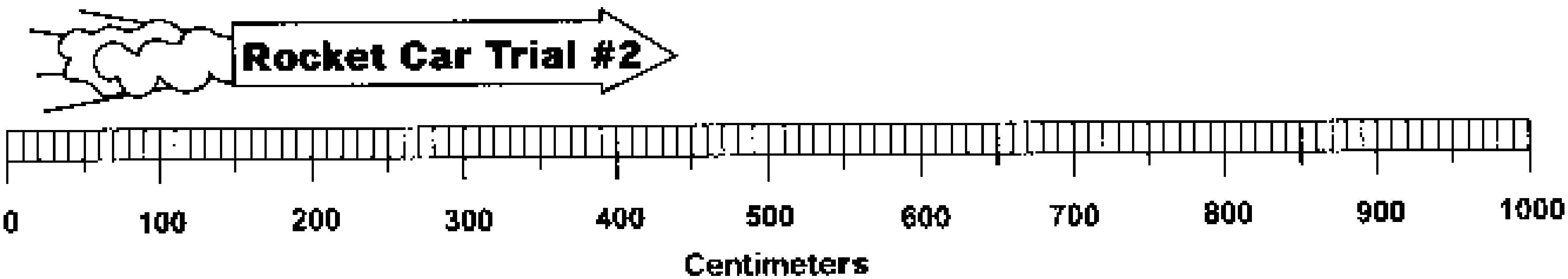
4. In which test did your car go the farthest? ____________

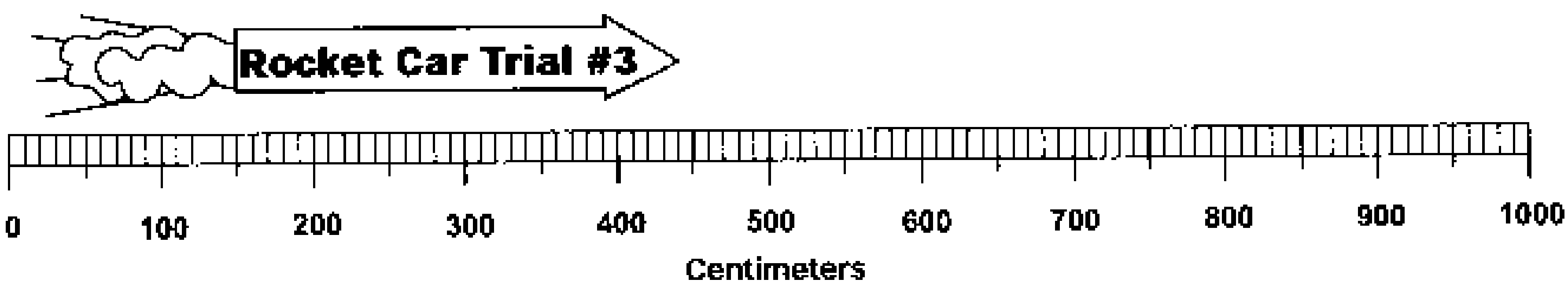
   Why? ____

   ____

Rocket Car Data Sheet







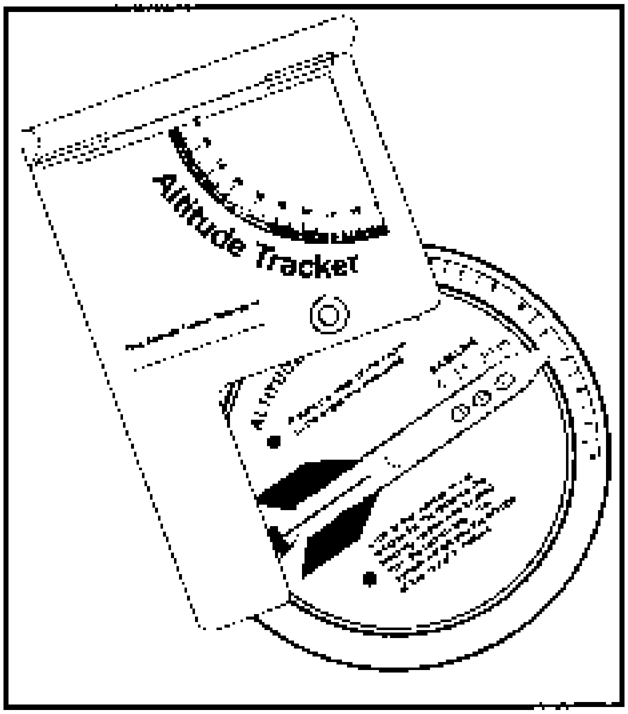
DESIGN SHEET

Design and build a new rocket car based on your earlier experiments.

Front View

Top View

Side View



Teacher Information

ALTITUDE TRACKING

Objective:
To estimate the altitude a rocket achieves during flight.

Description:
In this activity, students construct simple altitude tracking devices for determining the altitude a rocket reaches in its flight.

Science Standards:
Physical Science - Position and motion of objects

Science Process Skills:
Measuring
Interpreting Data

Mathematics Standards:
Mathematics as Communication
Mathematics as Reasoning
Mathematical Connections
Estimation
Number Sense and Numeration
Geometry and Spatial Sense
Measurement
Trigonometry

Management:
Determining the altitude a rocket reaches in flight is a team activity. While one group of students prepares and launches a rocket, a second group measures the altitude the rocket reaches by estimating the angle of the rocket at its highest point from the tracking station. The angle is then input into the altitude tracker calculator and the altitude is read. Roles are reversed so that everyone gets to launch and to track. Depending upon the number of launches held and whether or not every student makes their own Altitude Trackers and Altitude Calculators, the activity should take about an hour or two. While waiting to launch rockets or track them, students can work on other projects.

Altitude tracking, as used in this activity, can be used with the *Paper Rockets* (page 51), *3-2-1 Pop!* (page 43), and *Bottle Rockets* (page 81)[1] activities and with commercial model rockets. The Altitude Calculator is calibrated for 5, 15, and 30 meter baselines. Use the 5-meter baseline for *Paper Rockets* and *3-2-1 Pop!* rockets. Use the 15-meter baseline for *Project X-35*, and use the 30-meter baseline for launching commercial model rockets.

For practical reasons, the Altitude Calculator is designed for angles in increments of 5 degrees.

Materials and Tools:
- Altitude tracker pattern
- Altitude calculator pattern
- Thread or lightweight string
- Scrap cardboard or posterboard
- Glue
- Cellophane tape
- Small washer
- Brass paper fastener
- Scissors
- Razor blade knife and cutting surface
- Meter stick or metric
- Rocket and launcher

[1] See pages 64, 68, and 91 in this handbook.

Younger children, may have difficulty in obtaining precise angle measurements with the Altitude Tracker. For simplicity's sake, round measurements off to the nearest 5 degree increment and read the altitude reached directly from the Altitude Calculator. If desired, you can determine altitudes for angles in between the increments by adding the altitudes above and below the angle and dividing by 2. A more precise method for determining altitudes appears later in the procedures.

A teacher aid or older student should cut out the three windows in in the Altitude Calculator. A sharp knife or razor and a cutting surface works best for cutting out windows. The altitude tracker is simple enough for everyone to make their own, but they can also be shared. ★Students should practice taking angle measurements and using the calculator on objects of known height such as a building or a flagpole before calculating rocket altitude.

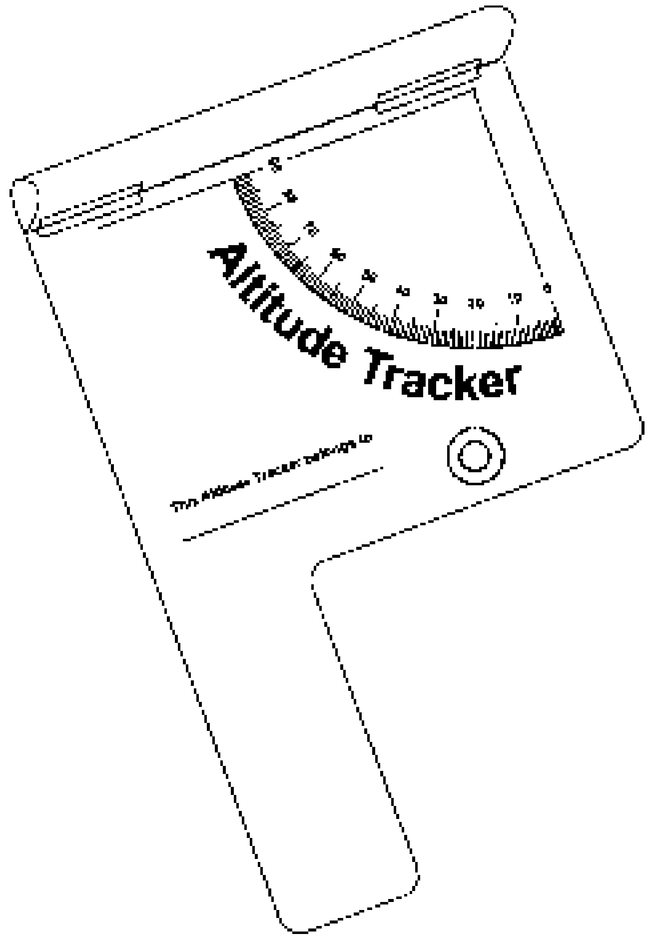
Background Information:

This activity makes use of simple trigonometry to determine the altitude a rocket reaches in flight. The basic assumption of the activity is that the rocket travels straight up from the launch site. If the rocket flies away at an angle other than 90 degrees, the accuracy of the procedure diminishes. For example, if the rocket climbs over a tracking station, where the angle is measured, the altitude calculation will yield an answer higher than the actual altitude reached. On the other hand, if the rocket flies away from the station, the altitude measurement will be lower than the actual value. Tracking accuracy can be increased, by using more than one tracking station to measure the rocket's altitude. Position a second or third station in different directions from the first station. Averaging the altitude measurements will reduce individual error.

Procedure:

Constructing the Altitude Tracker Scope

1. Glue the altitude tracker pattern on to a piece of cardboard. Do not glue the dotted portion of the tracker above the dashed line.
2. Cut out the pattern and cardboard along the outside edges.



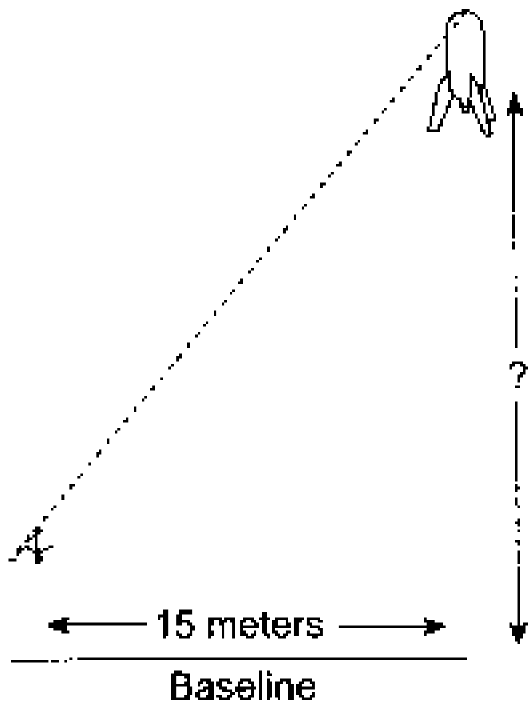
3. Roll the part of the pattern not glued to the cardboard into a tube and tape it as shown in the illustration.
4. Punch a tiny hole in the apex of the protractor quadrant.
5. Slip a thread or lightweight string through the hole. Knot the thread or string on the back side.
6. Complete the tracker by hanging a small washer from the other end of the thread as shown in the diagram above.

Procedure:

Using the Altitude Tracker

1. Set up a tracking station location a short distance away from the rocket launch site. Depending upon the expected altitude of the rocket, the tracking station should be 5, 15, or 30 meters away. (Generally, a 5-meter distance is sufficient for paper rockets and antacid-power rockets. A 15-meter distance is sufficient for bottle rockets, and a 30-meter distance is sufficient for model rockets.

2. As a rocket launches, the person doing the tracking will follow the flight with the sighting tube on the tracker. The tracker should be held like a pistol and kept at the same level as the rocket when it is launched. Continue to



aim the tracker at the highest point the rocket reached in the sky. Have a second student read the angle the thread or string makes with the quadrant protractor. Record the angle.

Procedure:
Constructing the Altitude Calculator

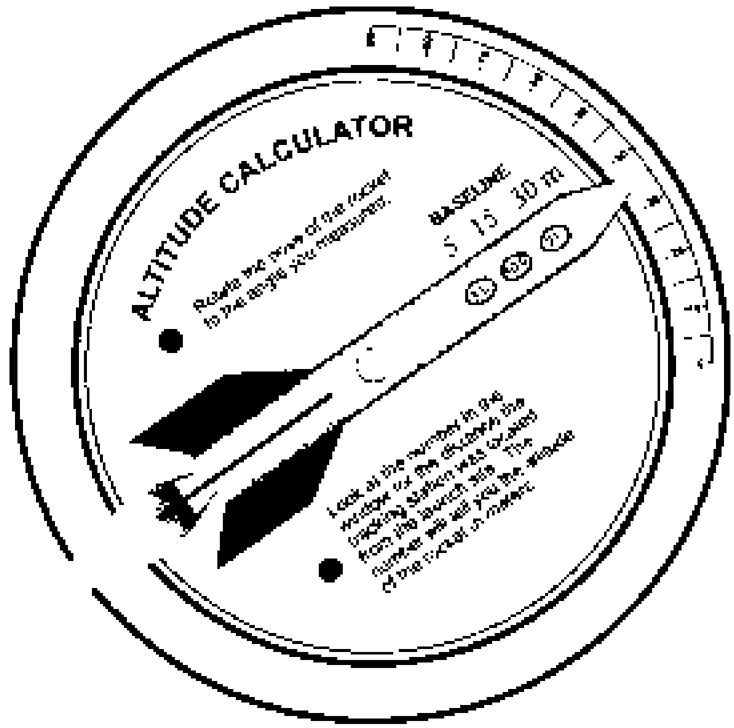
1. Copy the two patterns for the altitude calculator onto heavy weight paper or glue the patterns on to light weight posterboard. Cut out the patterns.
2. Place the top pattern on a cutting surface and cut out the three windows.
3. Join the two patterns together where the center marks are located. Use a brass paper fastener to hold the pieces together. The pieces should rotate smoothly.

Procedure:
Determining the Altitude

1. Use the Altitude Calculator to determine the height the rocket reached. To do so, rotate the inner wheel of the calculator so that the nose of the rocket pointer is aimed at the angle measured in step 2 of the previous procedure.
2. Read the altitude of the rocket by looking in the window. If you use a 5-meter baseline, the altitude the rocket reached will be in the window beneath the 5. To achieve a more accurate measure, add the height of the person holding the tracker to calculate altitude. If the angle falls between two degree marks, average the altitude numbers above and below the marks.

Advanced Altitude Tracking:

1. A more advanced altitude tracking scope can be constructed by replacing the rolled sighting tube with a fat milkshake straw. Use white glue to attach the straw along the 90 degree line of the protractor.



2 Once you determine the angle of the rocket, use the following equation to calculate altitude of the rocket.

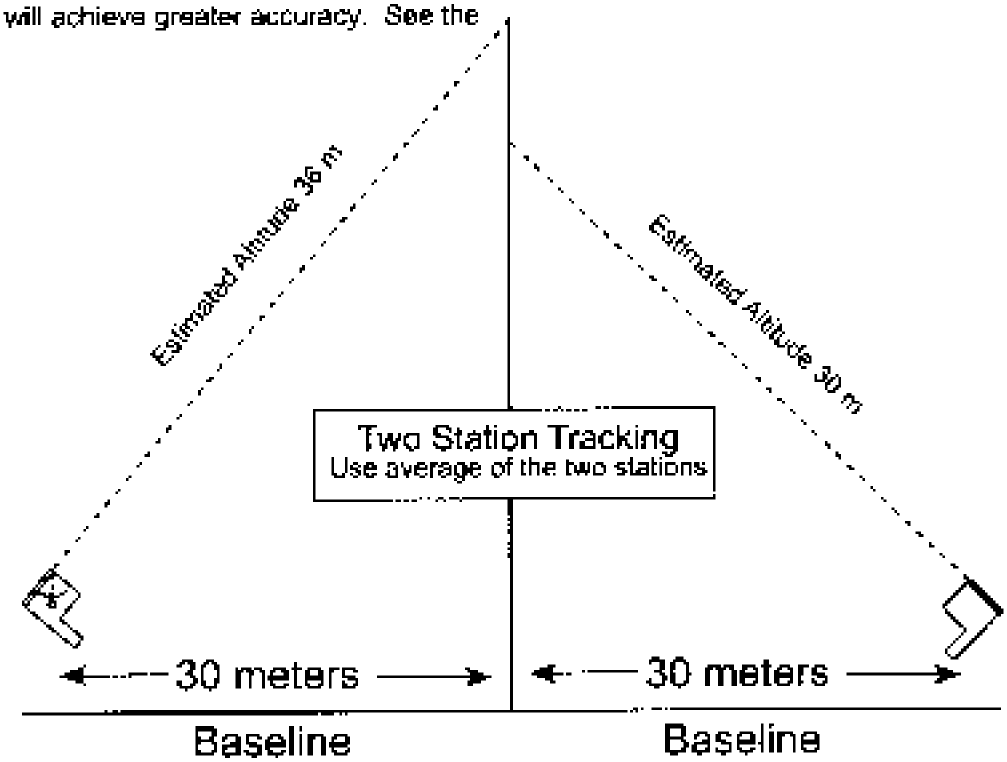
$$Altitude = \tan\angle \times baseline$$

Use a calculator with trigonometry functions to solve the problem or refer to the tangent table on page 86.[1] For example, if the measured angle is 28 degrees and the baseline is 15 meters, the altitude is 7.97 meters.

$$Altitude = \tan 28^\circ \times 15m$$

$$Altitude = 0.5317 \times 15m = 7.97m$$

3. An additional improvement in accuracy can be obtained by using two tracking stations. Averaging the calculated altitude from the two stations will achieve greater accuracy. See the figure below.

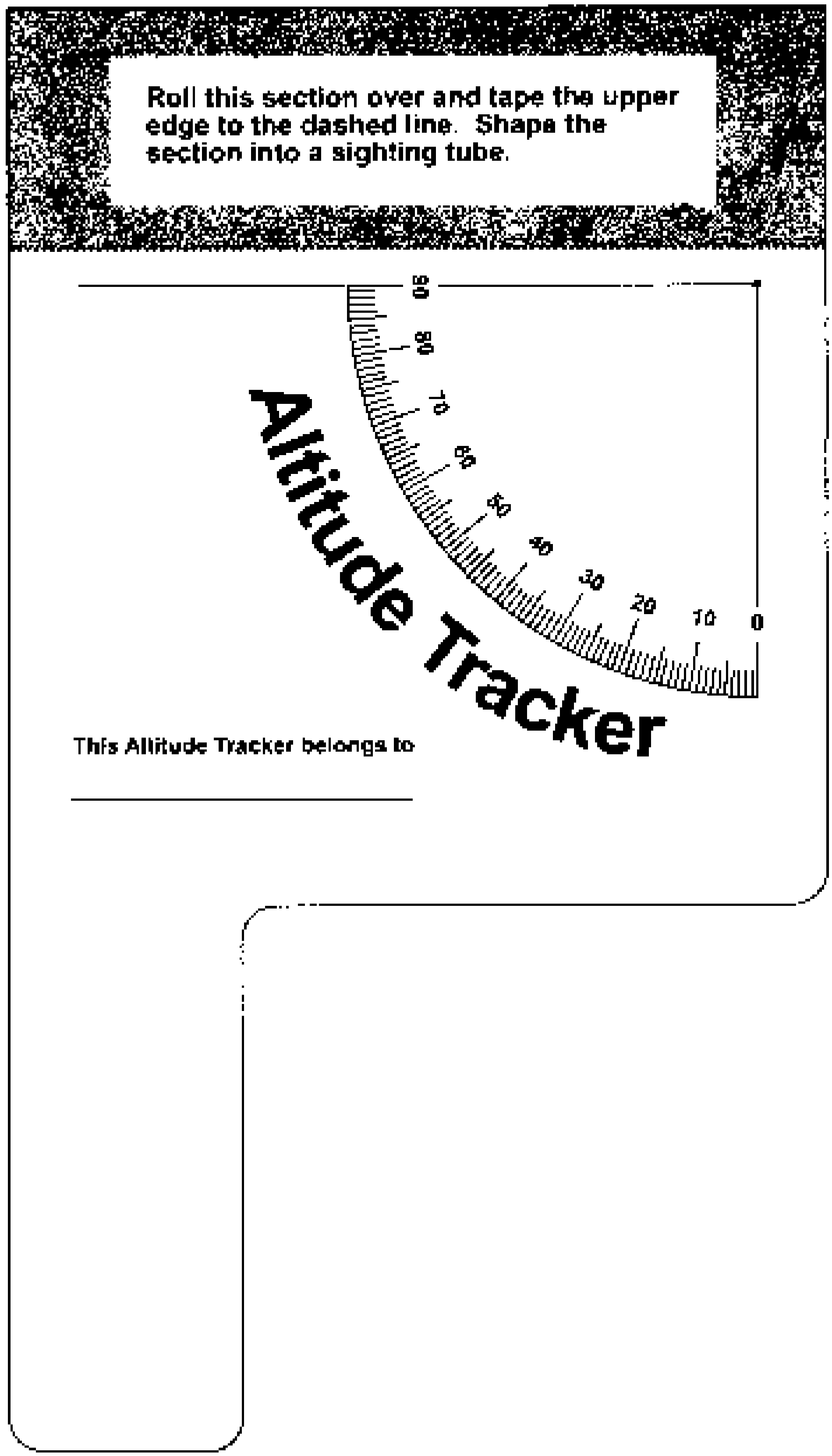


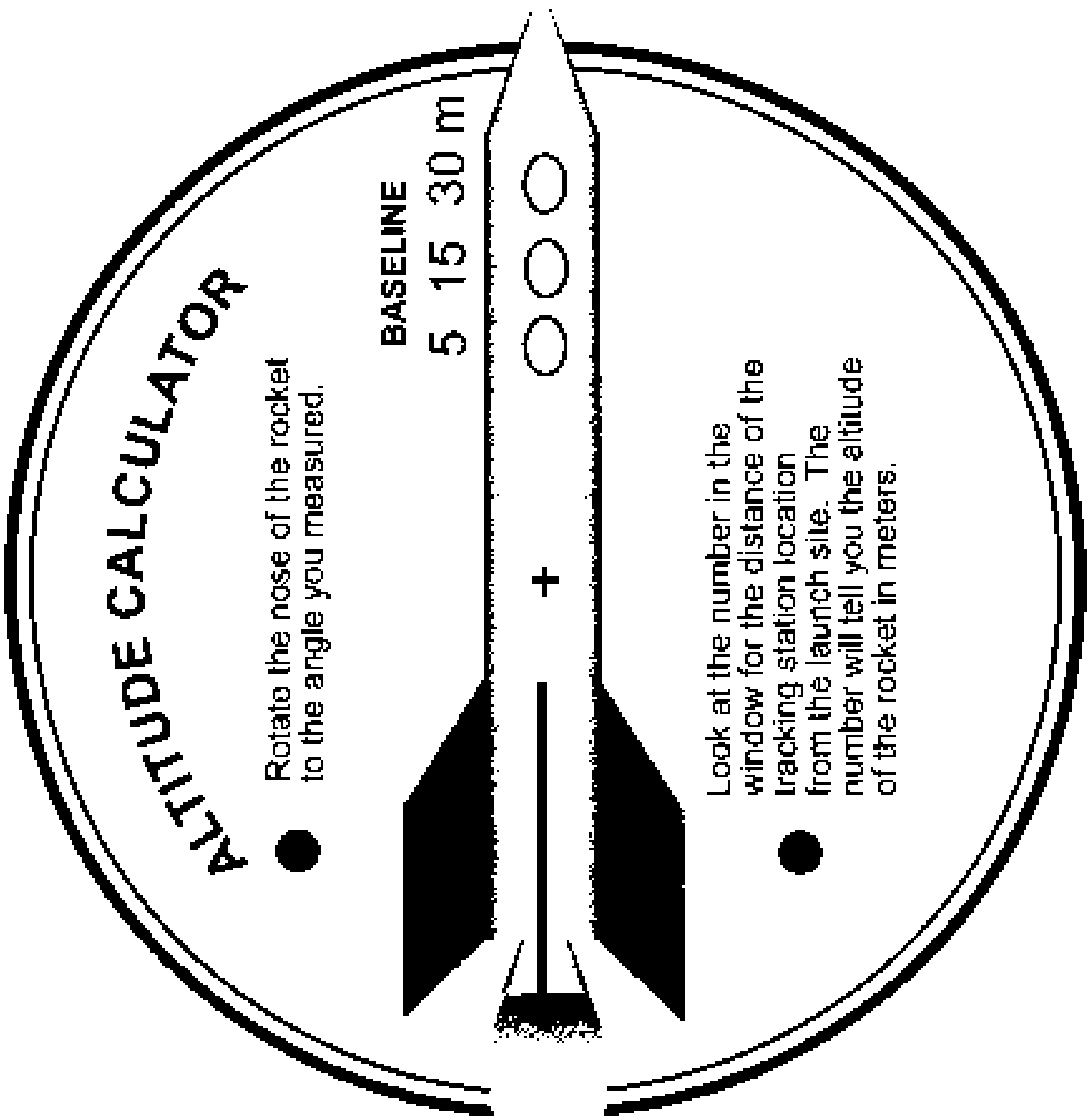
Assessment:
Have students demonstrate their proficiency with altitude tracking by sighting on a fixed object of known height and comparing their results. If employing two tracking stations, compare measurements from both stations

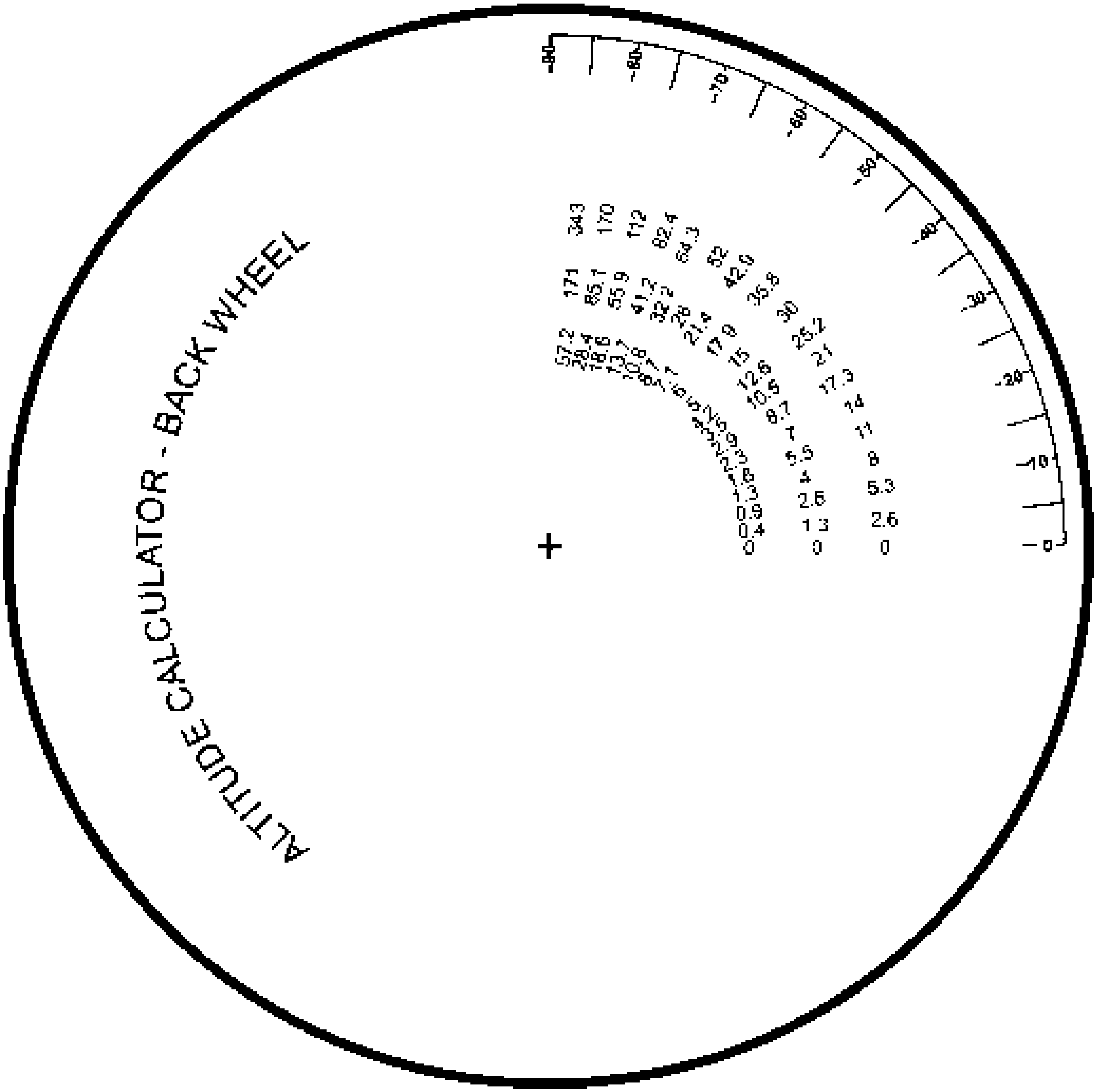
Extensions:

- Why should the height of the person holding the tracker be added to the measurement of the rocket's altitude?
- Curriculum guides for model rocketry (available from model rocket supply companies) provide instructions for more sophisticated rocket trcking measurements. These activities involve two-station tracking with altitude and compass direction measurement and trigonometric functions.

[1] See page 86 in this handbook.

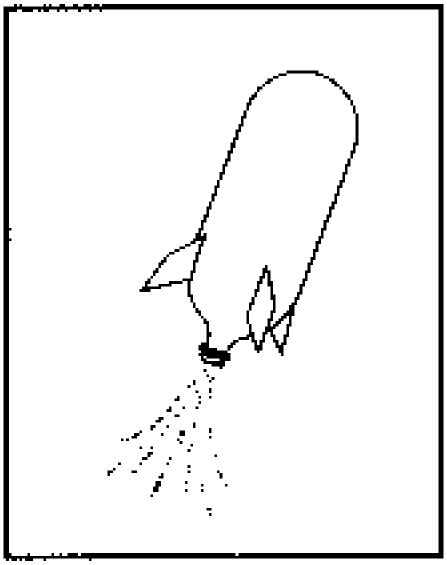

Roll this section over and tape the upper edge to the dashed line. Shape the section into a sighting tube.
90
80
70
60
50
40
30
20
10
0
Altitude Tracker
This Altitude Tracker belongs to


ALTITUDE CALCULATOR
Rotate the nose of the rocket to the angle you measured.
BASELINE
5 15 30 m
Look at the number in the window for the distance of the tracking station location from the launch site. The number will tell you the altitude of the rocket in meters.


ALTITUDE CALCULATOR - BACK WHEEL

Tangent Table

Degree	Tan	Degree	Tan	Degree	Tan
0	0.0000				
1	0.0174	31	0.6008	61	1.8040
2	0.0349	32	0.6248	62	1.8807
3	0.0524	33	0.6494	63	1.9626
4	0.0699	34	0.6745	64	2.0603
5	0.0874	35	0.7002	65	2.1445
6	0.1051	36	0.7265	66	2.2460
7	0.1227	37	0.7535	67	2.3558
8	0.1405	38	0.7812	68	2.4750
9	0.1583	39	0.8097	69	2.6050
10	0.1763	40	0.8390	70	2.7474
11	0.1943	41	0.8692	71	2.9042
12	0.2125	42	0.9004	72	3.0776
13	0.2308	43	0.9325	73	3.2708
14	0.2493	44	0.9656	74	3.4874
15	0.2679	45	1.0000	75	3.7320
16	0.2867	46	1.0355	76	4.0107
17	0.3057	47	1.0723	77	4.3314
18	0.3249	48	1.1106	78	4.7046
19	0.3443	49	1.1503	79	5.1445
20	0.3639	50	1.1917	80	5.6712
21	0.3838	51	1.2348	81	6.3137
22	0.4040	52	1.2799	82	7.1153
23	0.4244	53	1.3270	83	8.1443
24	0.4452	54	1.3763	84	9.5143
25	0.4663	55	1.4281	85	11.4300
26	0.4877	56	1.4825	86	14.3006
27	0.5095	57	1.5398	87	19.0811
28	0.5317	58	1.6003	88	28.6362
29	0.5543	59	1.6642	89	57.2899
30	0.5773	60	1.7320	90	———



Teacher Information

BOTTLE ROCKET LAUNCHER

Objective:
To construct a bottle rocket launcher for use with the *Bottle Rocket* and *Project X-35* activities.

Description:
Students construct a bottle launcher from "off-the-shelf" hardware and wood using simple tools.

Materials and Tools:

- 4 5-inch corner irons with 12 3/4 inch wood screws to fit
- 1 5-inch mounting plate
- 2 6-inch spikes
- 2 10-inch spikes or metal tent stakes
- 2 5-inch by 1/4 inch carriage bolts with six 1/4 inch nuts
- 1 3-inch eyebolt with two nuts and washers
- 4 3/4-inch diameter washers to fit bolts
- 1 Number 3 rubber stopper with a single hole
- 1 Snap-in Tubeless Tire Valve (small 0.453 inch hole, 2 inch long)
- Wood board 12 by 18 by 3/4 inches
- 1 2-liter plastic bottle
- Electric drill and bits including a 3/8 inch bit
- Screw driver
- Pliers or open-end wrench to fit nuts
- Vice
- 12 feet of 1/4 inch cord
- Pencil

Science Standards:
Physical Science - Position and motion of objects
Science and Technology - Abilities of technological design

Science Process Skills:
Measuring

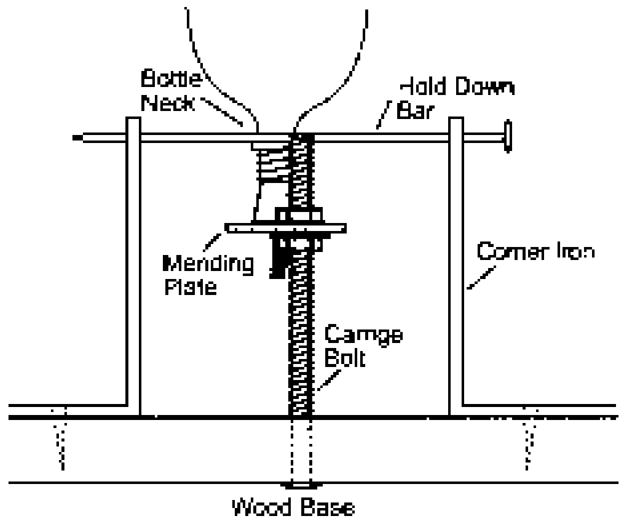
Mathematics Standards:
Mathematical Connections
Measurement

Management:
Consult the materials and tools list to determine what you will need to construct a single bottle rocket launcher. The launcher is simple and inexpensive to construct. Most needed parts are available from hardware stores. In addition you will need a tire valve from an auto parts store and a rubber bottle stopper from a school science experiment. The most difficult task is to drill a 3/8 inch hole in the mending plate called for in the materials list. Electric drills are a common household tool. If you do not have access to one, or do not wish to drill the holes in the metal mending plate, find someone who can do the job for you. Ask a teacher or student in your school's Industrial arts shop, a fellow teacher, or the parent of one of your students to help.

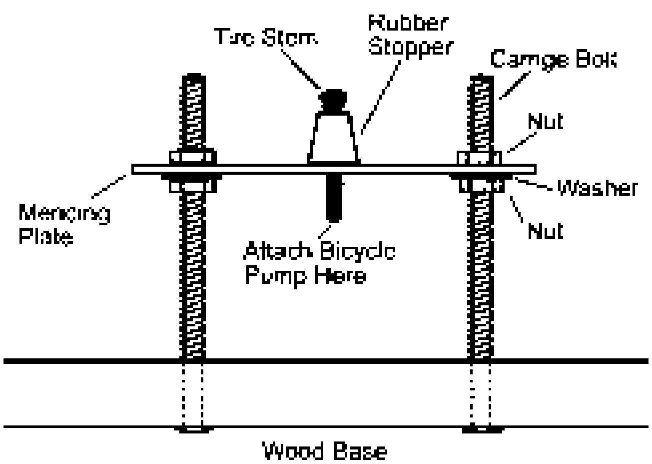
If you have each student construct a bottle rocket, having more than one launcher may be advisable. Because the rockets are projectiles, safely using more than one launcher will require careful planning and possibly additional supervision. Please refer to the launch safety instructions.

Background Information:
Like a balloon, air pressurizes the bottle rocket. When released from the launch platform, air escapes the bottle, providing an action force accompanied by an equal and opposite reaction force (Newton's Third Law of Motion). Increasing the pressure inside the bottle rocket produces greater thrust since a large quantity of air inside the bottle escapes with a higher acceleration (Newton's Second Law of Motion). Adding a small amount of water to the bottle increases the action force. The water expels from the bottle before the air does, turning the bottle rocket into a bigger version of a water rocket toy available in toy stores.

Construction Instructions:
1. Prepare the rubber stopper by enlarging the hole with a drill. Grip the stopper lightly with a vice and gently enlarge the hole with a 3/8 inch bit and electric drill. The rubber will stretch during cutting, making the finished hole somewhat less than 3/8 inches.
2. Remove the stopper from the vice and push the needle valve end of the tire stem through the stopper from the narrow end to the wide end.
3. Prepare the mounting plate by drilling a 3/8 inch hole through the center of the plate. Hold the plate with a vice during drilling and put on eye protection. Enlarge the holes at the opposite ends of the plates, using a drill bit slightly larger than the holes to do this. The holes must be large enough to pass the carriage bolts through them. (See Attachment of Mending Plate and Stopper diagram below.)
4. Lay the mending plate in the center of the wood base and mark the centers of the two outside holes that you enlarged. Drill holes through the wood big enough to pass the carriage bolts through.
5. Push and twist the tire stem into the hole you drilled in the center of the mounting plate. The fat end of the stopper should rest on the plate.
6. Insert the carriage bolts through the wood base from the bottom up. Place a hex nut over each bolt and tighten the nut so that the bolt head pulls into the wood.
7. Screw a second nut over each bolt and spin it about half way down the bolt. Place a washer over each nut and then slip the mounting plate over the two bolts.
8. Press the neck of a 2-liter plastic bottle over the stopper. You will be using the bottle's wide neck lip for measuring in the next step.



Positioning Corner Irons



Attachment of Mending Plate and Stopper

9. Set up two corner irons so they look like book ends. Insert a spike through the top hole of each iron. Slide the irons near the bottle neck so that the spike rests immediately above the wide neck lip. The spike will hold the bottle in place while you pump up the rocket. If the bottle is too low, adjust the nuts beneath the mounting plate on both sides to raise it.
10. Set up the other two corner irons as you did in the previous step. Place them on the opposite side of the bottle. When you have the irons aligned so that the spikes rest above and hold the bottle lip, mark the centers of the holes on the wood base. For more precise screwing, drill small pilot holes for each screw and then screw the corner irons tightly to the base.
11. Install an eyebolt to the edge of the opposite holes for the hold down spikes. Drill a hole and hold the bolt in place with washers and nuts on top and bottom.
12. Attach the launch "pull cord" to the head end of each spike. Run the cord through the eyebolt.
13. Make final adjustments to the launcher by attaching the pump to the tire stem and pumping up the bottle. Refer to the launching instructions for safety notes. If the air seeps out around the stopper, the stopper is too loose. Use a pair of pliers or a wrench to raise each side of the mounting plate in turn to press the stopper with slightly more force to the bottle neck. When satisfied with the position, thread the remaining hex nuts over the mounting plate and tighten them to hold the plate in position.
14. Drill two holes through the wood base along one side. The holes should be large enough to pass large spikes of metal tent stakes. When the launch pad is set up on a grassy field, the stakes will hold the launcher in place when you yank the pull cord. The launcher is now complete.

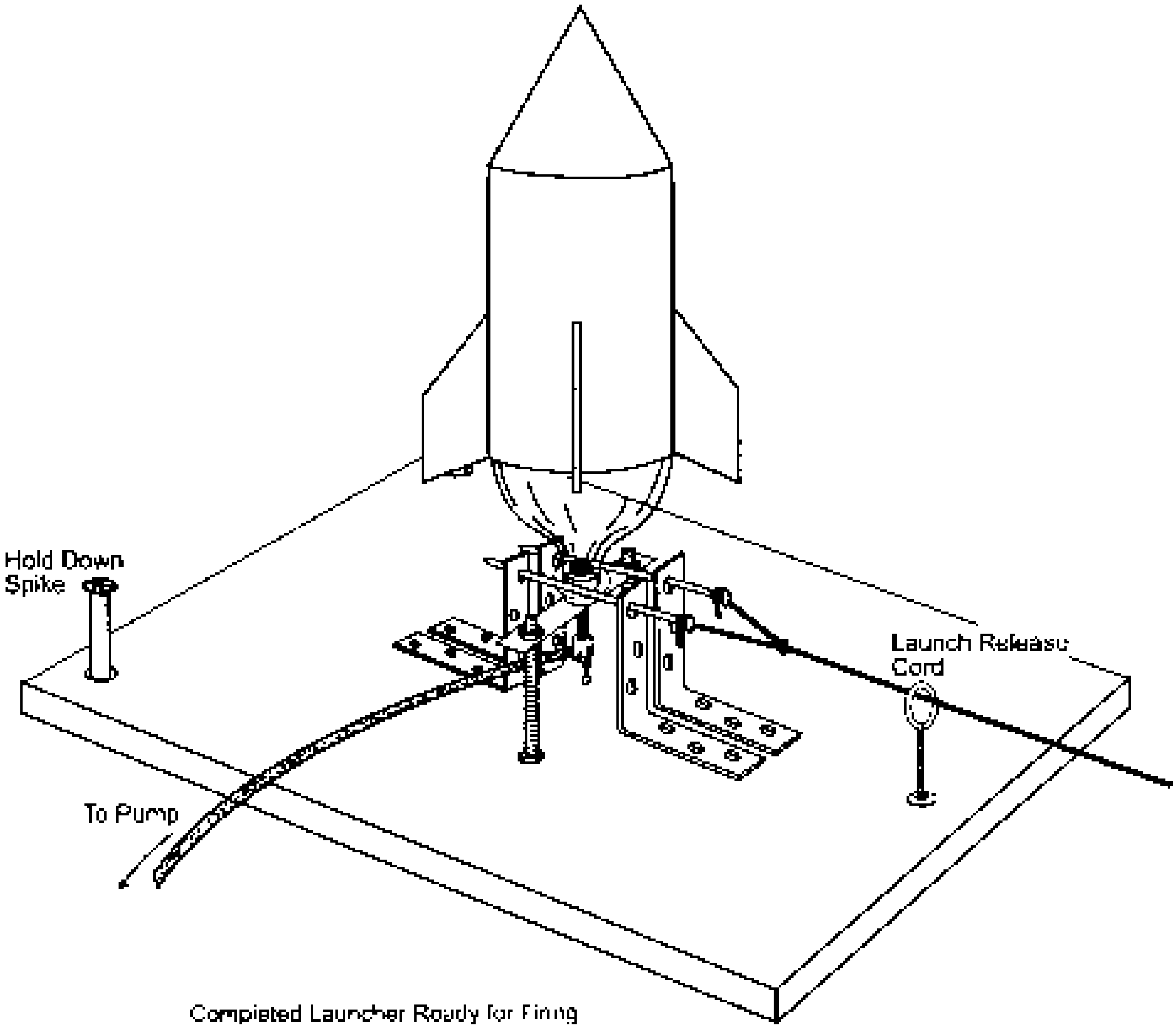
Launch Safety Instructions:
1. Select a grassy field that measures approximately 30 meters across. Place the launcher in the center of the field and anchor it in place with the spikes or tent stakes. (If it is a windy day, place the launcher closer to the side of the field from which the wind is coming so that the rocket will drift on to the field as it comes down.)
2. Have each student or student group set up their rocket on the launch pad. Other students should stand back several meters. It will be easier to keep observers away by roping off the launch site.
3. After the rocket is attached to the launcher, the student pumping the rocket should put on eye protection. The rocket should be pumped no higher than about 50 pounds of pressure per square inch.
4. When pressurization is complete, all students should stand in back of the rope for the countdown.
5. Before conducting the countdown, be sure the place where the rocket is expected to come down is clear of people. Launch the rocket when the recovery range is clear.
6. Only permit the students launching the rocket to retrieve it.

Extensions:
Look up the following references for additional bottle rocket plans and other teaching strategies:

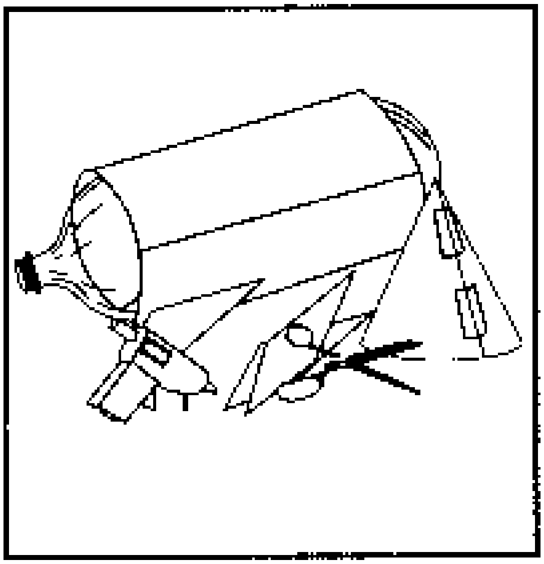
Hawthorne, M. & Saunders, G. (1993), "Its Launchtime!," Science and Children, v30n5, pp.17-19. 39.

Rogis, J. (1991), "Soaring with Aviation Activities," Science Scope, v15n2, pp.14-17.

Winemiller, J., Pedersen, J., & Bonnstetter, R. (1991), "The Rocket Project," Science Scope, v15n2, pp.18-22.



Completed Launcher Ready for Firing



Teacher Information

BOTTLE ROCKET

Objective:
To construct and launch a simple bottle rocket.

Description:
Working in teams, learners will construct a simple bottle rocket from 2-liter soft drink bottles and other materials.

Science Standards:
Physical Science - Position and motion of objects
Science and Technology - Abilities of technological design

Science Process Skills:
Measuring
Making Models

Mathematics Standards:
Mathematical Connections
Measurement
Geometry and Spatial Sense

Materials and Tools:

- 2-liter plastic soft drink bottles
- Low-temperature glue guns
- Poster board
- Tape
- Modeling clay
- Scissors
- Safety Glasses
- Decals
- Stickers
- Marker pens
- Launch pad from the Bottle Rocket Launcher

Management:
This activity can stand alone or be incorporated in the activity *Project X-35* that follows. Having the learners work in teams will reduce the amount of materials required. Begin saving 2-liter bottles several weeks in advance to have a sufficient supply for your class. You will need to have at least one bottle rocket launcher. Construct the launcher described in the previous activity or obtain one from a science or technology education supply catalog.

The simplest way to construct the rockets is to use low-temperature electric glue guns that are available from craft stores. High-temperature glue guns will melt the plastic bottles. Provide glue guns for each table or set up glue stations in various parts of the room.

Collect a variety of decorative materials before beginning this activity so students can customize their rockets. When the rockets are complete, test fly them. Refer to the *Altitude Tracker* activity starting on page 69[1] for information on determining how high the rockets fly. While one group of students launches their rocket, have another group track the rocket and determine its altitude.

When launching rockets, it is important for the other students to stand back. Countdowns help everybody to know when the rocket will lift off. In group discussion, have your students create launch safety rules

[1] See page 79 in this handbook.

that everybody must follow. Include how far back observers should stand, how many people should prepare the rocket for launch, who should retrieve the rocket, etc.

Background Information:
Bottle rockets are excellent devices for investigating Newton's Three Laws of Motion. The rocket will remain on the launch pad until an unbalanced force is exerted propelling the rocket upward (First Law). The amount of force depends upon how much air you pumped inside the rocket (Second Law). You can increase the force further by adding a small amount of water to the rocket. This increases the mass the rocket expels by the air pressure. Finally, the action force of the air (and water) as it rushes out the nozzle creates an equal and opposite reaction force propelling the rocket upward (Third Law).

The fourth instruction on the Student Page asks the students to press modeling clay into the nose cone of the rocket. Placing 50 to 100 grams of clay into the cone helps to stabilize the rocket by moving the center of mass farther from the center of pressure. For a complete explanation of how this works, see pages 21-22.

Procedures:
Refer to the Student Page for procedures and optional directions for making paper helicopters. See the extension section below for details on how to use the helicopters.

Assessment:
Evaluate each bottle rocket on its quality of construction. Observe how well fins align and attach to the bottle. Also observe how straight the nose cone is at the top of the rocket. If you choose to measure how high the rockets fly, compare the altitude the rockets reach with their design and quality of the construction.

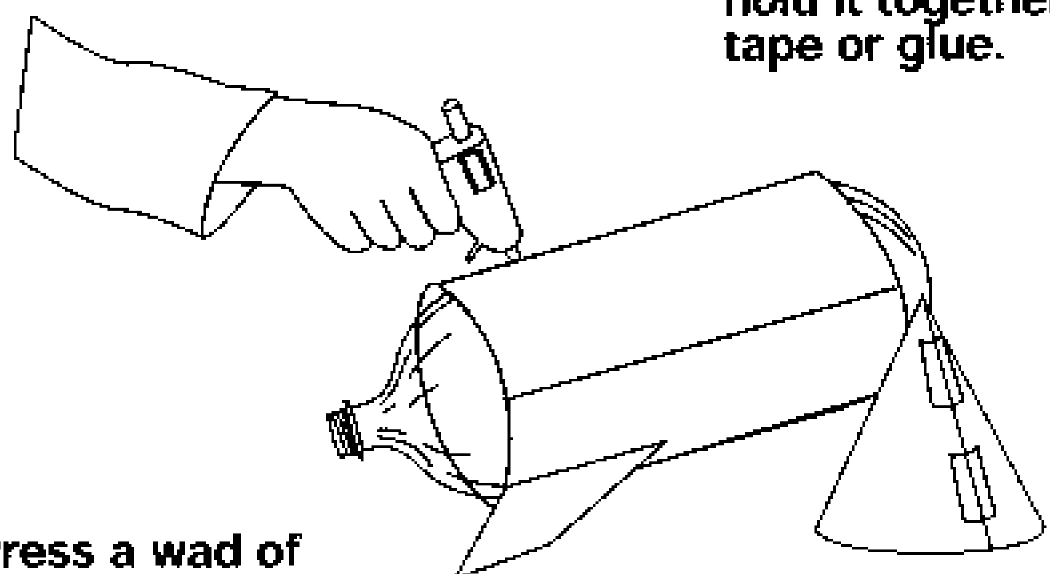
Extensions:
- Challenge rocket teams to invent a way to attach a parachute to the rocket that will deploy on the rocket's way back down.
- Parachutes for bottle rockets can be made from a plastic bag and string. The nose cone is merely placed over the rocket and parachute for launch. The cone needs to fit properly for launch or it will slip off. The modeling clay in the cone will cause the cone to fall off, deploying the parachute or paper helicopters, after the rocket tilts over at the top of its flight.
- Extend the poster board tube above the rounded end of the bottle. This will make a payload compartment for lofting various items with the rocket. Payloads might include streamers or paper helicopters that will spill out when the rocket reaches the top of its flight. Copy and distribute the page on how to make paper helicopters. Ask the students to identify other possible payloads for the rocket. If students suggest launching small animals with their rockets, discuss the purpose of flying animals and the possible dangers if they are actually flown.
- Conduct flight experiments by varying the amount of air pressure and water to the rocket before launch. Have the students develop experimental test procedures and control for variables.

Building A Bottle Rocket

1. Wrap and glue or tape a tube of posterboard around the bottle.

2. Cut out several fins of any shape and glue them to the tube.

3. Form a nosecone and hold it together with tape or glue.



4. Press a wad of modeling clay into the top of the nosecone.

5. Glue or tape nosecone to upper end of bottle.

6. Decorate your rocket.

Mathematics:

Two Six-Week Formats

Mathematics: Two Six-Week Formats

This section is written up a little differently than the others. Below you will find listed two different sequences we used with Girl Scout troops; the first will be brief. The first group of girls earned the Math Whiz badge. Next you will find a model sequence for six weeks based on another of our Girl Scout troop programs. This includes more of the actual challenges, questions and responses that come up in a typical session. Girls who attended the later sequence earned the Math Whiz and Puzzler badges. Both were very successful as far as engaging the girls and containing solid math content.

Career options are wide open to those who like math. Mathematician, professor, engineer, accountant, architect, carpenter, retail business owner, and computer programmer are just a few. See if you can brainstorm more.

Format 1: Scaling Down and Proportional Reasoning

Week One:

1) Brainstorm how math is used in everyday life.

2) Imagine what a mathematician looks like.

3) Interview the staff to find out what they do. (We were fortunate enough to have a staff member who has aPh.D. in math education and shattered their images of a male, nerdy mathematician in a lab coat with pocket protectors, crunching numbers!).

4) Shapes Around Us Bingo* is the next activity, and end with number five: Estimation.

5) Estimation - A preliminary guess at the number of chocolate kisses in a jar. Girls can write their names and guesses on small scraps of paper and hand them in. This will be continued next week.

**For the bingo game, before the session draw one card depicting rows of different 2-D and 3-D shapes, and make copies. Give a time limit of 5-10 minutes and let the kids wander the building, searching for geometric shapes on the card.*

Week Two:

1) Measuring Me (see Body Proportions in the next sequence for full description)

2) Scaling Down My Foot. Girls trace one of their feet. then measure and scale to ½ size. We asked, “What would your foot look like if you made it half as long. but kept it just as wide as it is now?” “What if a 2 year old had feet the size of mine?” Let them work on the answers, but the general idea is that the baby’s foot is still the same basic shape as an adult’s, but proportionally smaller. They have to figure out how to make it smaller all over, not just shorter or narrower.

3) Estimation. In Estimation, they were given a reference (a baggie with 20 kisses in it) and then allowed to look at the jar of candy from week one and refine their guesses of the week before. Two girls tied for closest estimate and walked away with the prize kisses! (Okay, being good Girl Scouts, they shared.)

Week Three:

1) Mini-Me. Have girls pair up and outline each other on butcher paper. Then ask them to take their own outline and shrink it to 1/10 their size! Two girls chose to shrink a book, and had great fun getting into the details, shrinking pages to put inside, and in a later session, scaling down a bookcase for it! Ratio and reducing an image all over is the continuing theme. Many will measure only the length and "eyeball" the width. When checked with a ruler, they can be quite accurate! However, encourage measuring.

2) Give them the challenge of using the same technique to scale down a piece of furniture at home and build it out of cardboard or paper. Bring it next week.

3) Have a new estimation jar containing red licorice or something. Take first guesses at the number of pieces and save for next week.

Week Four:

1) Any active, outdoor game for 10-15 minutes.

2) Admire any mini-furniture brought from home. Our group loved miniaturizing.

3) Read *Math Curse,* by Jon Scieszka, New York: Viking (1996), aloud and try some of the patterns suggested. For example, what would be the next 5 numbers in the Fibonacci series beginning with 1,1, 2, 3, 5? This was over the heads of some, but it was a good stretch and we were drawing the number sequences on butcher paper on the floor so it was both visible and thought-provoking, whether or not it was fully understood. We were having a good time with those and spent a half hour puzzling over them, so by the time we had snack, there wasn't much time to start the next activity.

4) Mini-me furniture - introduce the idea that in coming weeks they will make a scale model bedroom on paper, and furnish it with 3-D mini-furniture.

5) Give out notebooks and ask them to take on the assignment of keeping track of their use of math for two days. (Your mission, should you choose to accept it is to write down all the times you use math or numbers for anything...) Also give them a phone tree, so that each girl can call one other girl to ask if she is remembering to do the assignment.

6) Estimation jar. Give a frame of reference to last week's jar, such as a smaller jar or baggie with a known number of the same candy in it. "This small jar has 20 bite-size cherry twizzlers in it. Now look at both jars and estimate the number in the larger jar." Let them adjust their guesses to estimates, and give it away! Again in our case, we had two winners.

Week Five:

1) Listen to readings from some of the journals the girls kept on their math usage over a two-day period. One of our youngest girl's journal was cute and clever - she had considered her days as a series of math problems the way the book Math Curse had done.

2) Interlocking colored cubes. The cubes were great! First, have them make a cube that is 2x2x2 cubes. Then ask them to double that size. It was very difficult but intrigued the girls, and there was enough adult input that they didn't seem frustrated; rather they enjoyed the challenge. When math is made visible and concrete it makes it so much easier for many of us to grasp!

3) Measure and cut out flat scale-model bedrooms on heavy paper or poster board. The adults can help them to see why it is necessary to measure at several points on the paper so that the lines will be straight. We didn't have much time for this part, so we put them away for the next week.

Week Six:

1) Open with an active game again, since this is somewhat "schooly".

2) Hand out the poster board from the previous week. Finish up the floor plan.

3) Hand out actual written dimensions for furniture such as beds, dressers, and night stands, and have the girls reduce the proportions to 1/10 the size. Our girls were really focused on making the three dimensional furniture and accessories for the bedrooms. We provided scissors, sturdy paper, glue and tape. Help as necessary, but remember to let the girls do the work. One pair made a bunkbed and pillows and used a green napkin for blankets. We had one adult coming around as a bed inspector, measuring and inspecting the workmanship. As in real life, if we were really building a house or furniture, it would definitely be subject to inspection! Again, though some of the tasks were over the heads of some participants, we think that is how you learn. Kids won't learn to do new things by doing only what they know. This was a fun experience in measuring, scaling, ratio, and proportion. The girls got a lot out of it, and earned their Math Whiz badge in the process.

Format 2: Six Weeks of Math Disguised as Art, Puzzles, and Cooking! [1]

One Girl Scout troop leader who was meeting weekly with her Junior level scouts worked with the SYSTEM staff on three occasions, bringing her girls six weeks each of Rockets and Flight, Structures, and Math. When choosing the theme for this six week SYSTEM program, she said that many of her girls had expressed a strong dislike for math. She thought it would be good for them to earn their Math Whiz and/or Puzzler badge, and maybe change their ideas about math into a positive experience. Here's how the SYSTEM team (including the troop leader) set up the six weeks:
Week One: Tangram Puzzles
Week Two: Optical Art and Salsa Making
Week Three: Body Proportions
Week Four: M.C. Escher-style Tessellations
Week Five: Wooden Puzzle Making
Week Six: Parent Night - Demonstrate Puzzles, Are You a Square

Week One:
Tangram Puzzles

Materials:
- fun foam in assorted colors
- scissors
- tangram design pictures
- pens

Introduction:
Have a hidden picture activity for the girls to work on as everyone is arriving, and a set of Tangrams to play with on a table. Begin the session by telling the girls that the shape-puzzles are called Tangrams, and give each girl a handout about the history of the puzzle and some of the shapes you can make with it. We used Tantalizing Tangrams from Frank Schaffer's Classmate, Feb/Mar 1988, but two excellent web sites for tangrams are www.tangrams.ca and http://mathforum.org/trscavo/tangrams.html .

Procedure:
Once you have explained the handout and the girls have had a chance to explore the Tangrams, ask them to make a square with the seven pieces. After they do that, they can try to make some of the other designs. Again, the web sites have easily- downloadable pages of designs. Next, the girls cut their own Tangram puzzles out of Fun Foam.

Comments:
While working, discuss the names of the shapes, how to make a square from a rectangular sheet, some discussion of area and features of two-dimensional objects. For example, if the girls had exposure to a definition of area, and how to find the area of a square, then they could be reminded that whatever shape they made with their Tangram pieces would have the same area.

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[1]*Thanks to Bryan Sargus, Research Assistant, for his notes relating to this section.*

Week Two:
Optical Art and Salsa Making

Materials:

- handcuff puzzles (*See picture of handcuff puzzles on wrists, p. 126*)
- handouts of 7 inch square
- pencils, plain and colored
- rulers
- one inch plastic squares (optional)
- salsa ingredients, see recipe below
- tortilla chips
- bowls and utensils

Introduction:
As girls arrive they enjoy trying to extricate themselves from the handcuff puzzles joining them to another Girl Scout. These puzzles consist of two 5 ft. lengths of thin rope with slipknots at the ends. The loops of one rope are placed on one girl's wrists. The other rope is then passed behind that rope before being placed on another girl's wrists. They are then, in effect, linked together, and the challenge is to become unlinked without cutting or unknotting either rope. **Hint:** the solution has to do with the slipknots.

Procedure: Optical Art
Once they are all there they get into their small groups for the introduction to the evening's activity. The girls are each given a sheet of paper with a 7 x 7-inch square drawn on it and a 1-inch square of plastic. One adult begins by asking how big the plastic is. Most figure it correctly and she confirms that each side of the square is one inch long. She then asks them to figure out the size of the large square, using the small one to measure it. Most say it is 7 inches. She then asks them to make a mark for every inch on each side of the large square. As this is confusing to some, she demonstrates, and tells them they will be using this to make optical art. Rulers are necessary, as this is precision drawing. Once all the squares are marked, then connect the lines. Note: See the directions on the Optical Art, pp. 105-114 of this book, as it may be easier to use the ruler to mark and draw one square at a time than to make all the marks and then try to figure out which ones connect. As more squares are drawn, a pattern begins to emerge.

Comment:
This is another good time for a casual discussion of area, square units, or two-dimensional measurement. As the drawings are completed, they can be colored in such a way as to enhance the illusion of curves. Some girls do an amazing job of this.

Procedure: Salsa Making
The next activity involves making salsa for the snack. To save time, the troop leader has prepared the ingredients ahead of time. If you have more time, chopping and preparing the ingredients can be a very enjoyable activity in itself, and can be used toward a cooking badge. The girls work in pairs, and their task is to take the single-serving recipe and adjust it for six servings. This requires multiplication with fractions, (for example, 3/4 cup of chopped tomatoes multiplied by six) and some girls are not familiar with that process. Here is a way to illustrate

this concept. Draw six small circles and divide each into four sections. Ask one of the girls to come up and color in three of the four pieces in each circle and then count up the number of colored sections (18). Then explain that rather than using just ¾ cup of tomatoes, they will be using 18/4 cups, or 4½ cups of tomatoes. The girls seem to understand this illustration very well. Once they finish the calculations, they measure out and mix the ingredients. They have a great time, and the salsa tastes delicious!

Mild Fresh Salsa

Yield: One serving
3/4 cup diced tomatoes
1/6 cup finely chopped fresh cilantro
1 oz. chopped green chiles
1/6 cup sliced scallions
dash salt
dash pepper
combine and chill (or eat!)

Week Three:
Body Proportions

Materials:
- ball of string
- several measuring tapes
- paper
- pencils

Introduction:
When the girls are all present, a SYSTEM team member introduces the evening's activities. She explains that they will measure their height with a length of string and then estimate the number of times that string will wrap around their heads. They demonstrate with one child, take guesses, and then test the predictions. She tells them they will be doing the same thing in pairs, and taking other measurements as well.

Procedure: Are You a Square?
Measuring tapes are used to measure and cut pieces of string to each girl's height. They are asked to report the values they get in inches and then convert them to feet if they can. The adults help by giving some examples, pointing out values on the measuring tape, and helping to do the conversions, but not doing it for them. The girls do the first set of measurements and are surprised that their predictions are a bit higher than the actual number of times their height can go around their head. The actual values varied from about 2¼ to 3 times around the head. A brief discussion of the meaning of the word proportion followed.

Next, the girls will measure the length of their outstretched arms from fingertip to fingertip and compare that distance to their heights. Predictions are made. Will you be a rectangle or a square? In other words, will your height be greater than your arm span, your arm span greater than your height, or will they be about equal? On a large sheet of butcher paper taped to the wall, they are to tape a small square or rectangle corresponding to their prediction, and labeled with their name. All girls predict they will be rectangles, taller than they are wide. After that, they pair up to do the measurements. Many of the girls are surprised to find out that they are as wide as they are tall (give or take an inch) and are in fact closer to being squares. A brief discussion follows regarding the predictions vs. the reality.

Procedure: Scaling Down Your Foot
Next, a team member asks each girl to trace her foot on a piece of paper. The girls do this, and she then asks them to draw that same foot, but half the size. Some simply divide the first foot in half and redraw the toes. "Is that a normal looking foot?" they are asked. "No," one replies, "it's too wide, but it's half a foot." "What would your foot look like if you were half your size?" "I'll just draw a baby's foot," replies one girl.

Some find it difficult to proportionally reduce the foot to half its size. They tend to reduce width only or length only, resulting in long, narrow feet, or short, wide feet. With a bit of clarification, they begin to draw proportionally smaller feet inside the originals. Here it would be wise to mention that they are reducing the proportions of an area, rather than halving the linear measurement of length or width.

One adult introduces another body proportion by asking, "What part of your body is the same length as your foot?" "Your other foot!" pipes up one girl. "Good answer!" "Okay, what else?" Let them explore measuring at this point. They can pair up for this, too.

Measure and record the lengths of various body parts. Forearm from wrist to elbow, upper arm from elbow to armpit or shoulder, back from waist to neck, circumference of neck and wrist, length of shin, thigh, hand, and face are all good. Then they can compare sizes such as length of foot in proportion to forearm, or length of one person's shin compared to another's. Keep away from "traditional measurements" such as chest, waist and hips, so as not to make girls even more self-conscious in this weight-obsessed culture of ours.

Week Four:
M.C. Escher-Style Tesselations

Introduction:
The girls get right to work on a "Count the Cubes" worksheet as they arrive. It has an illustration of a 3-D figure made up of many cubes with identical dimensions. The girls are asked to count the cubes and write down how many make up the figure. I found a web site about cubes and volume. It is http://freewind.legend.co.uk/~calverms/mesh07pg.htm. The evening's activity is introduced.

Procedure: See "Escher-Style Tessellations", pp. 115-117. The girls required several demonstrations of the cutting, placement, and subsequent tracing of the shape, before they were comfortably doing it on their own.

Comments: Be sure to include casual discussion of the math behind this design principle during the activity. The secret to forming tessellations lies in the sum of the interior angles of the regular polygons that are coming together to form the pattern. The sum of these angles at any vertex needs to be 180 or 360 degrees, or the design won't tessellate (i.e. there will be gaps or overlaps). Again, read the section on tessellations and make sure you understand the concept before engaging the children in discussion. This is a good activity in which to explore regular polygons as well as to introduce the concept of angles and how they are measured.

Week Five:
Making and Solving Puzzles

This activity requires precut cubes and glue for the SOMA puzzle, pre-drilled wooden rectangular blocks and pegs for the leapfrog puzzle, and pre-cut wooden squares and golf tees (any colors) for the star puzzle. Both the leapfrog and star puzzles can be made and played on paper with tokens, but making them with wood is fun and they last longer. See section on Math Puzzles (pp. 119-143) for these and more that can be done on paper or with wood.

After making the cube (SOMA®) puzzles (pp. 158-166), the girls can spend a few minutes assembling the blocks into cubes and other shapes illustrated on the SOMA® handouts. During the building it's a great time to engage the kids in conversation about their interest in math and how they have been using math to build things and even make art. It's very exciting to complete some of the shapes from the handouts. Be enthusiastic about their accomplishments and yours!

Ask the girls to set aside their puzzles because they will be making two more before the meeting is over. Next there is the Star Puzzle which features a square piece of wood with 8 holes in it. The girls are asked to use a pencil and ruler to connect the holes in a particular star pattern. Then they use the ruler and a permanent marker to darken the lines. The seven golf tees (of the same or various colors) are then used to do the puzzle. This puzzle can also be drawn on paper, and played with coins or any small objects.

The object is to start with an empty board, and beginning in an open spot, slide the tee or coin along the straight lines, placing each of the seven objects at a star point.

Next is the Leapfrog Puzzle. This also can be drawn or made of wood. Start with a block of wood long enough to accommodate a row of nine holes. Make or buy pegs that will fit nicely into the holes; you want them snug enough to stand upright, but loose enough to move easily. With a little instruction on the use of a drill, the kids can easily mark the holes and then drill them. To play this puzzle, place four pegs of one color in the first four holes on the board. Place four pegs of another color in the four holes at the other end of the board. Leave a hole empty in the middle. The object of this puzzle is to move one set of pegs to the other end of the board, while moving that set to the opposite end. You may only move forward, one space or one jump at a time. In other words, you cannot move a peg backwards, and you can move only one space, or jump one peg at a time. The pattern is such that you could do it with as many pegs as you wanted, if you had the space. (Author's note: My son can do this in seconds; but after 3 years of exposure to this puzzle I still can't remember the pattern or do the puzzle without help! I love it!)

If you want, you can explain the puzzles and how to make them, and then divide the girls up into groups of three or four, asking them to work at one of the puzzle stations and then rotate on to the next after completing their puzzles. When they are finished making the puzzles explain the objective behind each puzzle, but say that it is up to them to find out the solution.

Let them know that they will be allowed to keep some (or all) of the puzzles they make, but you will be keeping them until next week, when the parents come to visit. As always, leave time for the kids to clean up and have a snack!

Week Six:
Parent Night

Have the puzzles set up at different tables according to type. Assemble the parents, thank them for coming, and briefly explain what the girls have been doing over the past five weeks. You can play a math game (see that section of this book) like Guess, Digit, Place with the girls for a couple of rounds, and then have them sit with their parents. Hand out or have on butcher paper this set of questions from “Startling Statements”*:

1. In 1986, women made up 40% of the information technology workforce. What percentage did they make up in 1999?
2. In 1996-97, 53.1% of biological/life science master’s degrees were awarded to women. What percentage of engineering master’s degrees were awarded to women?
3. In 1996, the average mathematics proficiency score for male 12th grade students was 305. What was the average score for female students?
4. In 1999, 15% of white high school students reported calculus as the highest math course they’d taken. What was the percentage of Hispanic students who reported the same?

The answers are surprising to many. Many people overestimate on their responses, and it is a good place to remind them of the importance of encouraging science and math classes for all students, girls and minorities in particular. The actual answers are as follows:

1. 29%
2. 15%
3. 303
4. 8%

Now the parents and girls can circulate about the room enjoying the puzzles and perhaps viewing the optical art and tessellations from previous weeks. The girls can also ask their parents if they are squares and help them measure to find out! (See week three). Make sure the girls take their creations when they go home.

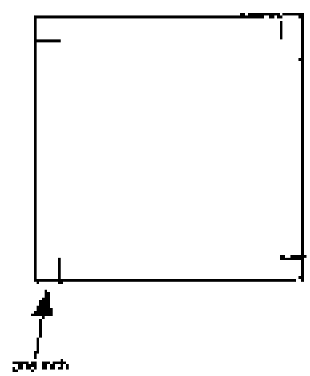
**Lawrence Hall of Science, University of California, Berkeley*
Startling Statistics can be found at www.lawrencehallofscience.org/equals

Math and Art
Optical Art

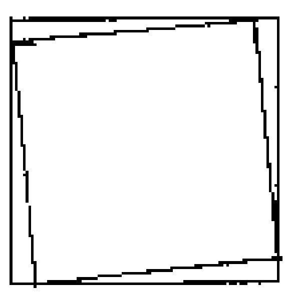
1. Today we are going to look at how math and art are related. What are some ways you can think of that math is like art or art is like math? (Both use shapes, patterns, measuring.) We will do a math/art project which uses all three of these common themes.

   We will make a design which illustrates Optical art. What does the word OPTICAL mean? Has anyone ever visited the optician or an optometrist? Optical means it has to do with our eyes. Op art plays a trick on your eyes. It is a form of art which uses straight lines or geometric patterns to create a spatial visual effect. Usually they use two colors (light and dark) to make a design appear to have motion or changing depth even though it is flat on the page.

2. I will give you a paper with a square drawn on it and a ruler. Your job is to measure exactly one inch from each corner and make a mark as shown:



   Next you will connect the spot on the square's edge where you marked in order around the square. What shape do you think this will create? Try it!



3. Notice we created a new square with triangles around its edge. Measure the size of this square. How does it compare to the original square?

   Your job is to repeate this process over and over again. Use the new square, mark one inch from each corner in the same way. Connect. Do this again and again until you can't make any more 1-inch marks. How do you think this design will look when finished?

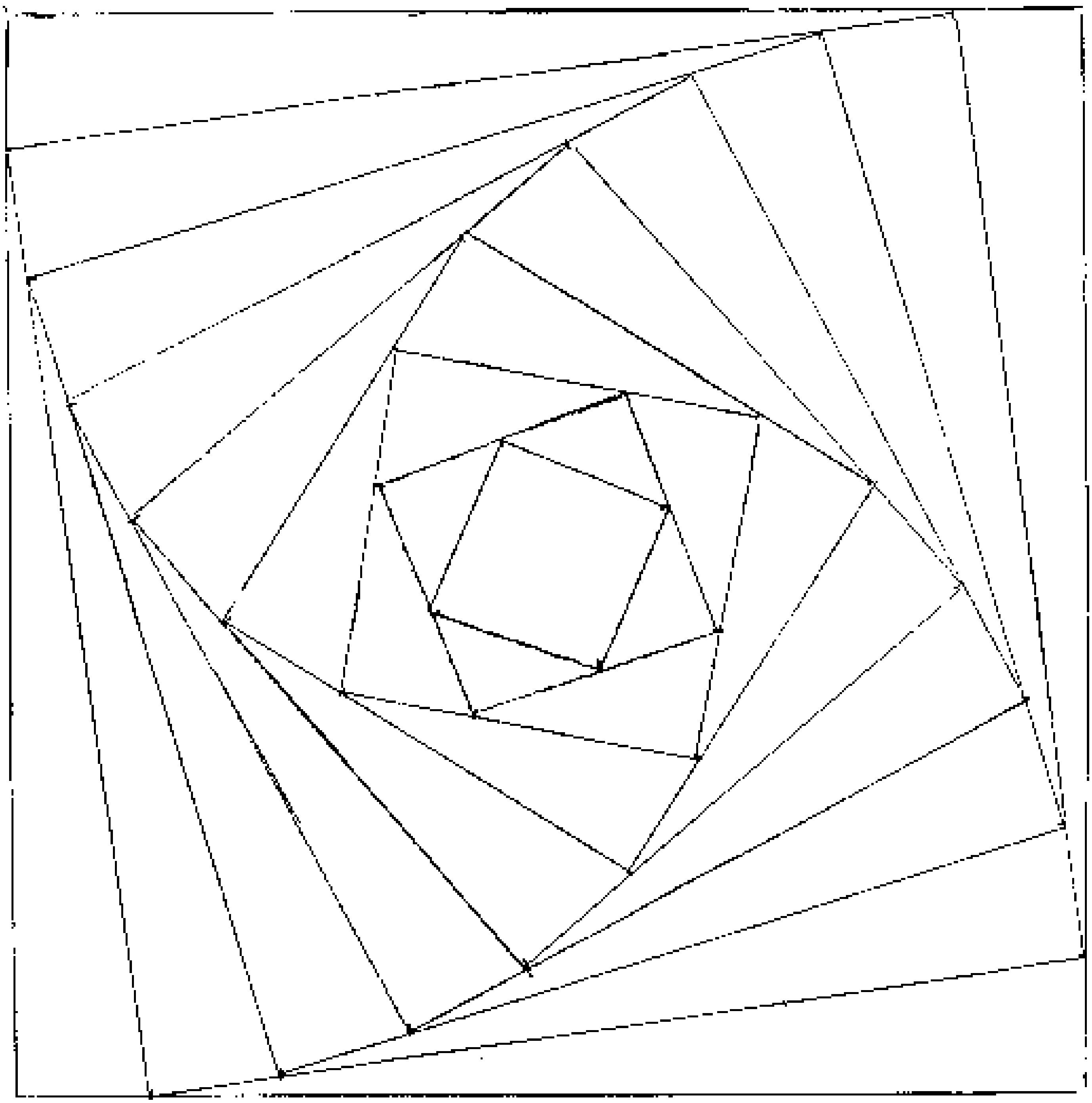
4. What do you notice about your design now that it is complete? [It seems to rotate to the right like a spiral.] Look at the lines we drew. We always drew straight lines, but in the design they seem kind of curved. This is an optical effect of this design.

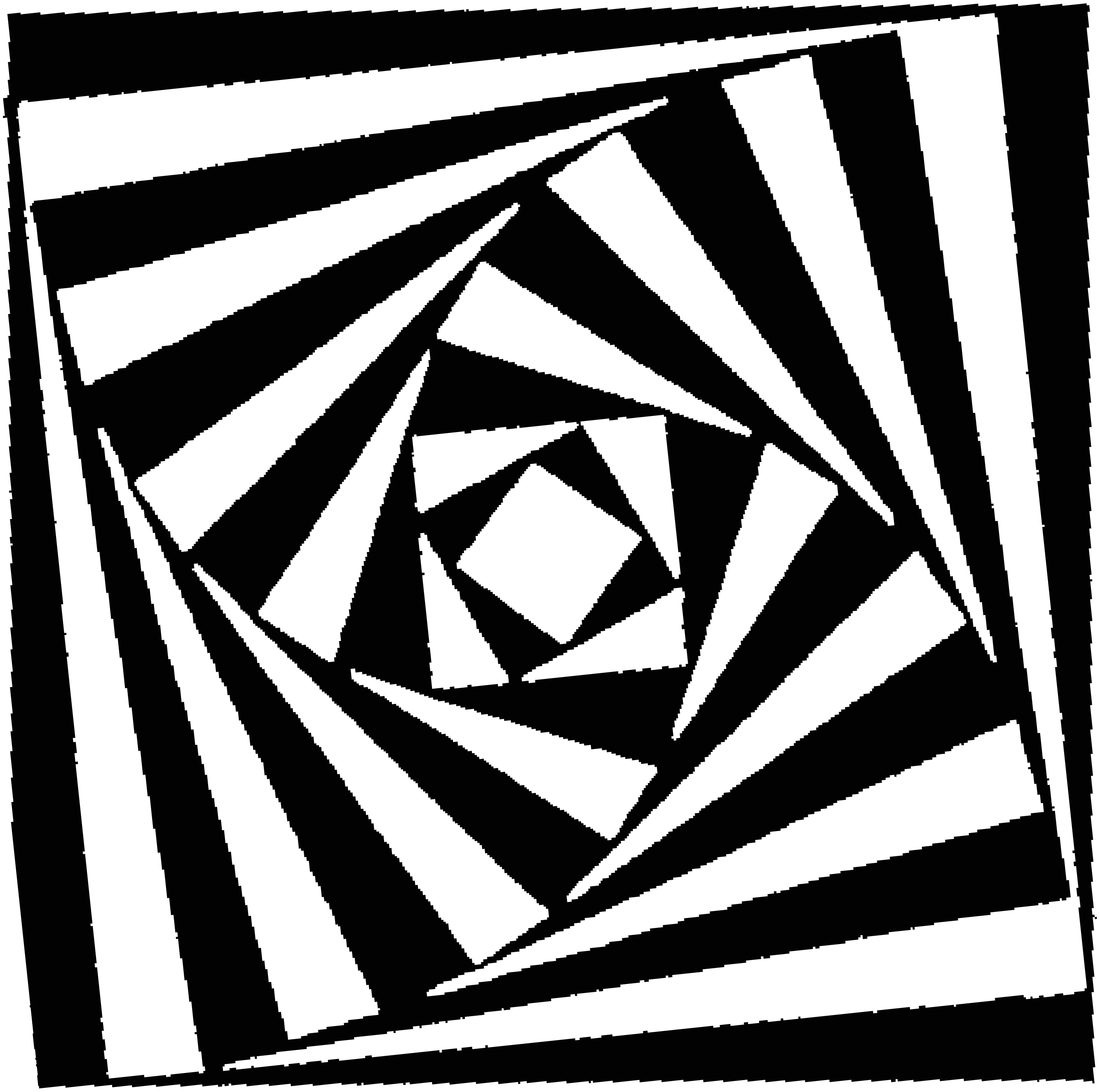
   We can increase the effect of the design by using color to fill it in. This kind of Op Art is usually colored in two contrasting colors. (See example on next page.) Choose two colors and complete your design. We can post and compare the effect of using different color combinations.

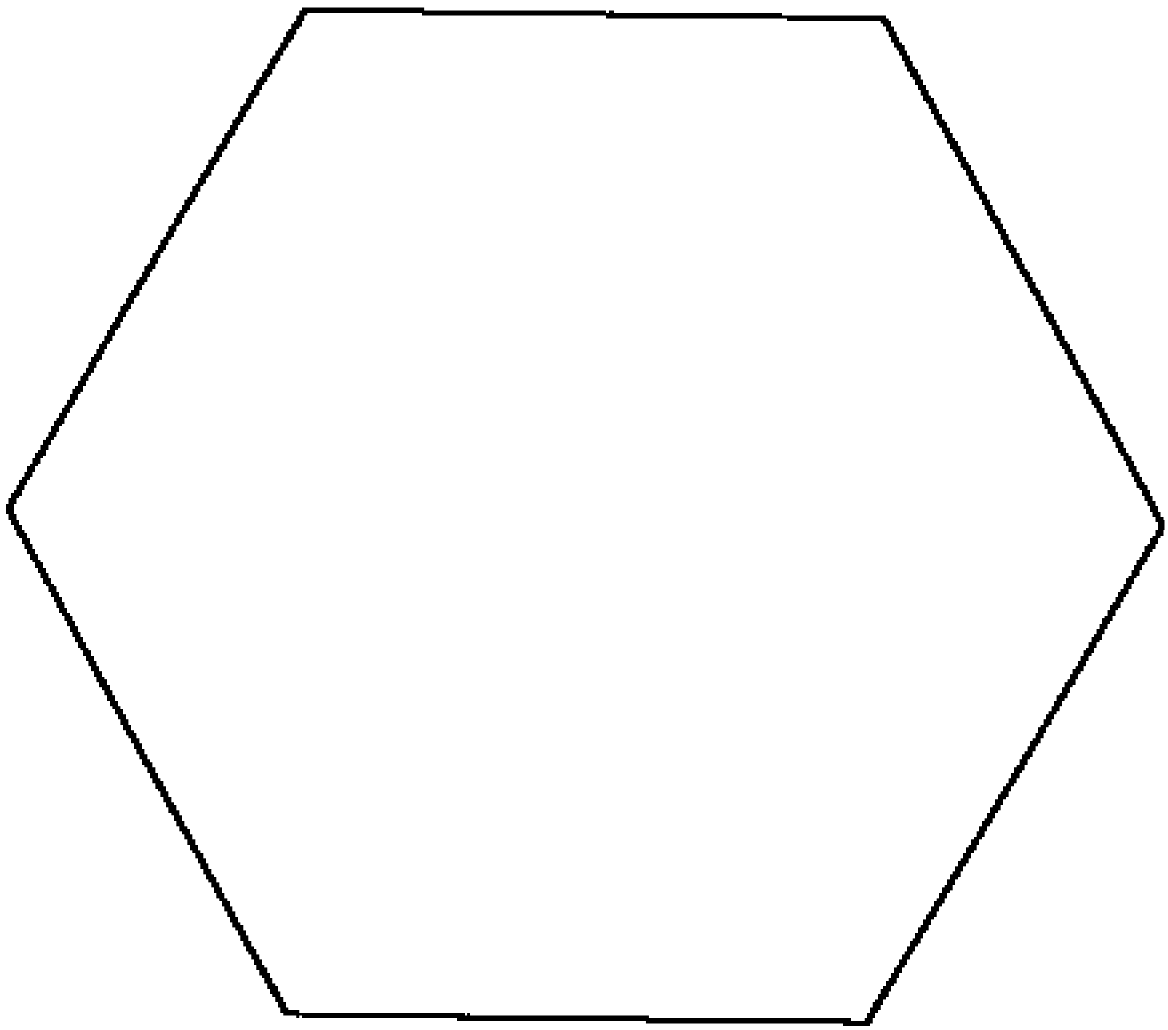
5. Now let's take this art lesson a step further. What are some things we could change and still make a design of this type? What do you think these changes would do to the optical effect?

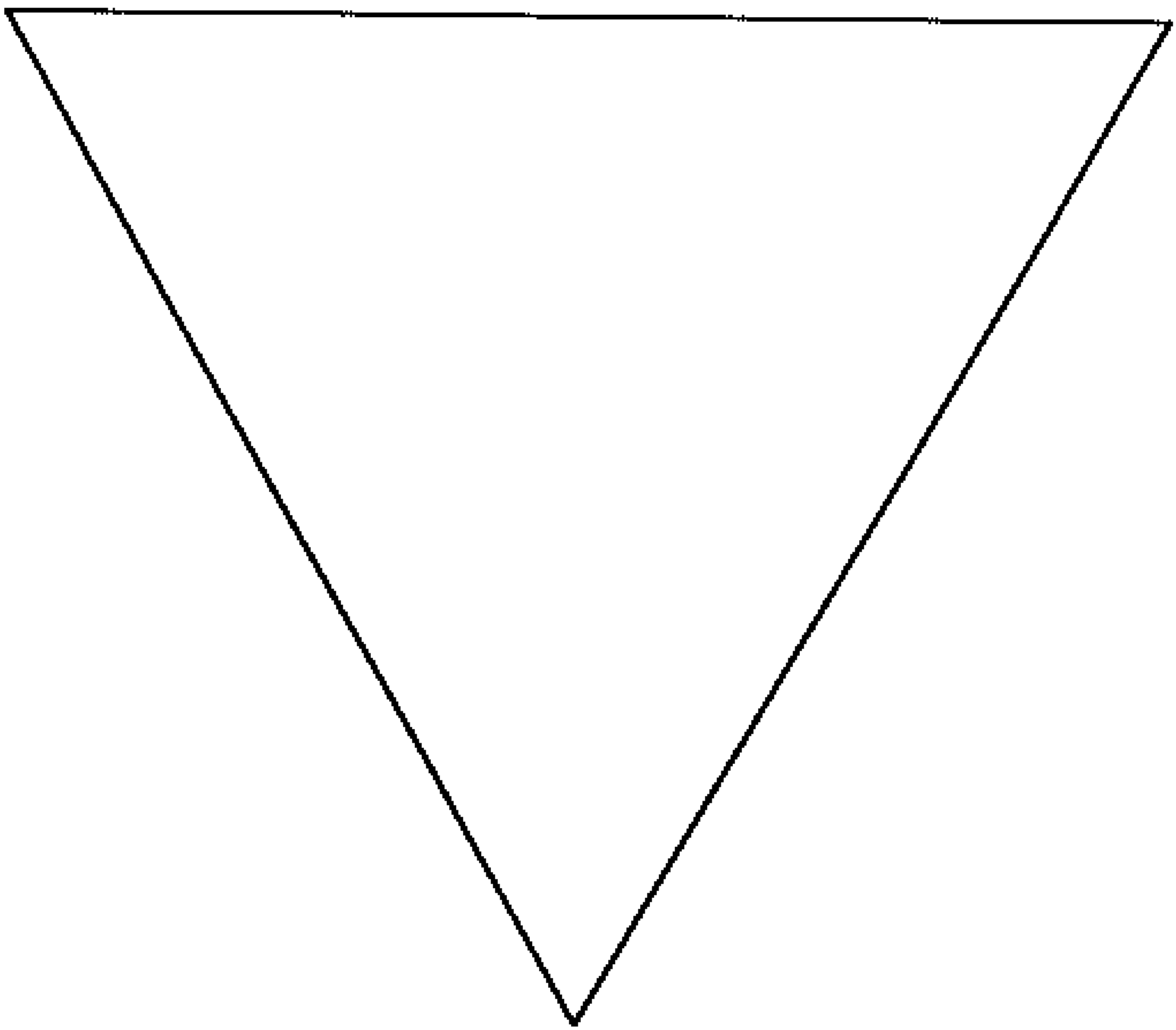
   [Possible "what if's":
   •What if we started with a different shape (rectangle, triangle, hexagon, etc)?
   •What if we reversed the color order in the same design?
   •What if we measure 1 inch to the left instead of to the right?
   •What if we use one cm or three-fourths of an inch? Two inches?
   •What if we vary the measuring amount in a pattern like 1-inch, 1/2 inch, 1 inch, 1/2 inch, etc?
   • What if we start with a larger/smaller square?

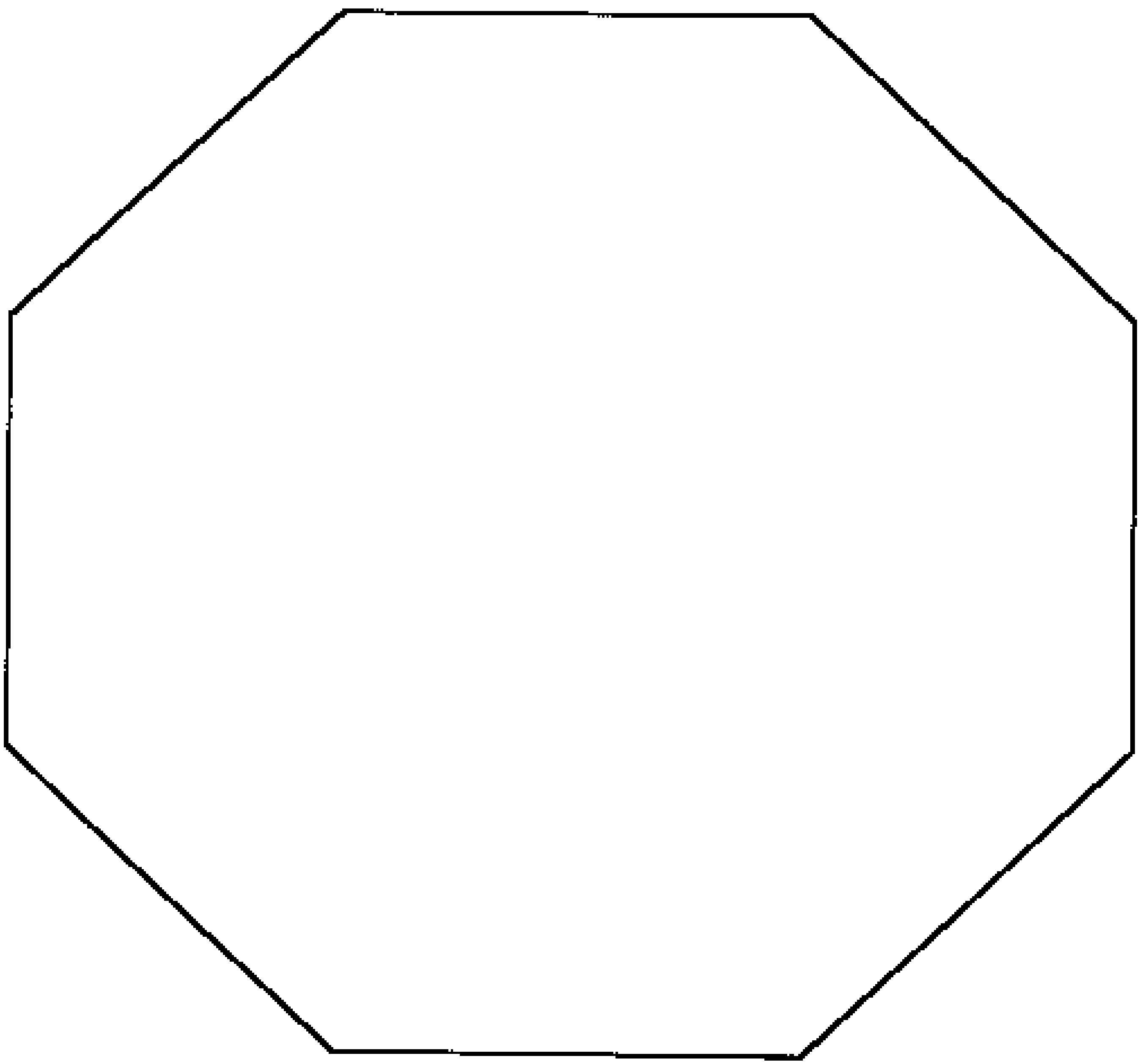
   Encourage students to predict then try some of these variations.]











Escher-Style Tessellations

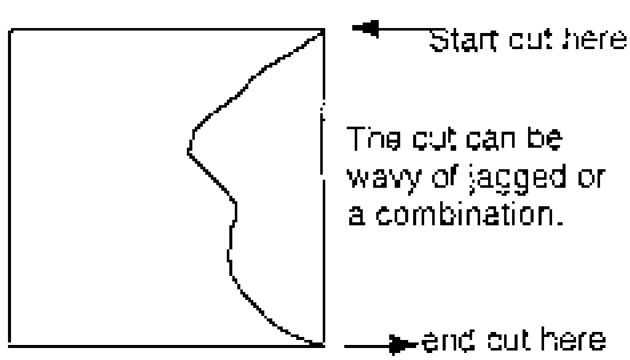
1. Have you heard of a mathematician named M.C. Escher? One of the things he is known for are his tessellation drawings. I will show you some tessellations that he has done. What are some of the things you notice about his drawings? Our lesson today will interweave concepts basic to art, to geometry and to design. We will learn how to make a design which will tessellate.

   A shape is said to tessellate if it can be used as a "tile" following these rules

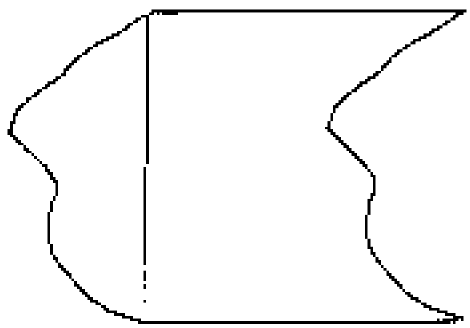
   1) they must completely fill a space (no gaps, no overlaps)
   2) corners meet corners, edges meet edges
   3) no flips.

2. Tessellations are related to angles. A tessellation works with a shape if the sum of the angles in that shape is 180 or 360 or if it is possible to work combinations of those angle to equal 180 or 360. What is the measure of each angle in a square? *(90°)* A square tessellates because we can form 360° when four squares meet at a vertex. In fact any quadrilateral will tessellate because the sum of the angles in the shape is 360°. All triangles tessellate because the sum of their angles is 180°.

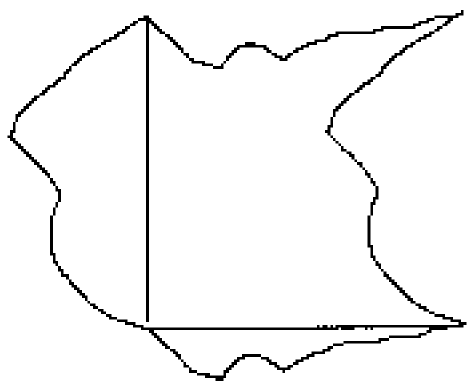
3. We will base our tessellation designs on a square. A tessellation made just of squares would be very boring, so let's see about modifying the square a bit. Take one of your 3" x 3" squares (cut from an index card). Modify it by cutting a portion in this way:



4. We want this shape to tessellate so we have to make sure we preserve the angles. By entering and exiting at corners we do this. Now take the cut-out and reattach it by taping it on the opposite side (slide it across).

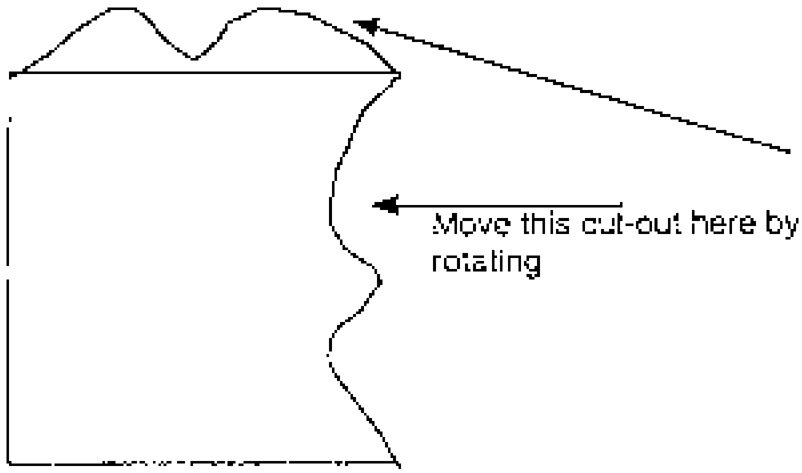


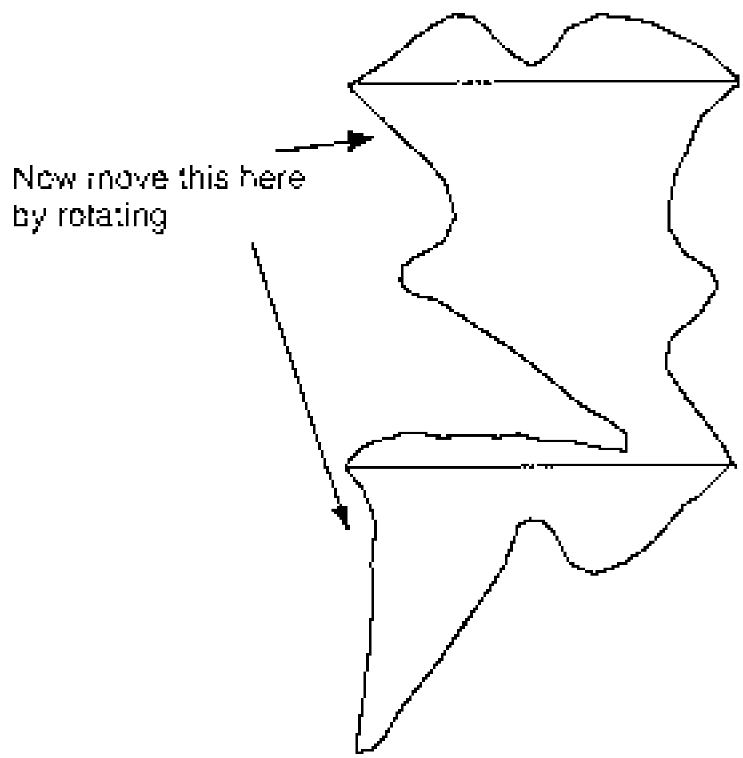
Now at the top of the card do the same. Cut by entering at a corner and exiting at the next corner. Reattach this piece by taping it on the bottom side.



This new shape is guaranteed to tessellate because we have not interfered with the sum of the angles being 360. Try it. Trace this shape on your paper. Move it and trace again and again. If it is difficult to trace because of the taping, trace it onto another sturdy piece of paper or cardboard, cut it out and use this to trace your design. What do you see? Name your design. Decorate your design.

5. Now use your second 3" x 3" square. Make a cut like the first one (in and out of adjacent corners). Reattach it in this way: Rotate the cut-out and tape it in place on the next side. Do the same with another side. This shape will also tessellate, but in a different way. See if you can tell what is different between the ways the two shapes tessellate.





Math Puzzles

Latin Squares Puzzle

Arrange the sixteen pieces so that each row, column and every diagonal contains no more than <u>one</u> of any color.

Latin Squares

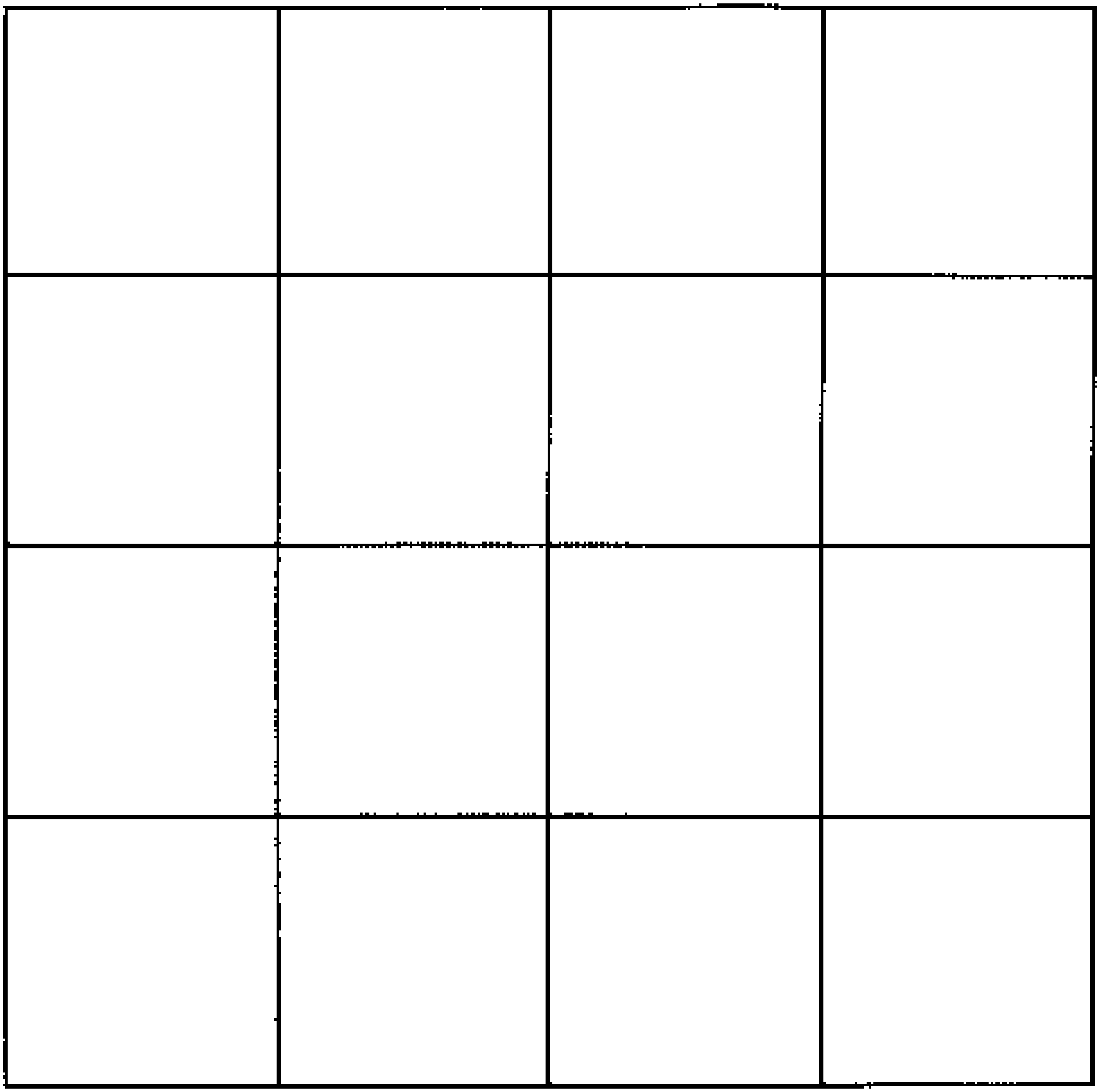
Materials: 16 foam butterflies, game board

1. Collect 16 butterflies: 4 butterflies in one color, 3 each in four other colors.

   Color #1: 4 butterflies
   Color #2: 3 butterflies
   Color #3: 3 butterflies
   Color #4: 3 butterflies
   Color #5: 3 butterflies
   16 butterflies

2. Collect a gameboard.

Latin Square Puzzle



Arrange the 16 pieces so that
each row, column, and every
diagonal contains no more than
ONE piece of any color.

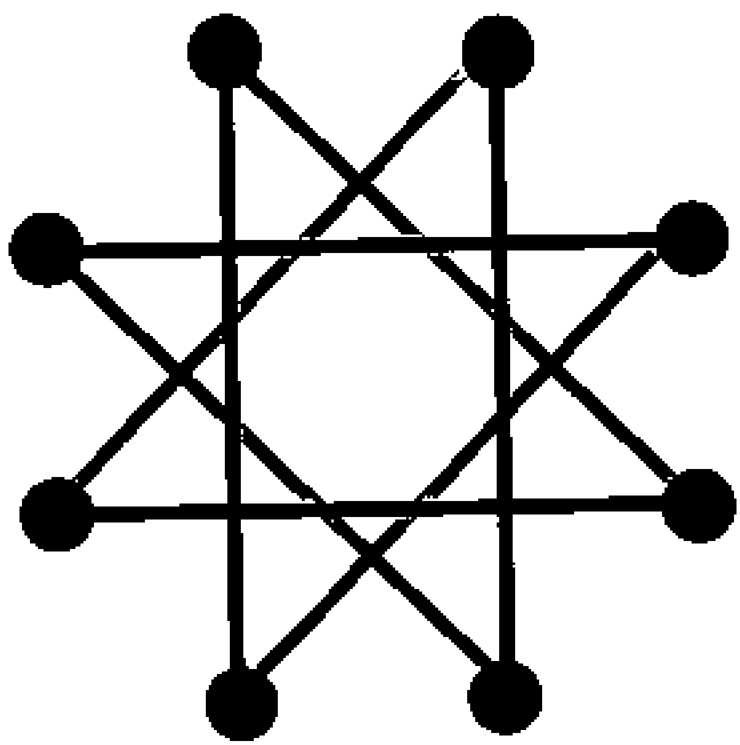
Star Puzzle

Begin with an empty board. Place a peg in an open hole and slide along a line into another open hole. Leave the peg there. Now place another peg in the same way. Continue until all seven pegs have been placed.

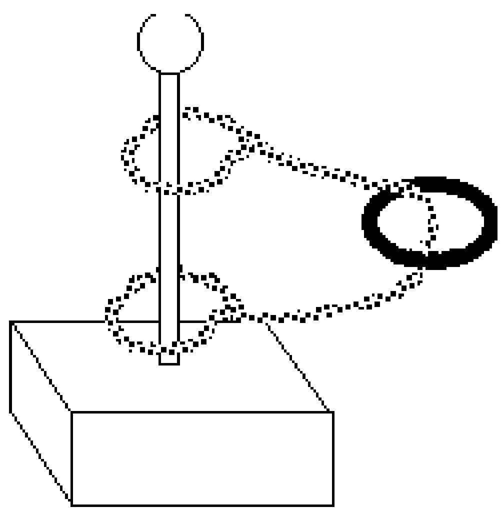
Star Puzzle

Materials: square board, 7 golf tees, permanent markers, ruler, sandpaper

1. Sand board to remove any rough spots.
2. Use a permanent marker and ruler to draw lines as shown. (Mark with pencil first to make sure lines are correct!)
3. Collect 7 golf tees in any colors. You may choose all tees the same color or choose a collection in mixed colors.



Pole Puzzle



Begin with the puzzle assembled as shown. Remove the ring from the rope without taking the rope off the pole. You may not untie the rope.

Pole Puzzle

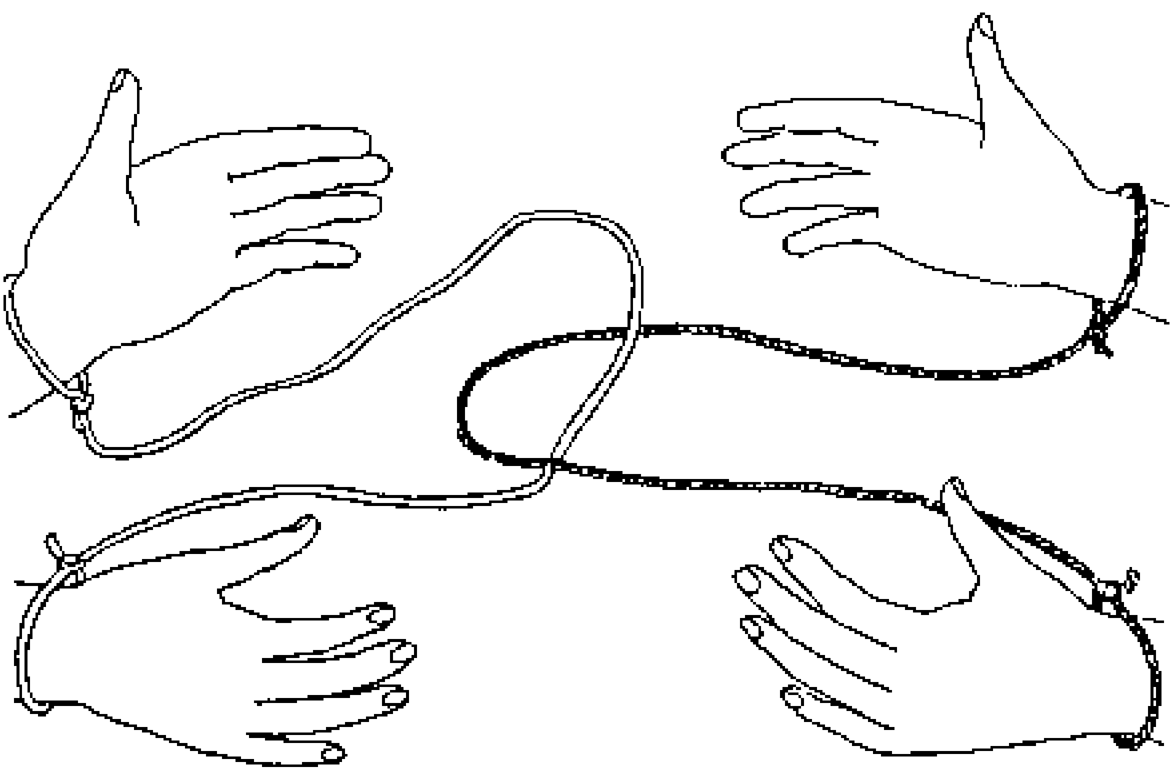
Materials: base, dowel, rope, ring, dowel cap, sandpaper, glue, electrical tape

1. Sand base to remove any rough spots.
2. Put a little glue around the end of the dowel and insert into the hole in the base. Gently pound into place with a hammer.
3. Place a small amount of glue inside the dowel cap. Place cap on the end of the dowel. Gently pound this in place.
4. Cut a piece of rope 30 inches long. Tape the ends to prevent fraying.
5. Form a loop at each end using a SLIP KNOT.

NOTE: See step-by-step directions for making a slip knot.

Handcuff Puzzle

Place ropes on your wrists and a partner's wrists as shown so that the ropes are interlocked. Now try to separate yourselves from each other without undoing any knot or cutting the rope.



Handcuff Puzzle

Materials: rope, color tape

1. Cut 2 lengths of rope each 5 feet long.
2. Tape the ends to prevent fraying.
3. Form a loop at each end of each rope using a SLIP KNOT.

NOTE: See step-by-step directions for making a slip knot.

Leap Frog Puzzle

Place four pegs of one color in the first four holes of the board. Place four pegs of another color in the last four holes of the board. Leave the center hole empty. Move the pegs as described below so that the color arrangement is reversed.

Two types of moves are permitted: A peg may move into an empty space next to it OR a peg may jump over one peg into an empty space. Pegs may only move forwards (towards their destination).

Leap Frog

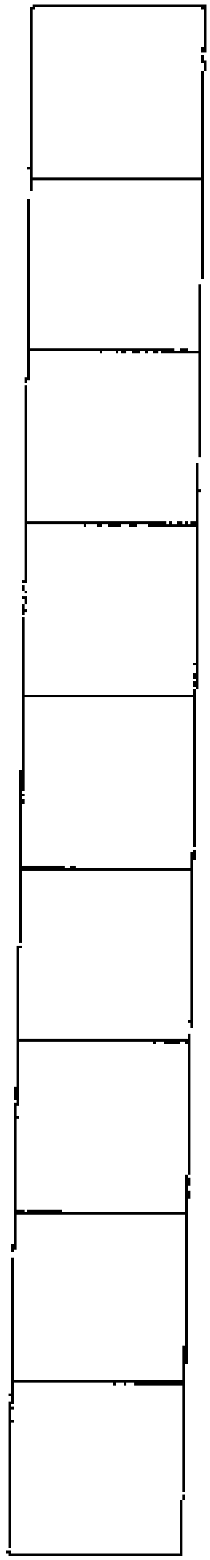
Materials: skinny board, 8 golf tees, sandpaper

1. Sand board to remove any rough spots.
2. Collect 8 golf tees: 4 each of two colors.

   Color #1: 4 tees

   Color #2: 4 tees

Board for Leap Frog



Heart Puzzle

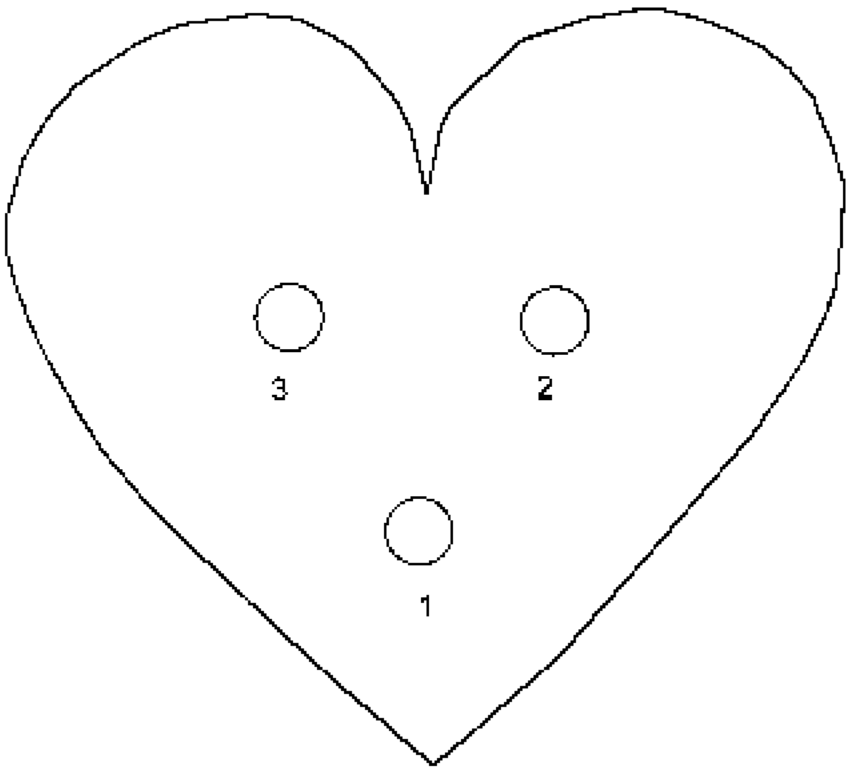
Remove the string from the heart without removing the bead or untying the string. Now replace the string on the heart.

Heart Puzzle

Materials: metallic cord, heart bead, wooden heart

1. Cut a piece of metallic cord 2 feet long.
2. Fold the length of cord in half, tie a knot near the cut ends.
3. Thread a heart bead on the cord and make a knot just above the bead to keep it from moving.
4. We will assemble these pieces (wooden heart and cords with bead) at the end of the workshop.

Heart Puzzle Assembly Directions



To thread the heart:

IN hole #1.

OUT hole #2.

IN hole #3

BACK THROUGH hole #1.

Thread bead through loop.

Pull loop back through hole #1 so that it rests on the side of the heart without the bead.

Foam Circle Puzzle

Put the foam pieces together to create a circle.

Foam Circle Puzzles

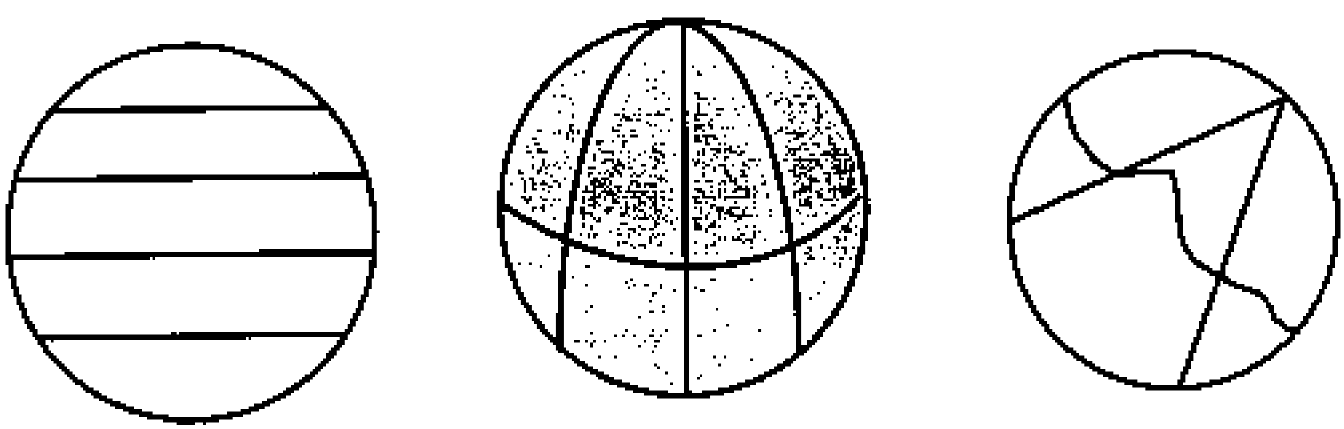
Materials: fun foam, cans, permanent markers, rulers

1. Choose <u>one</u> fun foam sheet. Use any size can as a template to trace a circle using permanent marker.
2. Mark this circle in any pattern using the permanent marker and a smaller can and/or ruler. (See sample designs.)
3. Cut apart to form a circle puzzle.
4. Use remaining foam to make additional puzzles. Trade foam with other participants so that each puzzle you make is a different color.

Sample foam puzzle designs

You may design your puzzle in any way you choose. Below are some suggestions. Puzzles should have no more than 8 pieces.

Keep in mind the age/ability of your students. Puzzles with many pieces are more difficult than puzzles with a few pieces



Banana Split Puzzle

Remove the cord and the large bead from the leather piece without untying the knots. Now replace the cord and large bead on the leather piece.

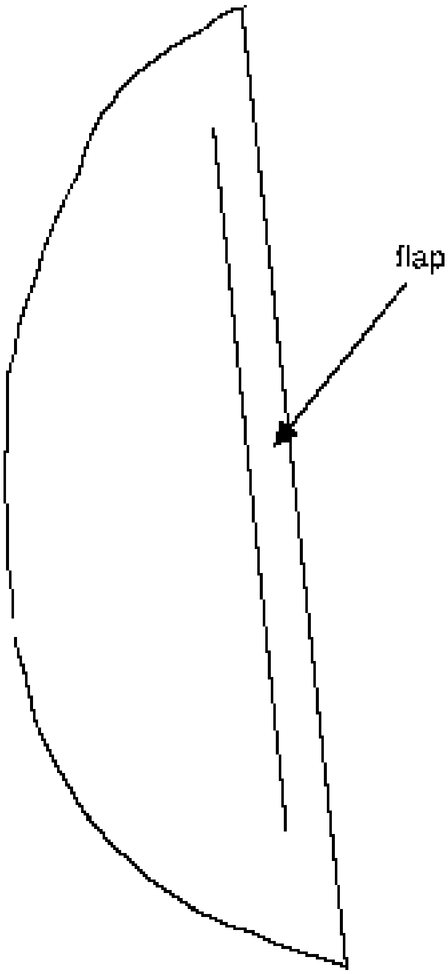
Banana Split

Materials: leather piece, 1 wooden ring, leather lace, 2 star beads, 2 wooden barrel beads, utility knife

1. Choose one leather piece (shaped like a banana). Cut a 1/4" slit in the leather as shown on the sample.
2. Cut a piece of leather lace about 12 inches long. Thread 2 wooden barrel beads and 2 star beads on lace and knot the ends as shown.

We will assemble these three pieces (leather, wooden ring, lace with beads on it) at the end of the workshop.

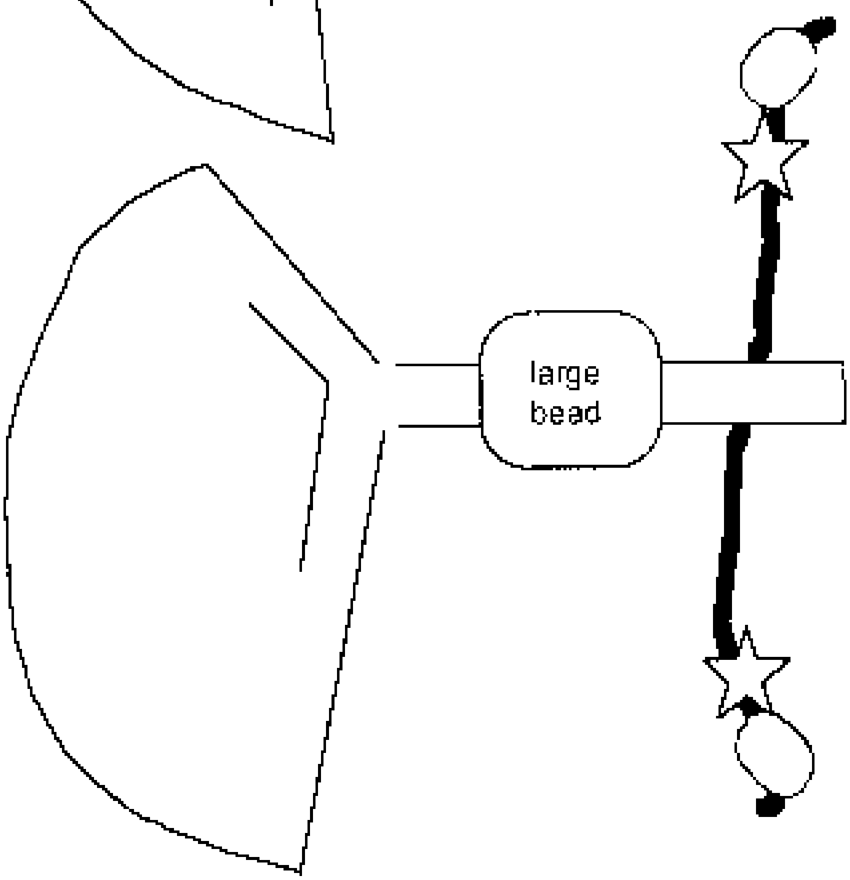
Banana Split Assembly Directions



Thread the flap through the large bead.

Run the cord halfway through the leather flap.

Pull the large bead off the leather flap onto the cord.

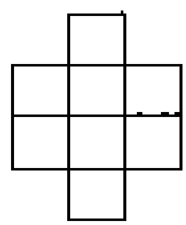


Think Deductively Puzzle

Arrange the eight numbered pieces in the squares on the game board so that two consecutive numbers are <u>not</u> in squares which share a side or corner.

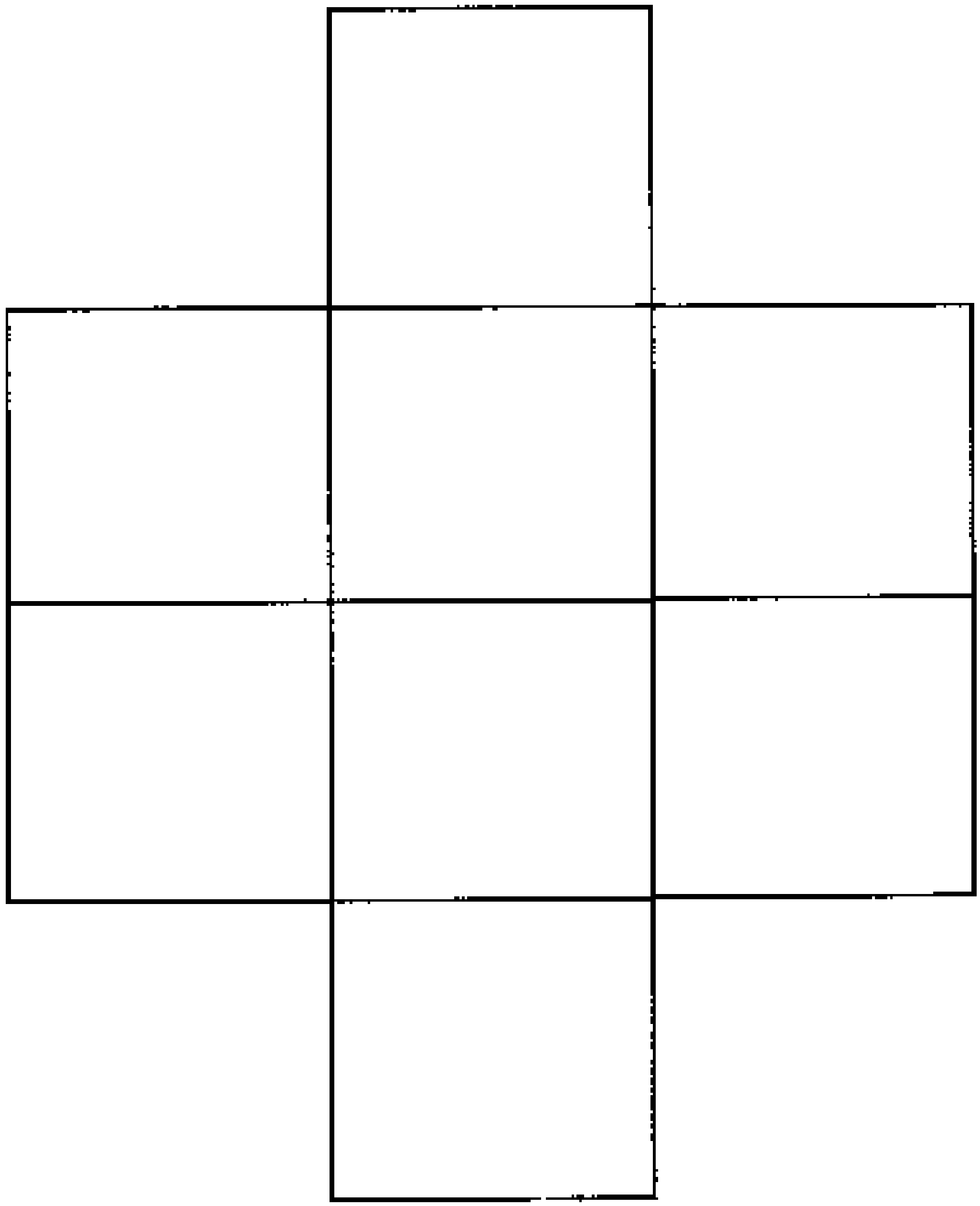
PUZZLE MATERIALS:

Board: 8 square board



Pieces: 8 tokens numbered 1 - 8

Board for Think Deductively

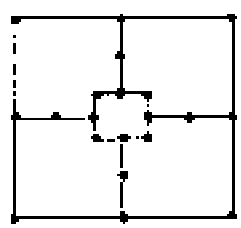


Tic-Tac-Toe Game

Begin with an empty board. The goal is to get three tokens of your type along any line on the board. Each player takes turns placing tokens of his/her type on an open space. If no player has three in a row after each player has placed all three of his/her tokens. then players alternate turns sliding tokens along a board line into another open hole. You <u>may not</u> jump tokens. You <u>may not</u> jump empty spaces. Play continues until one player makes Tic-Tac-Toe, three in a row.

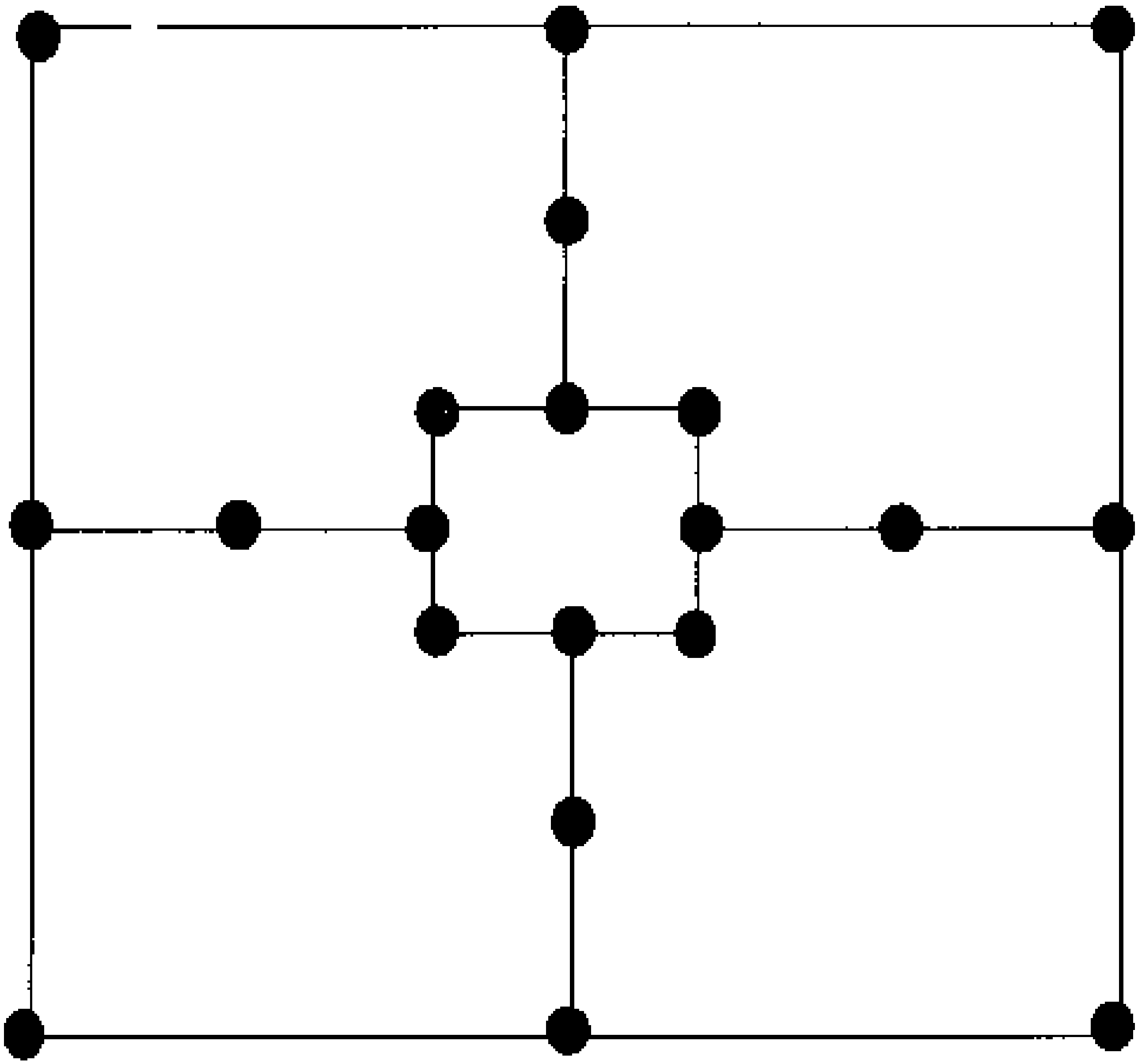
PUZZLE MATERIALS:

Board: Concentric squares:



Pieces: 3 tokens of one type (pennies)
3 tokens of another type (dimes)

Board for Tic-Tac-Toe



Easy, Fast, No-Materials-Necessary

Math Games

Guess

Age range: 1st grade and up

Number of players: any number

How to play: One person secretly chooses and number and writes it on a paper. Ask other players to guess. Record like this:

Guess	Clue
17	too small
89	too big
34	too small
40	too small
50	too small
71	just right

Guess, Digit, Place

Age range:	2nd grade and up
Number of players:	any number
How to play:	One person secretly chooses a number and writes it on a paper. Ask other players to guess. Record like this:

<u>Guess</u>	<u>Digit</u>	<u>Place</u>
109	0	0 (no digits correct, no digits in correct place)
123	1	1 (1 digit correct, 1 digit in correct place)
145	1	0 (1 digit correct, no digits in correct place)
462	2	1 (2 digits correct, 1 digit in correct place)
427	3	3 THIS IS THE CORRECT NUMBER!

Count By . . .

Age range: any age

Number of players: two players

How to play:

- Decide which number to count by (1, 2, 5, 10).
- Decide on a target number.
- Each person may count one or two numbers in the sequence. The winner is the player to say the target number.

Example: Count by 5's to 40.

Player 1 says: 5
Player 2 says: 10, 15
Player 1 says: 20, 25
Player 2 says: 30
Player 1 says: 35, 40. Player 1 is the winner.

Alphabet Math

Age range: 2nd grade and up

Number of players: any number

How to play: Pretend each letter is worth an amount like this:
a = 1¢, b = 2¢, c = 3¢ . . . z = 26¢.

Find the value of your first name, last name, favorite food, day of the week, birthday month, etc.

Try to find words worth exactly $1.00 or $.50. What is the most expensive word you can find?

The "H" Game

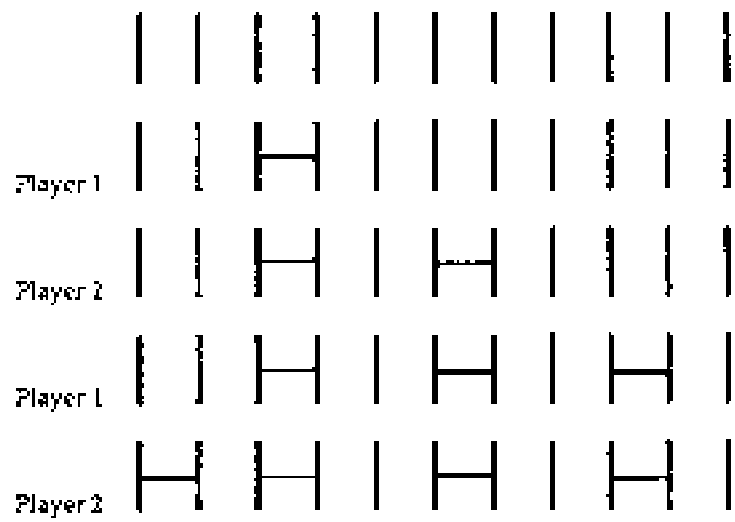
Age range: 1st grade and up

Number of players: two players

How to play:

- Draw 11 (or more) sticks in a row.
- Each player in turn makes an H using two sticks in a row.
- The last person who can play wins.

Note: Each H must not share a side with any other.



Player 2 won this game because Player 1 has no more possible moves.

Alphabet Race

Age range:	1st grade and up
Number of players:	two players
How to play:	• Write the whole alphabet on a piece of paper. • Take turns crossing off 1, 2, 3, or 4 letters (in order) from A to Z. • The player who crosses off the letter Z wins.

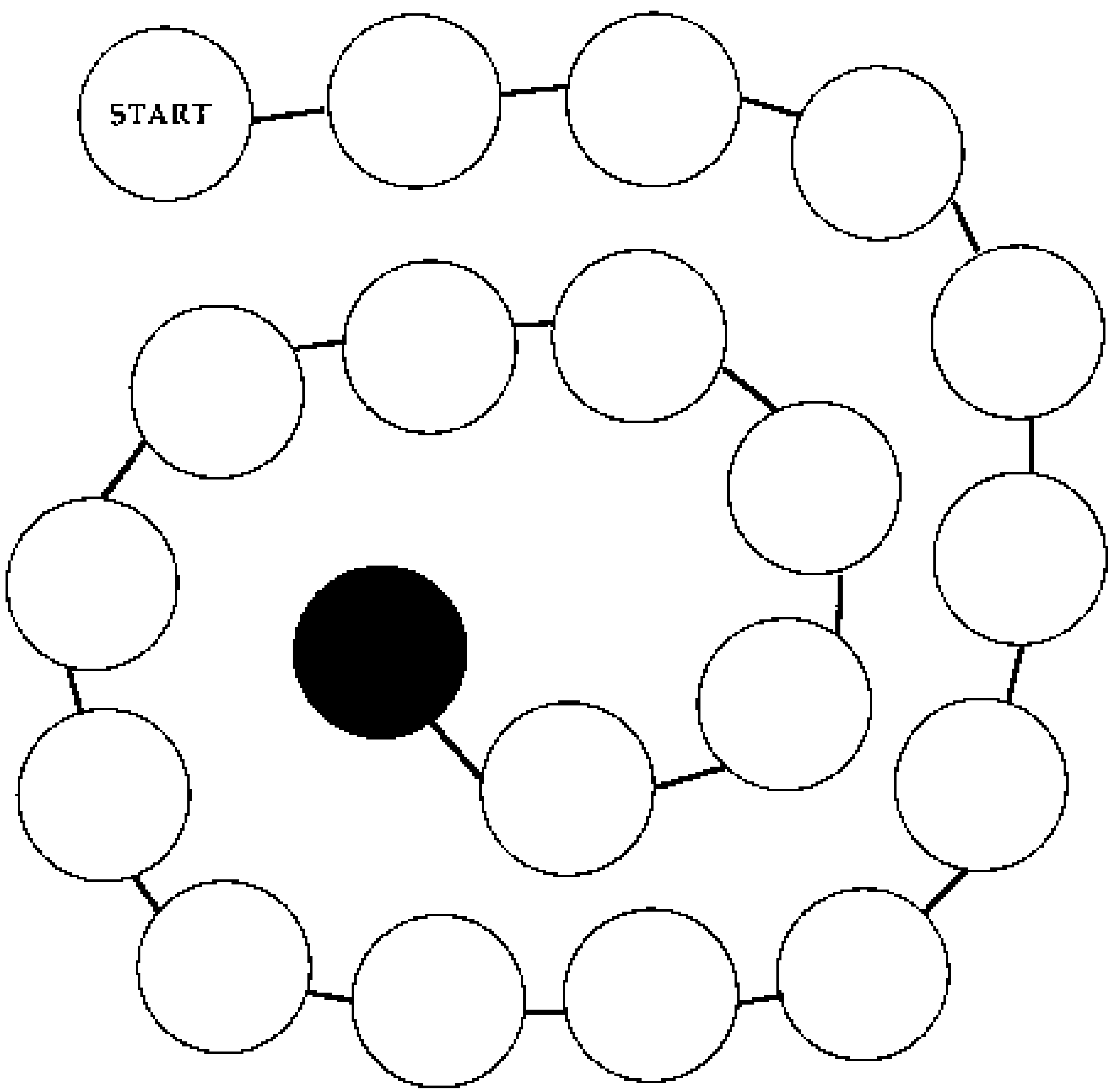
Black Hole

Age range: 1st grade and up

Number of players: two players

How to Play:

- Find a coin.
- Draw the "Black Hole" game spiral on paper.
- Flip to see who goes first.
- Take turns moving the coin from circle to circle, one or two circles on each turn.
- The player who lands on the "Black Hole" loses.

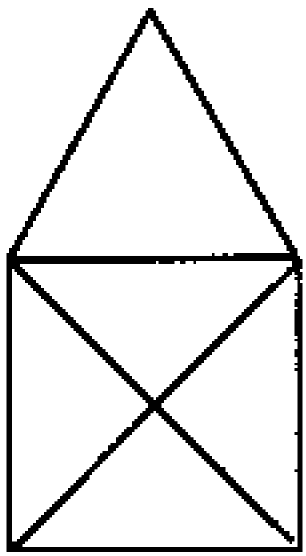


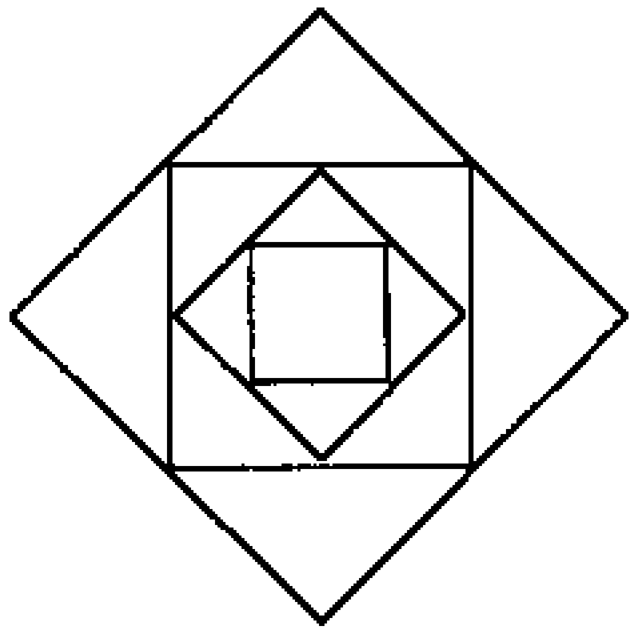
Can You Draw It?

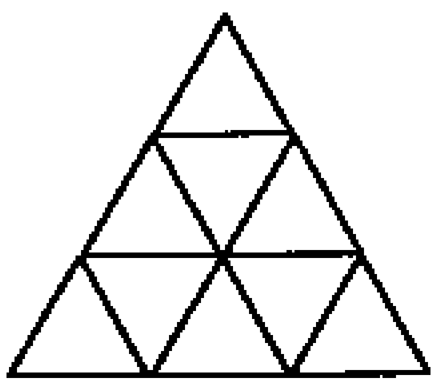
Age range: 3rd grade and up

Number of players: any number

How to Play: Draw these figures without lifting your pencil off the paper. You are <u>not allowed</u> to retrace any lines, but you <u>may</u> cross over lines.







Blind Circles

Age range: any age

Number of players: 6 or more

How to Play:

• Stand near other people in the center of the room .
• Close your eyes.
• Try to form a one large circle by holding hands (no peeking!!)

OTHER CHALLENGES:
Try to form 2 separate circles.
Try to form one line.
Try to form an X shape.
Try to form an S shape.

Trouble SUM

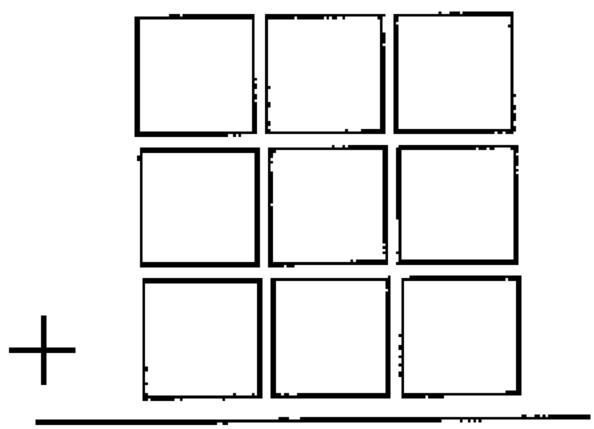
Age range: 2nd and up

Number of players: any number

How to Play:

- Make this diagram on paper.
- Write each number 1 - 9 in a different box.
- See if you can make it total 900.

OTHER CHALLENGES:
Find the largest possible total
Find the smallest possible total.



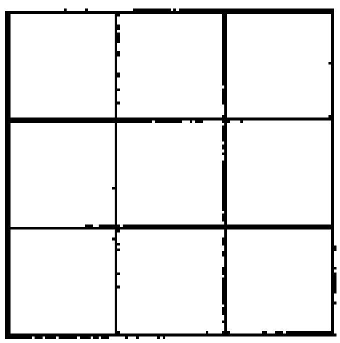
Magic Square

Age range: 2nd and up

Number of players: any number

How to Play:

•Draw this grid.
• Use each number 1 - 9 in a different box so that the total of each row, column and diagonal is 15.



ANOTHER CHALLENGE:
Make a 4 by 4 grid, use the numbers 1-16, make each row, column and diagonal add to 34.

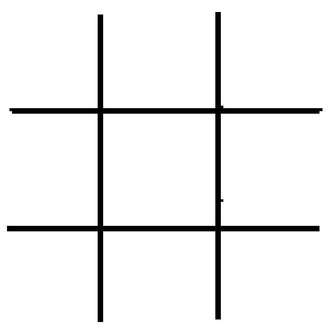
TICK-TACK-TOE

Age range: 2nd and up

Number of players: 2 players

How to Play:

- Draw a regular Tic-Tac-Toe grid.
- Write the even and odd numbers 1 - 10 below the grid as shown.
- One player uses even numbers, the other uses odds.
- On each turn write a number of your type (even/odd) in the grid. Cross off each number as it is used.
- The first person to complete a Tick-Tack-Toe with a sum of 15 wins.



2, 4, 6, 8, 10 1, 3, 5, 7, 9

MINUTES COUNT

Age range: any age

Number of players: any number

How to Play:

- Ask someone to time for one minute.
- Count as high as you can (out loud).
- See how high you get.

OTHER CHALLENGES:

Count by 2's or 5's or 10's.
Estimate how it would take to count to 1000.

Close the Lid Puzzle

Place all six pieces into the box so that all of the pieces fit within the box and the lid closes completely.

PUZZLE MATERIALS:

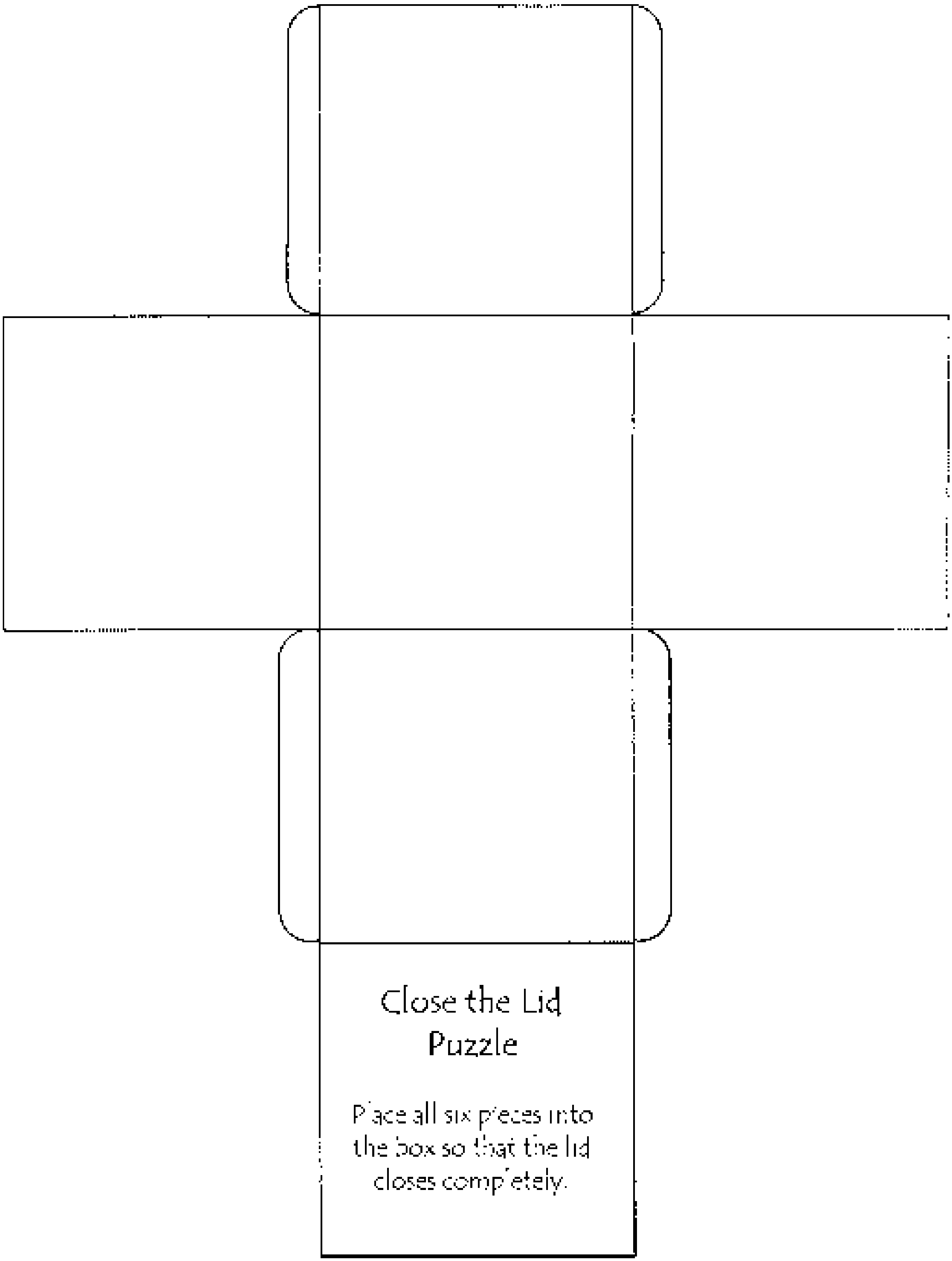
24 cubes of uniform size (see gluing directions)

Box with movable lid whose length, width and height are slightly larger than three times the length of one side of an individual cube.

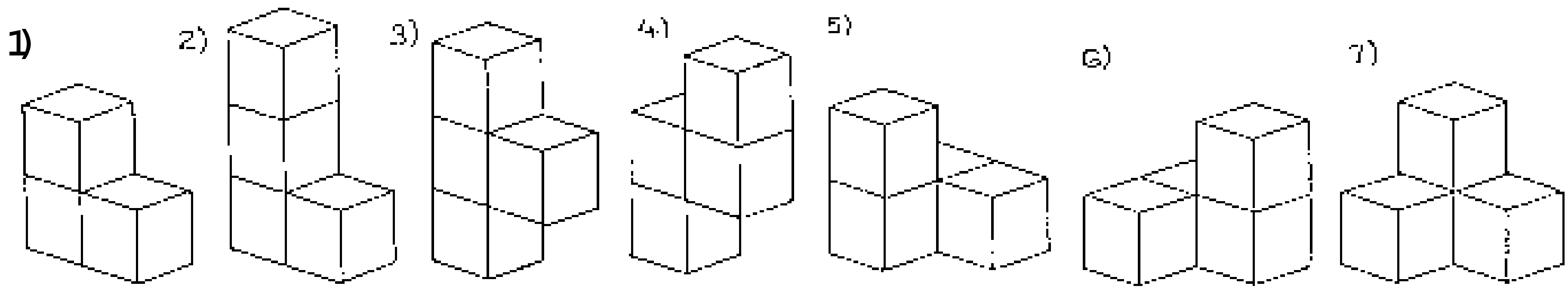
Close the Lid

Materials: box pattern, clear package tape, six glued cube pieces made at SOMA table

1. Cut out the box pattern and fold on every line.
2. Tape together using clear package tape to form a box with a moveable lid.


Close the Lid Puzzle
Place all six pieces into the box so that the lid closes completely.

Glue 27 cubes to form the 7 SOMA pieces shown below.
NOTE: Piece #5 and piece #6 are NOT identical.



Soma Puzzle

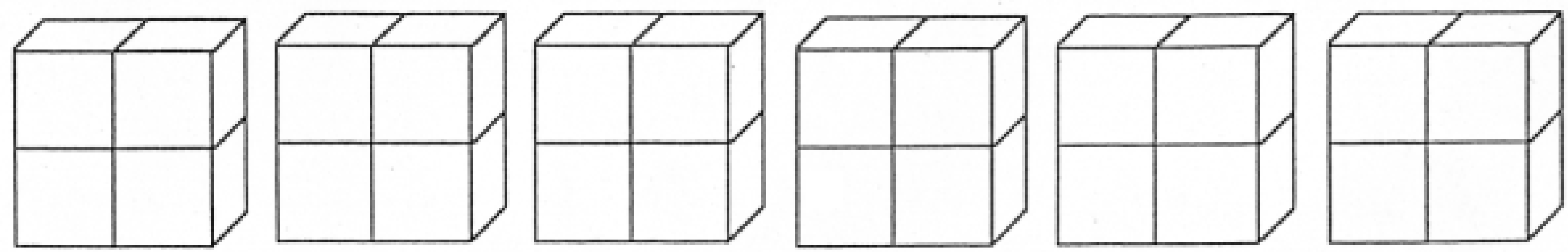
Place all seven pieces together to form a cube.

For additional challenges, try building the shapes pictured on the Soma Task Cards.

PUZZLE MATERIALS:

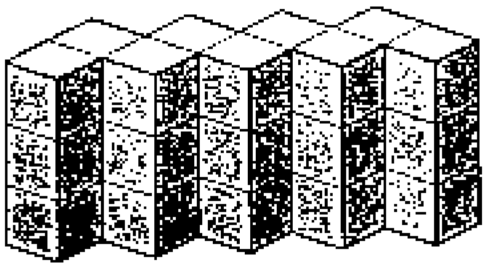
27 cubes of uniform size (see gluing directions)

Glue 24 cubes together to form 6 blocks as shown for "Close the Lid" puzzle (see p. 158.)



Soma Task Card #1

High Wall

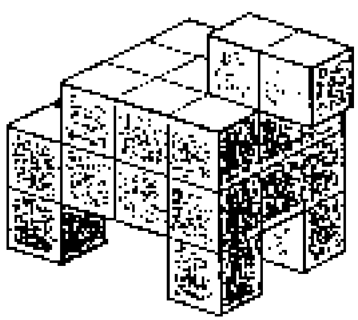


Soma Task Card #3

Long Wall

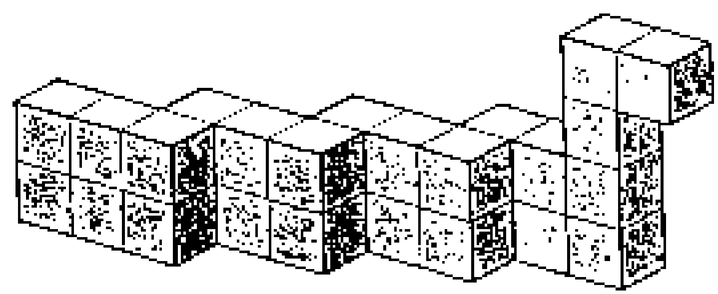
Soma Task Card #2

Dog



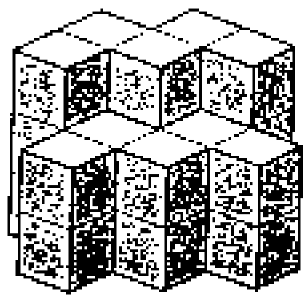
Soma Task Card #4

Snake



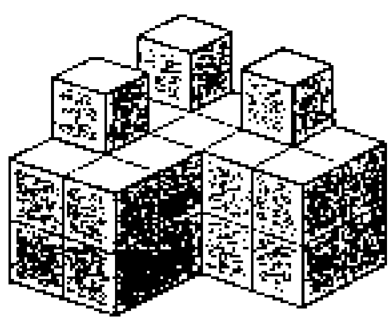
Soma Task Card #5

Double M's



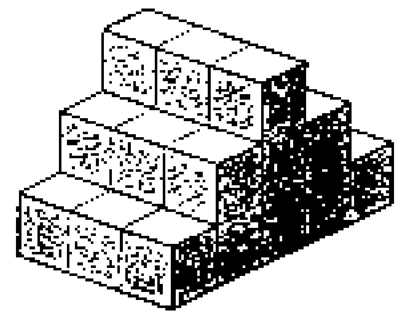
Soma Task Card #6

Factory



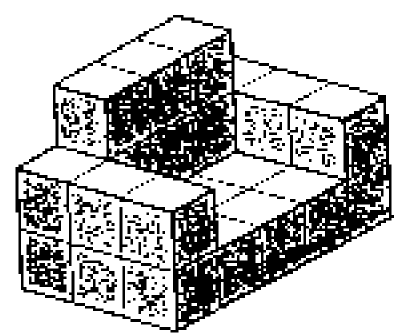
Soma Task Card #7

Steps



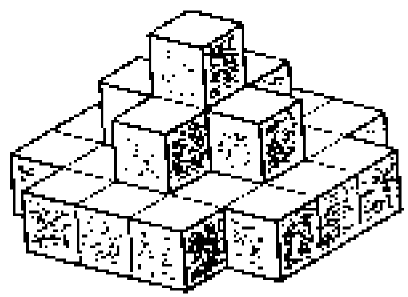
Soma Task Card #8

Sofa



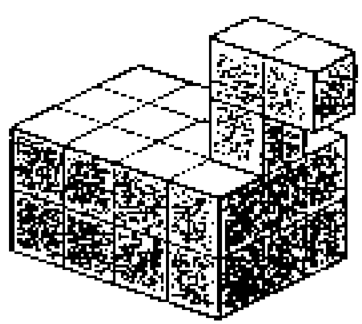
Soma Task Card #9

Pyramid



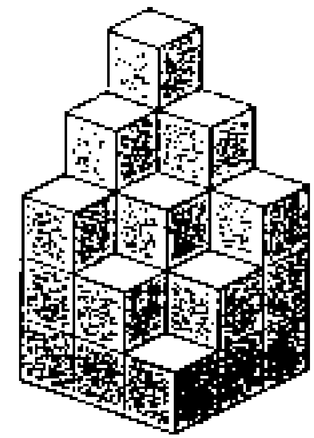
Soma Task Card #10

Duck



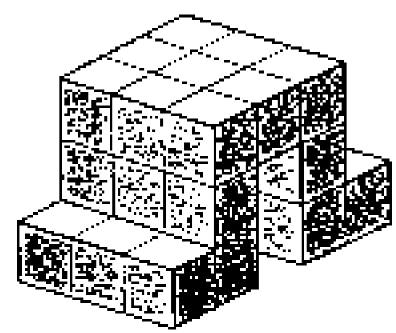
Soma Task Card #11

Crystal



Soma Task Card #12

Tunnel



Simple Machines

Simple Machines

A Six-Week or One-Week Format

Simple and not so simple machines are a terrific way to explore gadgets and engineering. As with any of the sections, this is simply a suggested format. If you are working toward a Girl Scout badge, you will probably be pulling one or two of these activities and combining them with activities from other units.

Week one: Machine Detectives (take apart broken machines)

Week two: Pulleys

Week three: Wheels, Axles, Inclines Planes

Week four: Gears (may not take an hour)

Week five: Define and start building for challenge

Week six: Challenge and parents visit

MACHINE DETECTIVES

Concepts:
Using tools, identifying parts of machines and their functions.

Ahead of Time:
Several weeks before the Simple Machine sessions start, ask everyone you know if they have any type of broken machinery around the house or garage. We were usually inundated with everything from clocks to computers. **Note:** Do not take apart computer monitors or televisions. They have parts inside that can blow up and shatter. Guess how we found out? ☺ No one got hurt, but don't push your luck - just stay away!

Introduction:
Most kids you meet will cherish the opportunity to grab a VCR, hair dryer, fax machine or can opener, and demolish it. But while you want them to have fun, you also want some learning to take place. SO, put away the hammers. Put out all sizes of screwdrivers, flat head and Phillips head. Put out wire cutters, small pry bars, wrenches, and pliers. We often had adults bring tools from home, well marked as to who they belonged to. Masking tape with your name on it or colored stickers work well.
Some machines do prove nearly impossible to open - if kids are still unable to open something after 20 minutes or so, they can use a hammer, with proper eye protection.

Materials:

- broken machines
- tools - see introduction
- newspaper
- access to hand washing
- small boxes or baggies for small parts storage

Procedure:
1) Start by asking them how many know what a simple machine is. Get as much input from the group as you can. You don't have to read them the definition, but here it is if you want it. **A simple machine is a simple device such as a lever, pulley, inclined plane, wheel, or gear that alters the amount or direction of a force applied to it.** So essentially, they are basic devices that are designed to make something move faster, easier, higher, farther, or in a different direction. Proceed to an explanation of the activity. Explain that you will be looking inside these complex machines to see if they use any simple machines inside, such as gears, wheels, and springs.

2) Have kids work in pairs or at the most groups of three. If working with all girls you can let them self-select partners or groups. If you are working with a mixed gender group, you may want to separate by sex, because you don't want the boys to take over within a small group. Boys (in general) may have had more exposure to tool use than girls, so they may feel more comfortable and want to take the lead. You want it to be a positive experience for everyone, and you want the tools in the hands of all, so just keep an eye out for that sort of thing.

3) Once partners are selected, have them take a small stack of newspaper and layer it on the floor or table so there's room to work, and the surface underneath is protected from grease and scratches.

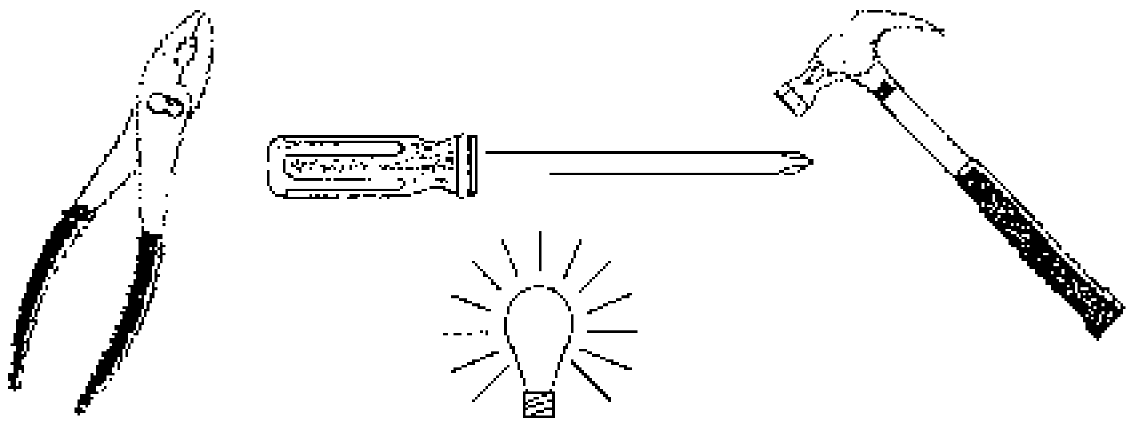
4) In an orderly way, have each team choose one large, or two small machines to take apart. Have the tools in a central location where people can come and get things they need and return things they aren't using. Teams can also circulate and borrow what they need.

Here's something fun that we did. If you will be needing invitations for a parent visit later on, give each team a box or bag to put small parts in. Just tell them that any small parts that are removable can go in there. Later in the day or week, hand out the paper and "guts" as we so delicately called the essential information. (e.g., "Please join us at SYSTEM Summer Camp at 1 p.m. Friday to see what we've been doing!") Now tell them that the small parts removed earlier can be put to good use as decorations for their invitations. We saw some remarkable creativity!

5) When they are done (in about an hour), have half the kids sit with their machines while the other half circulate and view what others have opened up. Encourage them to look for a similar machine to their own and compare the insides. For example, an older flat iron will be quite different from a modern one which will probably contain a circuit board.

Most machines do have circuit boards, but there are still a few simple parts, and you will get some older machines to take apart. Just the experience of being allowed to take something apart and to see what is inside is a new and valuable experience! We were never disappointed. You can't go wrong with demolition!

Machine Detectives



ANSWER THESE QUESTIONS FIRST!

1. What is the name of your machine?
2. What does your machine do?
3. What do you think you will find inside?

TAKE THE MACHINE APART. SAVE THE PARTS. CAN YOU NAME ANY OF THEM?

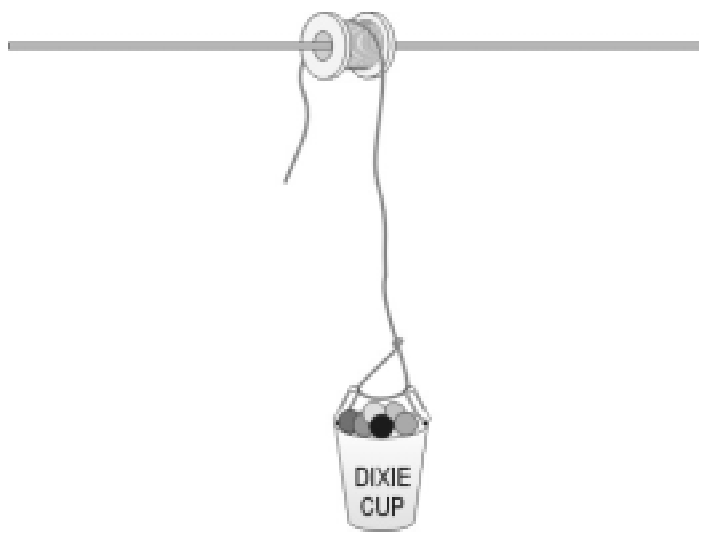
Get together with another group that took apart a similar machine. See if what you found in your machine is like what they found in theirs.

PULLEYS

Introduction: There are several things we did with pulleys. The activity we did at our first machines camp was in a classroom during the summer, so we used a couple of overturned desks that were on top of other desks to rig up the pulley.

Materials:
- Small wooden spools
- Dowels or skewers that will fit loosely through the hole in the spool
- String or ribbon
- Dixie cup-buckets
- Marbles.
- Masking tape
- paper clips to suspend bucket

Procedure:
Start by talking about pulleys and asking the group if anyone has seen a pulley, how they are used, what they are used for, etc. Then just give them the materials and a goal, such as "see how many marbles you can lift four feet off the ground" or something. What they need to do is simply thread the spool onto the dowel and suspend the dowel between two surfaces, securing it with tape. Throw the string over the spool, attach the bucket and pull! Let them figure it out - it's more satisfying, and they may come up with something different or more elaborate.



Comments:
Once the concept has been applied to a small object, you can move out to the playground with some ½ or ¾ inch rope and try to lift a friend off the ground. Tie a loop at one end for the rider to rest her bottom in, throw the rope over a swing set, hang on and lift! Just watch her head so it doesn't hit the top. At a later camp, we had a college student working with us who had climbing experience, so we rigged a pulley outside on a strong girder with a system of ropes and a harness and the kids loved pulling each other up. Always ask parents if they or someone they know has special knowledge or abilities they can share with the group.

WHEELS, AXLES, AND INCLINED PLANES

Introduction:
Though gears are just wheels with teeth, we approached wheels and gears as two separate centers. You may logically choose to combine wheels (and axles) with inclined planes for an effective center. For wheels, see the solar or battery powered car in the chapter on solar energy and the rocket racer in the chapter on flight. (Though it is called a rocket racer, it does have wheels.) Axles are included with wheels as they are simply the shafts that allow the wheels to revolve.

Objective:
To observe that wheels make it easier to move an object and how various wheels affect speed.

Materials:
The materials you need depend on whether you choose car one or car two. If you use car three, there's no building involved.

Car one:
See Solar Car materials lists (p. 200)
Additional wheels such as bottle caps, plastic lids, spools (as variables)

Car two:
blocks of wood approximately 4" x 2" x 2" for car bodies
wooden wheels and axles from craft or hobby store or catalog
electric drill
rulers or measuring tape
additional wheels, as for car one.

Car three:
manufactured toy cars

Procedure:

1) Start with discussion questions. (see below).

2) Since the focus here is the wheels, not the power source, you may choose to omit any external power source and simply push the vehicles or roll them down an inclined plane.

3) If you do combine wheels with inclined planes, be sure to **control the number of variables** you allow. For instance, if you change the body of the car, the wheels and the surface of the inclined plane, you can never be sure which of the three variables served to increase (or decrease) the speed of the car down the ramp. Did the new wheels slow it down? You won't know if they did, if you also changed the surface from wood to sandpaper. So change only one thing at a time, and test after each change.

4) To build car two: measure, mark and drill holes in four places EQUIDISTANT from the bottom and from the end, for the axles to fit into. Make sure the holes are close enough to the bottom that when the wheels go on, they touch the ground. Attach the wheels. If holes are lopsided or too high, wheels may not all touch the ground and car will roll strangely, if at all.

Sample discussion questions:

1) What purpose do the wheels on a skateboard, car, or bike serve? Allow time for thought and the discussion that may ensue.

2) How (well) do car wheels go on pavement? How do they go on gravel or dirt roads? How do they go on snow or ice? Why? What's the difference in these surfaces?

3) How about bicycles - can you ride them on ice? Why or why not? How do bike tires differ from car tires?

4) Is it easy or hard to stop on each of those surfaces? Why?

5) Name just a few of the thousands of ways our world would be different without wheels! These questions serve to stimulate thought, and to get the kids thinking about concepts such as acceleration, stopping, friction and more broadly, inventions in general. Even if they can't verbalize exactly what they mean, they will begin to think. If they already have an idea of friction, they may be able to take things a step further and begin to contemplate the purpose of tire width and treads.

Inclined Planes

Introduction:
Inclined planes are simple machines used to raise or lower a load by sliding or rolling it. An inclined plane or ramp can be built with a stack of books and a plank of wood. You can easily control two variables with this ramp. 1) Slope - by adding or removing books from underneath one end of the plank, you can change the slope or height of the inclined plane. 2) Surface - by using push pins and a variety of materials, you can change the surface of the slope. Waxed paper, felt and sandpaper effectively change the amount of friction created when rolling or sliding something up or down the track.

Objective:
Test various vehicles, surfaces and slopes to explore friction and ease of work on inclined planes.

Materials:
- Wooden plank(s) about 4 - 6 inches wide and 3 - 6 feet long. One will do for a group of 4-5, but if you have more kids doing this all at once, it helps to have three or four planks set up, each with a different surface.
- Several hardcover books for under the end of each plank
- Roll of waxed paper

- Strips of felt (to fit plank)
- Strips of sandpaper (can buy sandpaper for belt sanders or just arrange sheet sandpaper along the length of the plank)
- Push pins to secure materials to the plank(s)
- Vehicles to roll or object to slide (a book or a weight)

Procedure:

1) Make vehicle if necessary or use manufactured toy cars.

2) Make predictions before testing. For example: I think this particular car will go faster with the inclined plane at this height than if I lower the slope to this height. I think it will go slower (or faster) on the waxed paper vs. the plain wood surface. Whatever you are testing, make a prediction first.

3) If you wish, set a finish line to be reached some distance out from the end of the plank**,** and see which combination of variables can help you reach this goal. By using this car at this slope on this surface I can reach the finish line. As noted before, test each variable separately, so you can see which change makes a difference each time.

GEARS

One time we made cardboard gears and another time we used pre-made sets of gears found in any toy store. The basic information you want them to get from this center is this: Gears are toothed wheels or cylinders that mesh together. They can do three things. They transmit motion or change the speed or direction of an object, depending on whether you use an odd or an even number of gears.

You could combine wheels with gears to play with gear ratio, and how they help to increase the efficiency of the wheels.

You can find a good gear activity at: www.galaxy.net/~k12/machines/gears1.shtml.

MARVELOUS MACHINES

Name: ______________________________ **Date:** __________

GEARS 1

INTRODUCTION

Gears are just wheels with teeth. You can use gears to slow things down or speed them up, to change direction or to control several things at once. First we'll look at gears of the same size.

MATERIALS

- 1 set of gears
- 2 labels

PROCEDURE

1. Put one axle in each of the four small gears

2. Find or make a mark on one tooth on each gear.

3. Use the stickers to label one gear as the driver. "D", and one as the follower. "F" We will use the driver to move the follower.

4. Put these two gears on the base board with the marked teeth touching. See Figure 1.

Figure 1

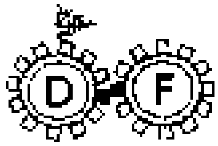


Figure 2

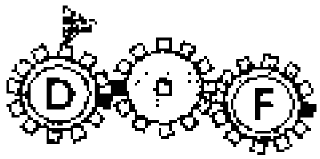
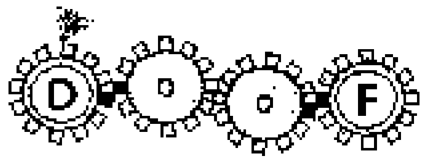


Figure 3



5. Turn the driver one complete time around in a clockwise direction. Watch the follower as you do. Record how many times the follower turns and in what direction.

6. Now put another gear between the driver and the follower as in Figure 2. Turn the driver as in step 5 and record what happens to the follower

7. Finally, repeat this procedure with two gears between the driver and follower. See Figure 3.

NUMBER OF GEARS IN BETWEEN	TURNS	DIRECTION
0		
1		
2		

DEDUCTION

Look at your results. What pattern or rule can you deduce about how the follower gear will turn?

PREDICTION

Let's say that both the driver and the follower were medium sized gears. What do you think would happen if we turned the driver one time around in the clockwise direction? How many times do you think the follower will turn and in what direction?

Solar Energy

Solar Energy

A One-week Format*

Solar energy, reflection, absorption, heat, and condensation are some of the science concepts covered in this section. These are activities used throughout the camp week in various ways. (See the page on camp format.) Mondays we worked as a whole group (20-40), maybe breaking into smaller groups, but all doing the same activity, whereas the other activities were done as center rotations or free choice.

Monday: Sun prints, sun and earth, and sundials - begin early and mark sundial every hour.

Tuesday and Wednesday centers: solar oven, heating homes and water with solar energy, solar-powered cars.

Thursday free choice activities: can include solar still, wood burning, solar stone (navigator) and a giant natural sundial**, as well as anything else you can find. Many wanted to revisit and refine earlier projects, such as the fascinating solar cars.

Friday: Prepare a feast from the solar ovens and the foods you've dehydrated during the week, have a solar car race or set up all the solar items you've made and have the kids give their parents the grand tour.

Other ideas: At another solar camp, we made a fire clock, which worked by placing bells at intervals along the length of a stick of incense and burning it. We also discovered insulation as a way of keeping heat out, (or in, depending where you live!), and light catchers made by joining together twelve five-sided figures (pentagons), forming a solid called a dodecahedron. (Which you know if you've ever seen or read "The Phantom Toll Booth".)

Note: *We tried the solar ovens in an after school program, but the sun really needs to be directly overhead for many of the solar things to work properly, so these are best used in a camp setting.

**We made the giant sundial by painting and setting out stones for the hour markers and driving a stick into the ground for the hour "hand".

SUN PRINTS

Science content: More **chemistry** than solar! I think this works the same as a blueprint. Blueprints were invented in 1842. The paper is “sensitized” by two chemicals, ferric ammonium citrate and potassium ferricyanide. When the sensitized paper is exposed to light, the two chemicals react to form a darker blue. The part obscured by the objects remains the original blue. Washing it in water produces a negative image, with the once covered area appearing white.

Materials:
- sun print paper*
- dishpan of water
- objects for the prints

Procedure:
Collect a variety of tiny objects with which to make your prints. Buttons, keys, fun foam shapes and small plastic animals are a good supplement to natural items that the kids can collect that morning. Leaves, seeds, twigs, feathers and flowers all make beautiful prints. If you are inviting parents later in the week, these make a good cover for the invitation.

Comments: If you have more kids than paper, just cut it all in half!

** It is available at creative-type kids’ toy stores. Teachers’ stores also have it. I mentioned our experience with this in the introduction, so try following the directions on the package, but if you have extremely strong sunlight, you may have to make adjustments.*

SUN AND EARTH

Category:
Solar and Math - The sizes of the sun and earth

Introduction:
An informal discussion and this dramatic demonstration of the sun's size in relation to earth is a good introduction for making sundials, but it can stand alone as well.

Materials:
- string, several feet
- pennies, two rolls
- stick
- chalk

Procedure:
1) Take two rolls of pennies (100) and a stick (or piece of chalk) and string and have everyone go outside. You need an area wider than a sidewalk. (Read on.) If you have a dirt area, use a stick. If you have pavement, you need the chalk.

**Show the students one penny, and tell them to pretend that it is the earth. Ask them if this penny represented the earth, how big do they think the sun would be. Allow them to work in groups, and talk it over. Then have each group draw a circle (using chalk or a stick) that represents the size of the sun, if the earth were the size of a penny.

2) Next tell the kids that they are going to make a line of pennies to represent the diameter (explain the term) of the sun. Have the kids place 100 pennies in one long line with their edges just touching.

3) Ask the kids to find the center penny. Tell them they are going to make a "human compass" to make a circle around the diameter of the sun they just created.

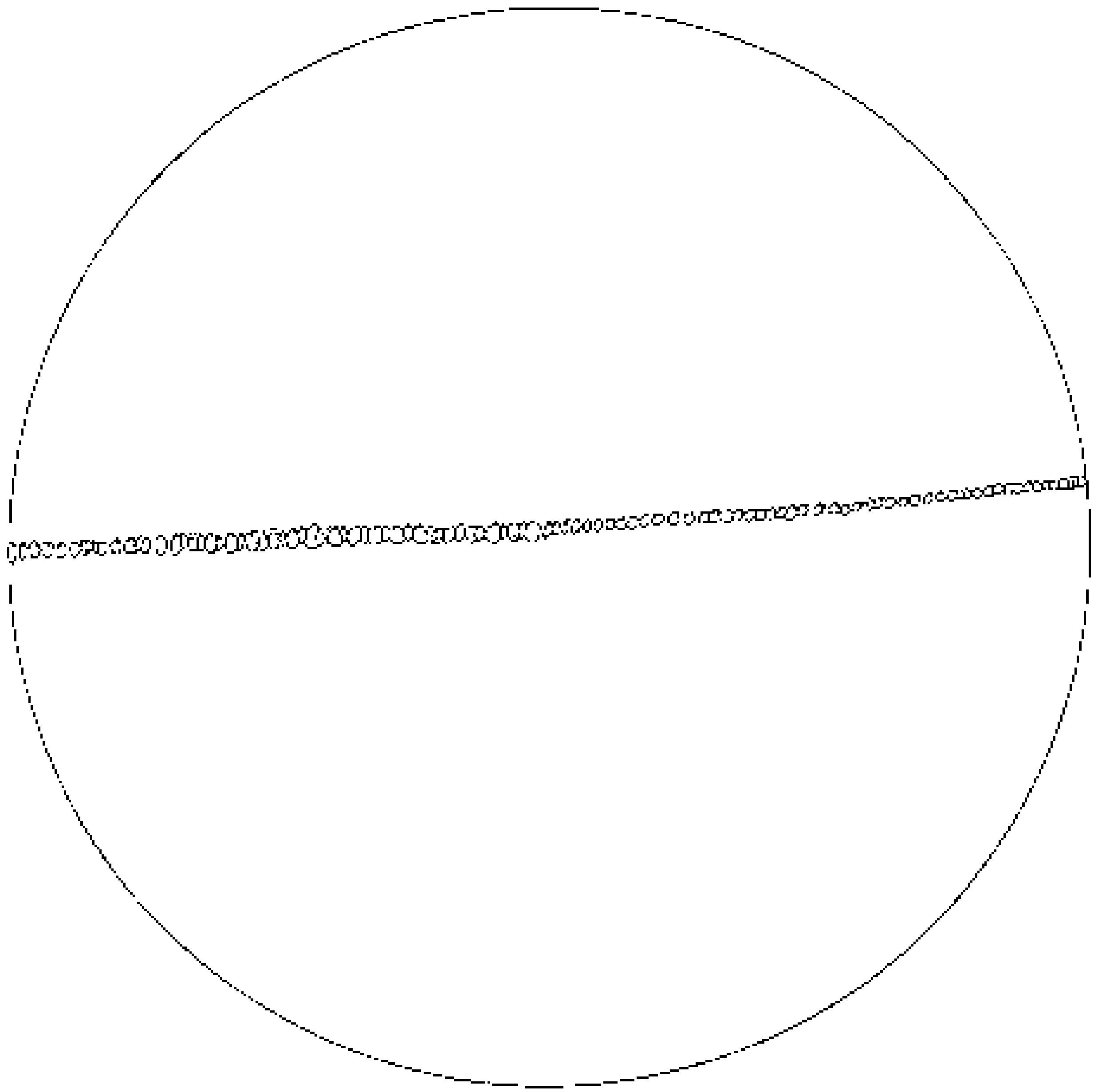
4) Have one person hold the end of the string in the center of the pennies.

5) Have another person take the end of the piece of string and walk to one end of the line of pennies.

6) Cut the string a little longer than that length so you can tie that end of the string to the stick or piece of chalk.

7) Walk in a circle, drawing a line on the ground as you walk. The first person, (who is holding the string at the center of the pennies), may have to turn as the second person goes, but remind them to do their best to keep the end of the string at the center of the pennies. The second person holds the line taut as she/he draws the circle.

You will end up with a giant circle bisected by a line of pennies through the equator. Those pennies represent the diameter of the sun, and the big circle represents the sun itself. Set the single penny next to the "sun" and compare their sizes. One hundred earths could line up next to each other along the equator of the sun.



SOLAR OVEN

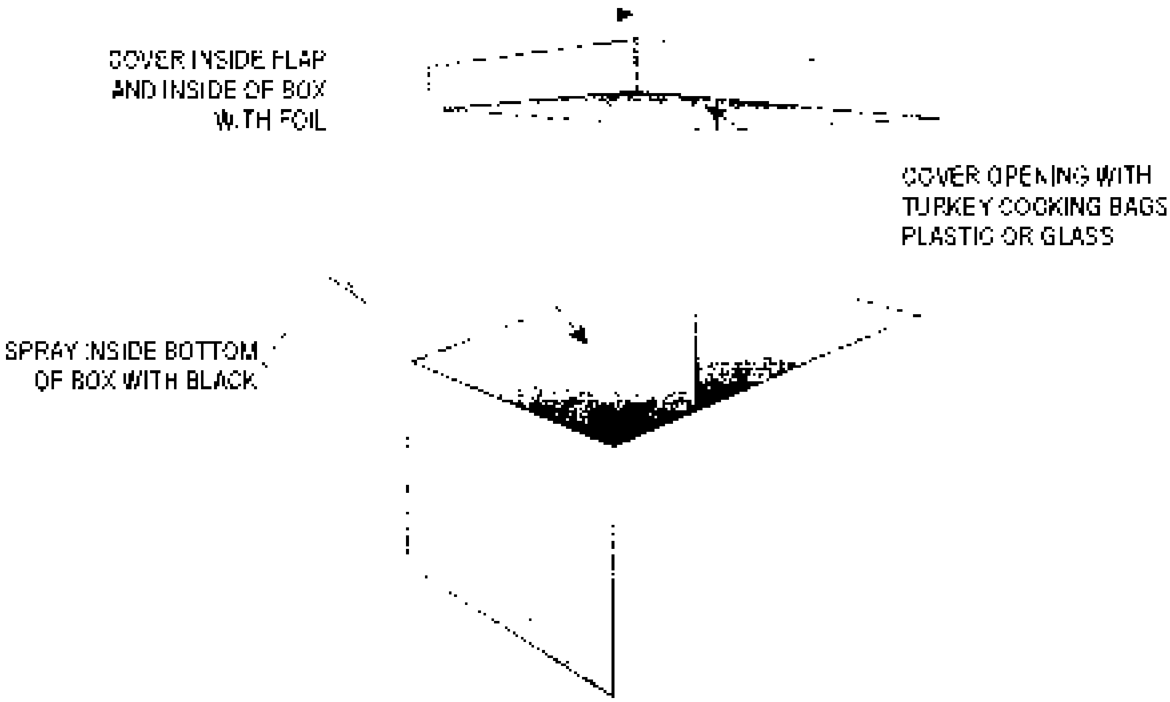
Introduction:
This is one of many sets of directions you can find for a solar oven. The main points to remember are these: You need **three things** to cook successfully with a solar cooker. **What are they?** (Be sure to begin your session by asking the girls the same thing. See the websites pages for more ovens.
1) sunlight
2) something to reflect light
3) something to absorb light

So keeping those three requirements in mind, you know that:
1) It must be sunny the day of your project.
2) You want the inside of the oven to reflect as much sun as possible onto the food or cooking vessel. What cheap, easy-to-buy cooking material best reflects light? (Aluminum foil)
3) You want the surface under the food, or if cooking in something, the cooking vessel itself to absorb the heat. What color absorbs light, or makes you hotter if you wear it in summer? (Black)
In addition, the more airtight, the better. The heat will come in through the plastic and stay in.

You're ready to begin. You can use one box per oven, or for better heating through insulation, place one box inside a slightly larger one and fill the space with newspaper. Line both with foil.

Materials:
- Cardboard boxes with lids, one or two per girl or team,
- Aluminum foil, several rolls, depending on number of ovens
- Non-toxic black paint or black paper (if you use toxic paint, just paint a day or two before using the oven and leave in the sun - fumes will cook off before you put food in. Spray paint is easy to use.
- Newspaper for insulation (optional)
- Box cutters, knives or heavy-duty scissors
- Tape/glue
- Black pot with black lid (optional, depending on what you're cooking)
- String, wire or sticks
- Turkey cooking bags, plastic or glass to fit under top opening.
- Oven thermometer (optional, but fun to see how hot it gets in there and how you can improve heating capacity)

Procedure:
Line the inside of the box with foil and keep the foil as smooth as possible. If it's all crunched up, the light will bounce off in all directions. Spray paint the **inside** **<u>bottom only</u>** of the box black or line it with black paper or tile.



Cut three sides of a flap in the lid, making sure it is a little smaller than the plastic or glass you have. Cover the inside of the flap with foil. Later you will position it at an angle, using string or sticks, so that the sunlight is bounced off the foil and into the box.

Next, flip the lid over and glue the turkey bag, plastic or glass over the opening. Now, you're ready to cook. If you are making nachos, quesadillas or s'mores, you can place them on a black baking tray or plate, directly on the bottom of the oven, or slightly raised if possible. Otherwise, use the black pot and cover with black lid. Be sure to use pot holders when you take anything out!

Cooking: It's best to preheat the oven, just as with conventional cooking. If you have all day, set the oven out early in the morning. Position it toward the sun so that when you stand behind it, the shadows are equal on both sides. Every half hour to hour, go out and check on it, repositioning the oven as the sun moves across the sky. (Or as the earth moves around the sun, I should say.) DO NOT open oven to stir things or check on them unnecessarily. The oven loses a great deal of heat every time it opens.

Recipes:

<u>Nachos</u> - tortilla chips, shredded cheese, salsa, black olives
Spread chips on tray, sprinkle cheese liberally over the chips, and top with salsa and olives. Heat until cheese is hot and bubbly.

<u>Quesadillas</u> - flour or corn tortillas, shredded cheese
Place one tortilla on tray, cover with cheese, top with another tortilla. Heat until cheese melts. Remove from oven and slice into wedges.

<u>S'mores</u> - graham crackers, milk chocolate candy bars, marshmallows
Place one graham cracker square on tray, cover with a slab of chocolate and a marshmallow. Fit as many on the tray as you want. When the marshmallow and chocolate get soft and melted, take them out, top with another graham cracker and enjoy!

<u>Solar Beans</u>
Cook:

- 1 lb. bacon (crumble when done)
- 1 onion, chopped

Mix with:

- 2 cans lima beans
- 1 large can baked beans
- 1 can kidney beans
- 1 can Ranch Style beans
- 1 can pork and beans
- 1 can chili beans
- 1 cup brown sugar
- 2 Tbsp. White vinegar

Do not drain beans, pour all into large pot, place in solar oven and cook several hours OR bake at 350 degrees for 1½ hours, OR simmer in crockpot for several hours.

If your oven is really good and you get it to reach temperatures of 300-350 degrees, you can bake cookies, meatloaf or anything.

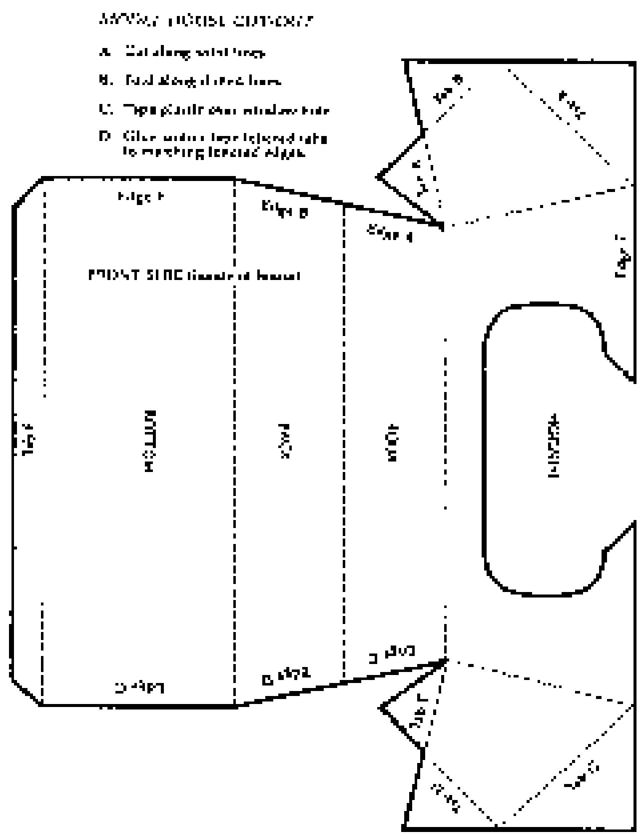
SOLAR HOMES
Building Model Houses

Overview

In this activity the students discuss the ways energy is used in their homes and the sources of this energy. The idea of heating homes with solar energy is introduced. Each student builds a model house out of paper to find out how sunlight can be used to heat homes.

Time Frame: 45–90 minutes

What You Need



For a class of 32:

- ❑ 10 plastic bags, 1-qt. size (heavy duty ziplock type)
  or
- ❑ 5 pieces of clear acetate, 8 ½" x 11" (22 cm x 28 cm)
- ❑ 16 rolls of clear tape
- ❑ white paper to cover windows

For each student:

- ❑ 1 Celsius thermometer (see Technical Notes, page 51 for more information)
- ❑ 1 model house cut out sheet (master included, page 11)
- ❑ 1 pair of scissors
- ❑ 1 ruler

Optional:

- ❑ overhead projector
- ❑ transparency of cut-out
- ❑ 16 glue sticks or small containers of glue

Getting Ready

OPTION: A stiffer cut-out is easier for students to work with and can be prepared by attaching the cut-out onto file folder stock, using a glue stick.

1. Make one copy of the model house cut-out for each student. Use the heaviest paper available for duplicating the cut-outs.

2. For each student, cut one rectangular window, 2" x 4 ¾" (5 cm x 12 cm) out of the plastic bags or clear acetate. Cutting several layers at once can make this go quickly.

3. Assemble all the items listed in the "What You Need" section.

4. Build one house yourself. Follow the instructions listed under "Construction Steps" on page 10.

5. *Optional:* Make a transparency of the model house cut-out for use with an overhead projector.

Building the House

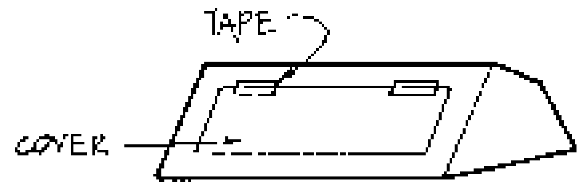
1. Introduce the subject of solar energy use by asking your students some questions. "What things in your house use energy?" If "house heater" and "water heater" are not included on the list, add them yourself. Ask, "Can you guess which things on our list use the most energy in your home?" [In most homes, the house heater or air conditioner use the most energy.] Ask, "What is the source of the energy you use to heat your home?" [Usually our energy comes from fuel, such as gas, oil, or coal, that is burned to make heat.]

2. You may want to add that this burning of fuels creates air pollution. Ask your students, "Do you know any problems that air pollution causes?" [acid rain, health problems such as lung disease] Burning fossil fuel for energy also releases large amounts of carbon dioxide into the atmosphere, which many scientists believe may be contributing to "global warming." In addition, if we keep using these kinds of fossil fuels to such a large extent, we will run out of them. Scientists are searching for alternative ways to provide energy.

3. Tell the students that they are going to conduct experiments to find out how ordinary sunlight can be used to heat homes. Explain that before architects build a full-size solar house, they first experiment with small model houses. Tell the group that they will be making such model solar houses in order to conduct some experiments of their own.

4. Explain that in their solar house experiments, the ***observed result*** will be how hot the house gets. Ask, "What are some ways that houses can differ?" [shape, size, color, number of windows or doors, etc.] Tell the class that in order to conduct a ***controlled experiment***, they will focus on one ***variable***—the presence or absence of windows. This will be the ***experimental variable***

5. Show the class an intact model house cut-out sheet. Then show them your sample house and point out the window. Demonstrate how the window can be covered with a scrap piece of paper. The cover can be taped onto the house along the top edge of the window as shown in the illustration.



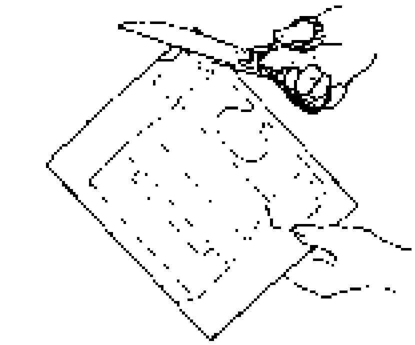
6. Divide the class into groups of four. Explain that each student will build a house with a plastic window. Within each group, two students will leave the plastic windows uncovered and two will cover the plastic windows with paper.

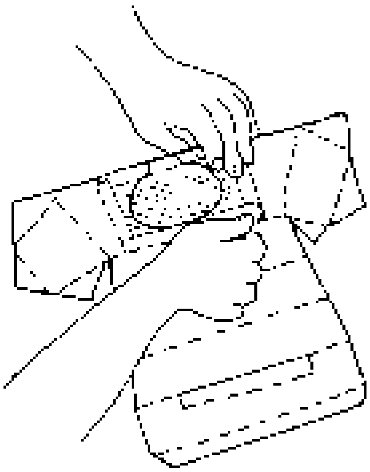
7. Emphasize that the whole class will construct the houses together, step by step, so they shouldn't rush ahead before all the instructions have been given.

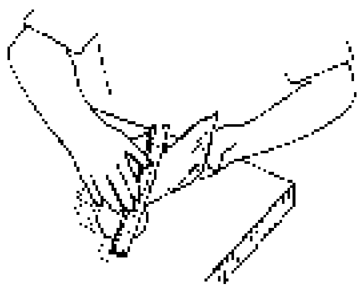
8. *Optional*: If you use an overhead projector, now is the time to project the cut out transparency and point out the dotted lines, the solid lines, the tabs, the edges, etc.

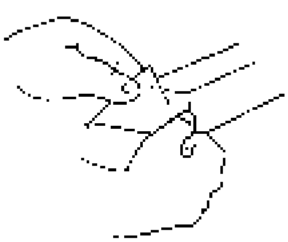
9. Have the students help you distribute the construction materials. Demonstrate the building process one step at a time. Allow time for your students to complete each step before you demonstrate the next step. You may wish to hold the cut-out vertically against the chalkboard during each step so all the students can see what you're doing.

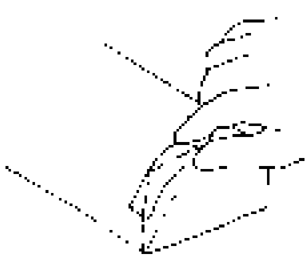
10. Tell the students not to begin any construction step until after you have demonstrated it. Advise them to proceed carefully, as mistakes can be difficult to correct.











Construction Steps

1. With scissors, cut along all solid lines of the cut-out. After cutting, ask the students to write their names on the back of the "bottom" section of the cut-out (the side with no writing on it—this will become the outside of the house).

2. Tape the plastic window over the window hole on the front side of the cut-out (the front side will be the *inside* of the finished house). Tape all four edges completely for a good seal.

3. Fold along all dotted lines. Use a ruler to help make straight folds. Fold so the lettering will be hidden inside the house.

4. Tape the lettered tabs to the corresponding lettered edges. Remember, the side of the cut-out with print should end up on the **inside** of the house. It is easiest to fasten tabs to the outside of the house, in order, from A through F. **But don't tape Tab G yet!**

5. Slide the thermometer face up into the house at Tab G, so it can be viewed through the window. Now tape Tab G shut. Just one piece of tape will do. (To remove the thermometer or to modify your house for the "Going Further" activities, you will need to remove this piece of tape to get into the house.)

6. It is very important to seal all the holes and cracks in your house with tape.

7. Students who are to cover their windows should do so with an appropriately sized piece of paper, taping the edge along the top of the window. A small piece of tape can be used to temporarily hold the bottom edge down.

8. Collect the houses and store them in a safe location. They will be used in the next activity, "The Solar House Experiment."

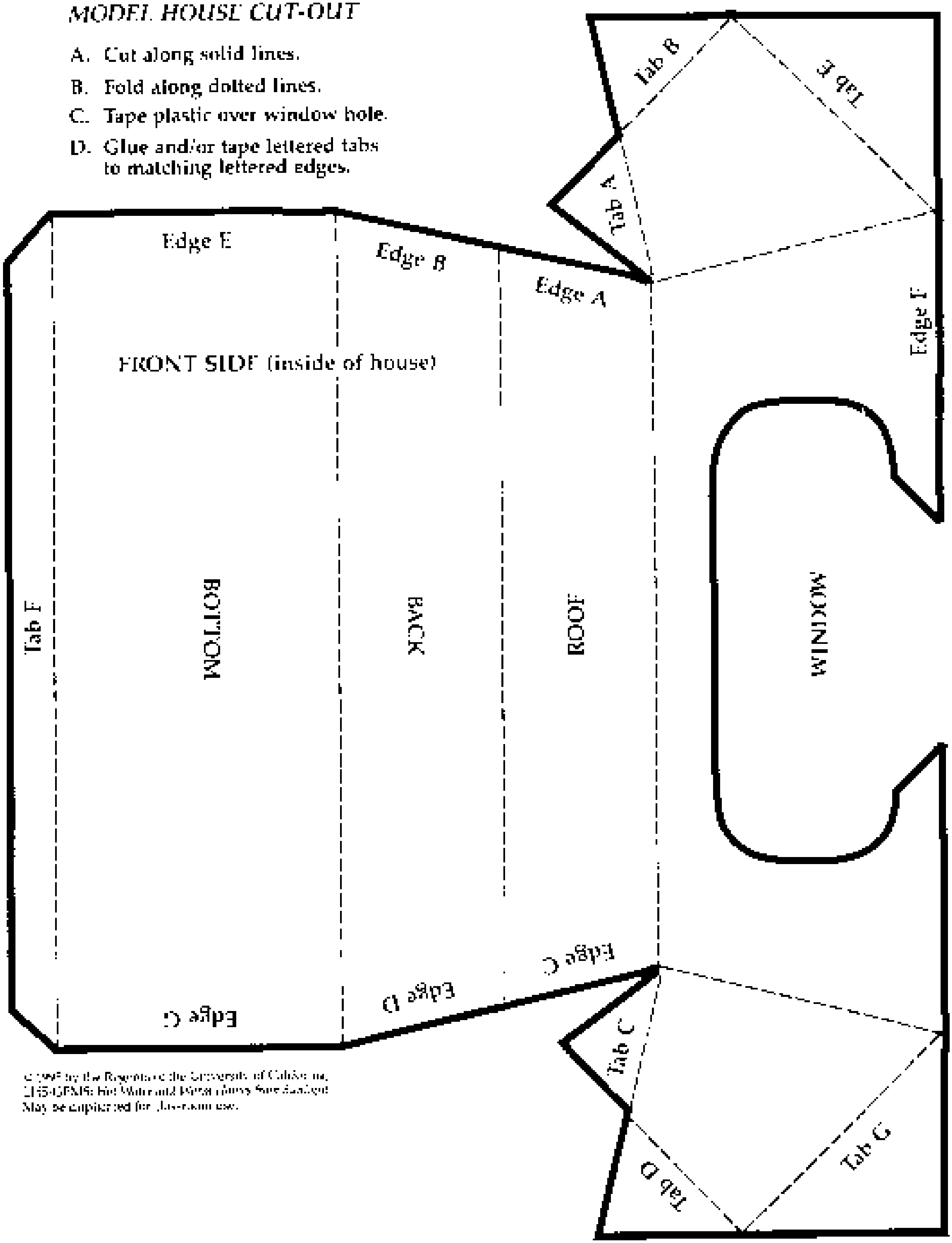
MODEL HOUSE CUT-OUT

A. Cut along solid lines.

B. Fold along dotted lines.

C. Tape plastic over window hole.

D. Glue and/or tape lettered tabs to matching lettered edges.



The Solar House Experiment

Overview

Using the model houses constructed in Session 1, students go outside to conduct the Solar House Experiment. The experimental variable is whether the window is covered or not covered. The observed result is the net temperature change in the house during an 11-minute period. The students, working in groups of four, graph the results minute-by-minute.

This activity is best done on a sunny day with little or no wind, when air temperatures are over 14° C. But even on cloudy days your students will get interesting results!

Time Frame: 30–45 minutes

What You Need

For the class:

- ❑ 1 minute timer or watch with second hand

For each group of 4:

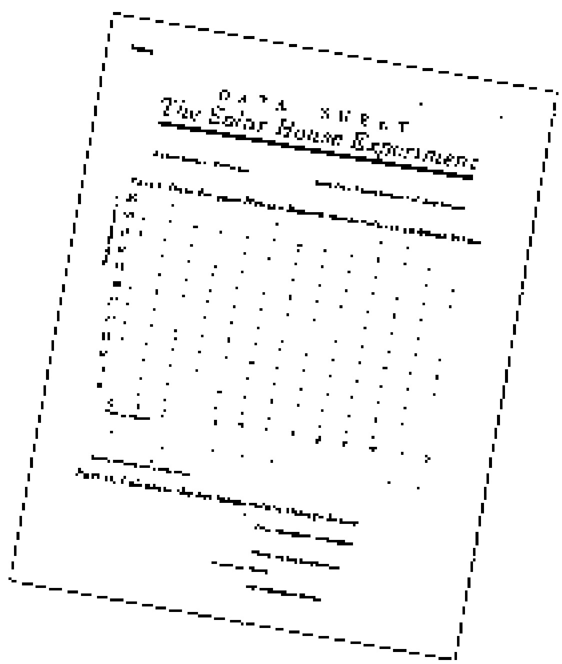
- ❑ 1 roll of transparent tape

For each student:

- ❑ 1 model house with thermometer (constructed in Session 1)
- ❑ 1 piece of cardboard, 6" x 8" (16 cm x 20 cm), to be used as ground insulation for the house
- ❑ 1 data sheet, "The Solar House Experiment" (master included, page 16)
- ❑ 1 pencil

Optional:

- ❑ 1 manila file folder or clipboard for recording data


DATA SHEET
The Solar House Experiment

Getting Ready

1. Duplicate a data sheet for each student.

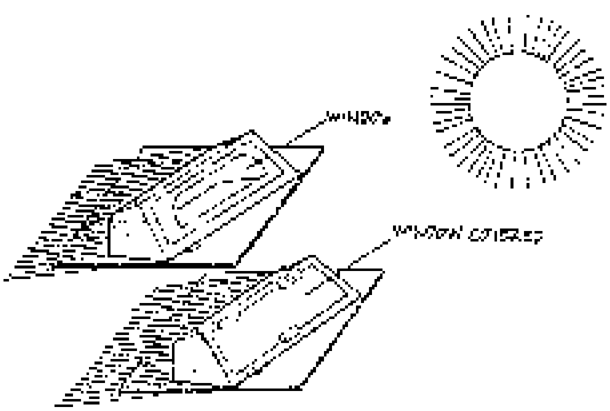
2. Cut the 5" x 8" piece of cardboard (of the same thickness and color) from some cardboard cartons. Each student will place his or her house on a piece of cardboard to insulate the house from the ground. The house can be secured to the cardboard with a small piece of tape.

3. It is probably easiest for you to serve as the group timer, calling out intervals of one minute, at which time your students read and record the temperatures of their houses. But you could also have each group time their own experiment, in which case each team will need a timing device.

4. Select a suitable and sunny outdoor site, on level ground, for the experiment.

Experimenting

1. Review the experimental design. Ask, "What is the same about all the houses? What are the constants?" Then ask, "What is the experimental variable—the variable you are testing in the experiment?" (covered or uncovered window) "What will our observed result be?" Ask your students to predict which house will heat up the most. Explain that when the houses are set up, all windows should face the sun.



2. Demonstrate how to set up the house on the cardboard insulation and secure it with tape (especially if it is a windy day). Remind the students to position the thermometer so it can be read through the window. Those students with covered windows simply lift the flap to see through the window.

3. Give each of the students a data sheet and explain that they will record the starting temperature in the triangle and the temperature each minute in the designated box. Have each student fill out the experimental variable (covered or uncovered window) and the specific characteristics of his or her house (either "window covered" or "window uncovered").

4. Divide the students into groups of four. Distribute the houses and the cardboard insulation pieces. Give each group one roll of tape. Move outdoors to your experimental site with your students. Remind them to bring all their equipment, including a pencil.

5. After all the groups have recorded the starting temperature, have each group move their houses into the sunlight. Then you begin timing the experiment. Remind the students that all windows must face the sun. Check each group to be sure their houses are positioned properly. Caution the students about accidentally shading their houses with their own shadows.

6. Have your students take temperature readings every minute for five minutes and record their readings on their data sheets.

7. Leave the houses in the sunlight for another five minutes. During this time tell your students to complete the graph on their data sheets. Continue announcing when each minute passes.

8. Using the extra class thermometer, take the air temperature on top of one of the cardboard insulation pieces. This will give the students an idea of the air temperature surrounding their houses.

9. After a five-minute interval, have the students take and record two more temperature readings on their houses (minutes 10 and 11). "Did the temperature change during minute 11?" If there is some doubt, have them take another reading after another minute. Eventually, the house temperatures will stabilize. This is a condition known as *equilibrium*, which occurs when the rate of heat entering the house equals the rate of heat lost by the house. Ask your students to record their final (equilibrium) temperatures on their data sheets, then take all the materials back to the classroom.

10. Have the students save their data sheets for the next activity session, "Discussing the Solar House Experiment."

Equilibrium is a concept that applies to many scientific phenomena. Here are a few other examples:

1. *If the air pressure inside a balloon equals the air pressure outside the balloon, the balloon stays the same size.*

2. *If the rate of immigration to a country equals the rate of emigration, the population stays constant.*

3. *If the rate of water flowing into a bathtub equals the rate of water going down the drain, the depth of water in the tub remains constant.*

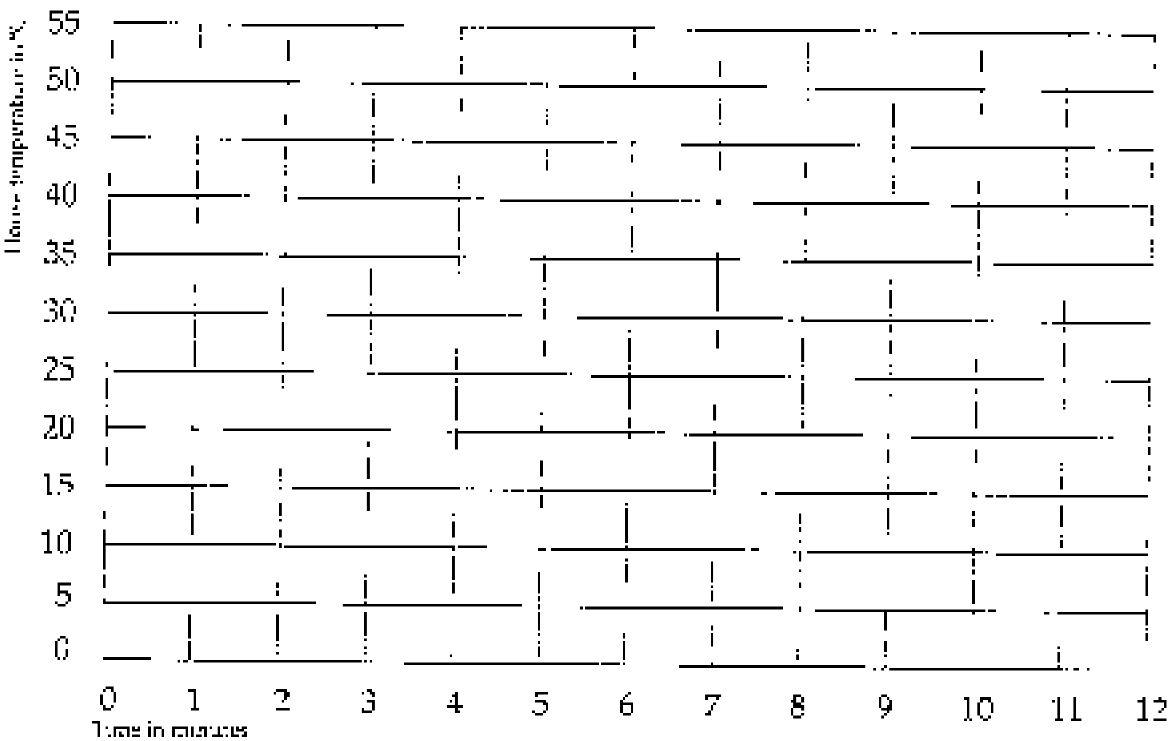
Names______ _ __________ ______________________ __________ __________ ______

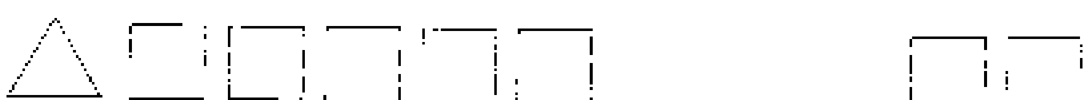
DATA SHEET:
The Solar House Experiment

_______________________ ______ __ _________________

Experimental Variable Specific Characteristic of this house

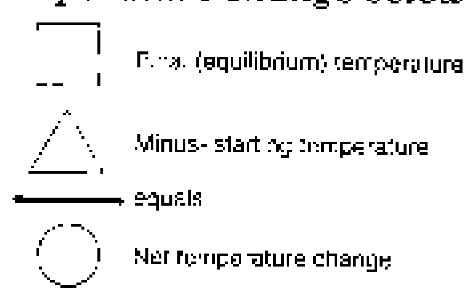
Part I. Data for your House—Record temperatures in boxes below:





Record temperatures in these boxes

Part II. Calculate the net temperature change below:



The Solar Water Heater Experiment

Overview

In this activity, students discuss conventional home water heaters and then conduct an experiment to heat water using aluminum pie pans and sunlight. The experimental variable is whether the pan is enclosed in a plastic bag (covered) or not (uncovered).

This activity is best done on a sunny day with little or no wind. But even on a cloudy day you will get interesting results!

Time Frame: 45 minutes

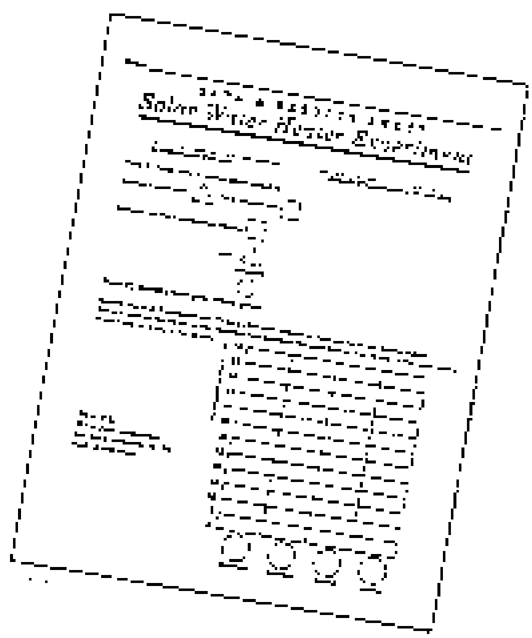
What You Need

For a class of 32:
- ❑ 16 clear plastic bags (standard size for produce) with twist ties
- ❑ 1 1/2 gallons of water (4–6 liters) in two buckets or basins

Note: The temperature of the water should be the same as or less than the outdoor air temperature, but NOT warmer.

For each student:
- ❑ 1 paper cup (5 oz.)
- ❑ 1 aluminum pie pan
- ❑ 1 piece of cardboard 6" x 8" (16 cm x 20 cm)
- ❑ 1 data sheet "The Solar Water Heater Experiment" (master included, page 36)
- ❑ 1 thermometer (Celsius)
- ❑ 1 pencil

Optional:
- ❑ 1 manila file folder or clipboard for outside recording



Getting Ready

1. Select an appropriate, sunny outdoor site on level ground to conduct the activity.

2. There will be a 15- to 20-minute wait from the time the students have their experiments all set up to the time when they begin to record results. Plan ahead for this time. One option is to carry out a discussion of the conclusions of the house heating experiments. Or you can discuss some types of solar water heaters the students may be familiar with from their own or neighborhood homes.

3. Assemble all the items from the "What You Need" materials list.

Conducting the Experiment

1. Explain that the second biggest energy user in many homes is the water heater. Ask the students, "What do you use hot water for at home?" "How does the water get hot?" [Again, by burning fuels, either directly—in gas water heaters, or indirectly—in the process of making electricity for electric water heaters.] Remind your class that fuel sources are decreasing, while pollution is increasing, so we are looking for other ways to heat water.

2. Introduce your class to today's challenge—conducting solar water heater experiments using aluminum pie pans as model water heaters. Tell the students they will be experimenting to find out which condition produces the warmest water: pan covered or pan uncovered. Ask them to describe how to set up a *controlled experiment* to find out. When the students mention "amount of water" as a variable to be controlled, show them the 5 oz. cup that will be used to measure water.

3. In class, demonstrate placing the thermometer in a pan, putting the pan (without water) into a plastic bag, and setting it on a level surface on top of the insulating cardboard. The bag is sealed with a twist tie after the water is poured into the pan. Caution your students not to attempt to carry the pan once it is filled with water—water should be poured only after the pan is placed in its experimental position, in the sunlight.

4. Divide the class into groups of four. Assign two students in each group to cover their pans, and two students to leave their pans uncovered.

5. Distribute the data sheets and explain to the students that they will only record starting temperature in the triangle and the final temperature in the square. Measurements do not need to be taken every minute, as was done in the house heating experiments. Have each student fill out the space at the top for the experimental variable (coverings) and write down the specific characteristic of his or her pan of water (covered or not covered).

6. Distribute the pans, thermometers, bags, paper cups, and cardboard insulators to your students, and take the class outdoors to the experiment site. The plastic bags make convenient carrying containers for the student equipment. Remind the students to take pencils for recording. You take out the water.

7. Have the students set up their pans and thermometers on cardboard insulators on level ground in the sunlight. Those students who are to cover their pans should put their pans in a bag before setting them on the insulators, but should not yet seal the bag.

8. Tell your students to pour one full paper cup (5 oz.) of water into their pans and to take the temperature of the water by immersing the thermometer and leaving it there. After about 30 seconds, the students should read and record the starting temperature. Have them feel the temperature of the water with their fingers. Students using covers should then seal their bags with twist ties.

9. Allow the pans of water to heat for 15–20 minutes.

10. Return to the water heaters to take the final temperature reading. Ask your students to record this temperature on their data sheets. Then have them feel the temperature of the water with their fingers again and compare this with how the water felt initially.

11. Have the students pour the water out on plants or the lawn, collect the materials and return to the classroom. All the materials, including the paper cups, can be reused. Data sheets should be saved for the next activity.

Names____

DATA & RESULTS SHEET:

Solar Water Heater Experiment

____________________ Experimental Variable

____________________ Specific Characteristic of this dish

Part I. Your own experimental results:

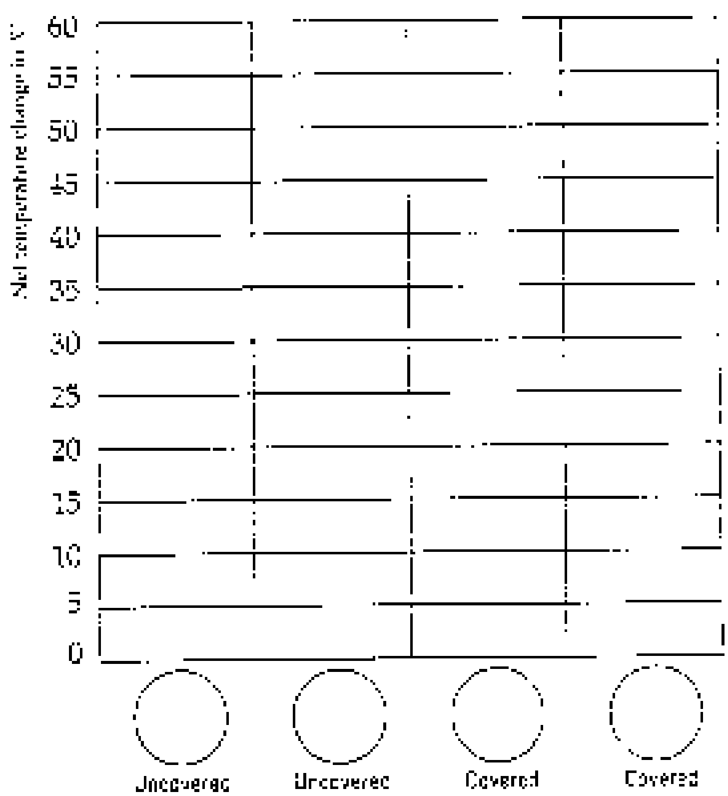
Starting Temperature

Final Temperature

Calculate the **Net Temperature Change**

Part II. Results from your whole group.

Record the **Net Temperature Change** for each heater in your group in the circles below. Draw a line on the chart at the recorded temperature for each heater and shade in the area below these lines to make a bar graph.



Part III.
Write your conclusions for this experiment on the back of this sheet.

SOLAR-POWERED CARS

Category:
Solar energy or energy sources

Objective:
Allow girls to explore an area that may be new to them, become familiar with using tools, and learn about simple machines and the power of the sun

Introduction:
This is a great project, because the girls get to open a bag of parts, and just spend some time trying to figure out how it all goes together in the shape of a car. They use tools and work in teams of two. They seem to enjoy the process and the end result.

Materials:
We used Walnut Ridge Problem-Solving Kits* ($6-$8) from a hobby shop. For the particular kit we used, only scissors, a small hammer, and tape are necessary. But if you can, have a toolbox available with basic tools: hammers, screwdrivers (flathead and Phillips), wire cutters, pliers. What's essential are the tiny motors and solar panels. If you don't use kits, the little motors can be bought separately for around a dollar apiece. The solar cells were the expensive part (about $5-$7 each) but if you use them over and over with lots of kids, it's worth the initial expenditure. You can buy the kits and/or bags of gears and wheels in hobby shops. Solar cells are available at some hobby shops, Radio Shack, and solar stores. Both times we bought solar cells and motors, I got them over the Internet at www.siliconsolar.com.
Make sure they are in stock and that you allow delivery time of about a week.

Procedure:
These kits contain a flat wood body, some small bits of plastic tubing, wheels, Styrofoam, a few screws and other things, and a motor. They are made to work and be powered in a variety of ways. There is a secret set of directions you can view if all else fails! The motor can run off an AA battery or a solar cell. The solar cells had not arrived by the time we were to do the first round of centers, so we used batteries the first day. Actually it worked out well that the solar cells arrived late, because to me, using a battery first made it clearer that the solar cell replaced the battery as an energy source for the motor. Also, you can test them indoors with the battery and when the car is running properly, you can take it outside to hook up the solar cell.

Later, I saw a similar version of the car, but it was made with a paint stirrer for the body (cheaper than kits), and gears, so it went faster. If you add gears to the wheel assembly, you're also introducing them to another "simple machine". (Simple machines are wheels, gears, inclined planes (or wedges), and pulleys.)

Comments: Hands off is best. You may have to tape your mouth closed and tie your hands behind your back, but it's so much fun to see the girls succeed. If they need help with things requiring fine motor skills, by all means help, but don't do it for them. Ask questions that help them narrow their choices or broaden their perspective, but let them discover as much as possible on their own. They'll feel so good about themselves, and so will you! This approach is much more relaxing once you get used to it. There's no pressure to be everywhere at once around the table, doing what they could be doing for themselves.

Extension:
This is much more about the building than the racing of the car. If you want to expand, you can do another hour or more on friction, acceleration and inclined planes. Remember that with scientific experimentation, change only one variable at a time. Provide different surfaces for the car to run on. You could use actual outdoor surfaces, or supply strips of felt, sandpaper, and wax paper. See what level of friction is most efficient for the wheels you have.

Provide a plank and a stack of books and see what happens when you change the slope of the plank. Can the car make it up the track with a one-book slant? How about two? Try going down. Time the car's descent. Now add a book. How much faster did it go? When it gets very steep, are there problems with the car's stability?

Reminder:
If you are using the solar cells rather than batteries, make sure you have sunlight (not a good project for a cloudy or rainy day or an evening).

** Walnut Ridge Group makes these "Problem-Solving Kits" that are so cool! There's a flying machine, a mousetrap car and assorted other kits. And the best part is they are not kits in the strict sense of the word. There's plenty of room for invention. In addition there are bags of different-sized wheels and other "pieces and parts". Try your local hobby shop for these and other great things like propellers, balsa wood, rockets, motors and dowels of all sizes.*

SOLAR STILL

Category: Solar energy

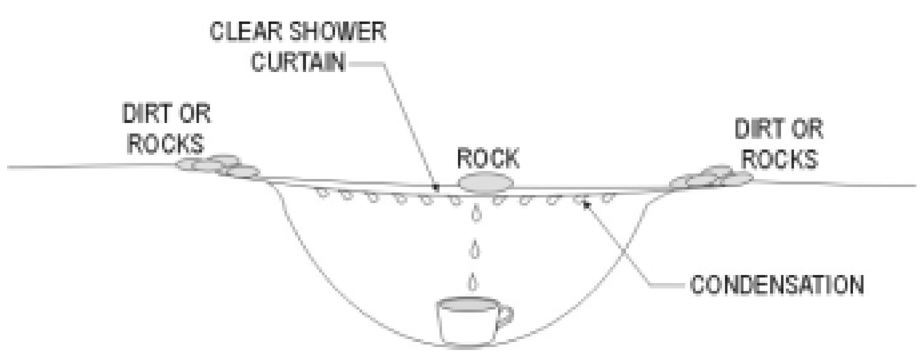
Objective:
Actually a survival tool, it is also a dramatic demonstration of condensation.

Materials:
- shovel(s)
- clear plastic shower curtain (new)
- cup or bowl
- rock

Procedure:
Dig a pit approximately 2 feet deep by 2 feet across. (We wore out in the 105 degree heat trying to dig in rock-hard earth before we got the hole that big, but it still [no pun intended] worked!) Place a bowl or cup in the bottom of the pit. Place a section of clear shower curtain across the top of the pit and bury the edges in the dirt, so no air can get in. Place a fist-sized rock in the center of the plastic, so it weighs the plastic down, directly over the container in the bottom. As the moisture from the dirt walls condenses on the plastic, it will roll toward the center and drip into the container. If you can, add some plants or bits of cactus into the hole to add to the moisture trapped there.

Comments and Questions: Come back several times over the next few hours and see if there is enough water to keep a person alive in an emergency. Is the energy expended digging the hole worth the amount of water you get? Has it rained recently? What is the climate in your area? What are some other factors that may affect the amount of water you collect?

We all enjoyed doing it and seeing the results for ourselves.



WOOD BURNING

Category:
Solar Energy

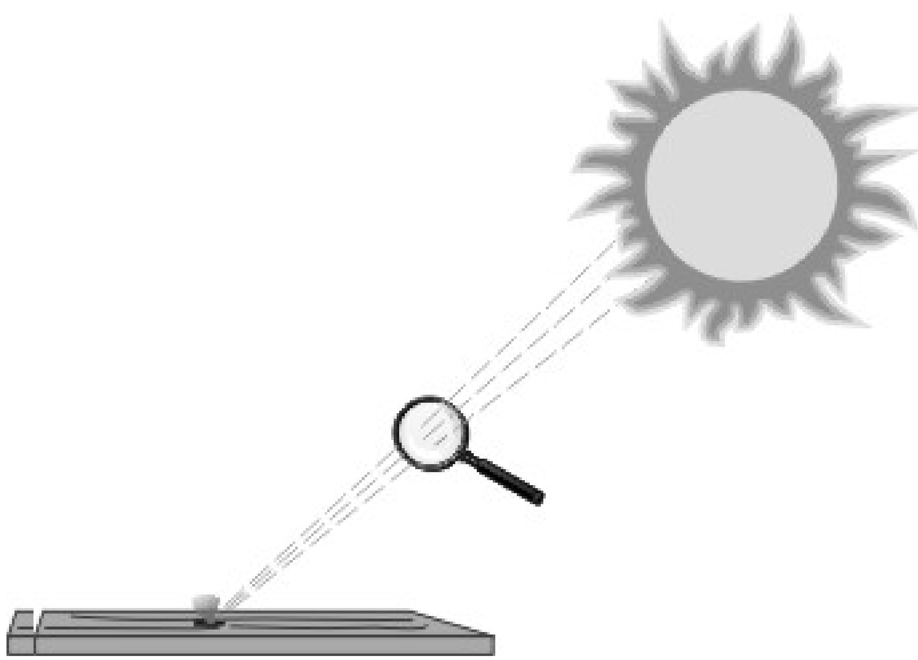
Concept:
Heat

Introduction:
We used this as one of several free-choice centers during a week-long Solar Energy camp. It was a huge hit, of course, since you get to burn something! And what a great way to see the power of the sun!

Materials:
- sunshine
- 5" to 10" piece of soft wood, such as pine or balsa - one per person
- magnifying glass - one per person

Procedure:
All you do is direct the sun's rays into the smallest possible point on the wood, and it immediately starts smoking and burning. (At least in the Arizona summer sun, it seems immediate.)

Simply keep moving the magnifying glass and you can write your name, or make a picture or sign for someone. If you like, make the design with pencil and then trace the lines with the moving magnifying glass.



VIKING BEARING DIAL OR SOLAR STONE

The solar stone is a rather intriguing instrument, possibly used by Vikings in the 10th to 13th centuries to navigate ships, both during the day and at night. At our first camp, we made them out of cork, dowels, cardboard and nails. I don't have the author's name so I couldn't get permission to reprint but thought they were worth mentioning. On the web site pages I listed a site that shows a very good drawing of one that you could use to make one. Go to the site (*see p. 265*) and scroll down. It's the first picture after all the text.

Here is the basic idea: Cut a 4" circle out of cardboard and cut a hole in the center the size of the cork you have. Cut the cork in half and glue it to a 5 " piece of dowel. That is the handle. Place the cardboard circle down over the cork so you can rotate it. Mark the four directions on the face. Push a nail into the top of the cork and another into the side, half-way up.

Go outside at noon and aim the side nail the direction you are walking. Hold the tool so that the top nail casts a shadow on the dial. Turn the dial so that North lines up with the shadow. Since the sun's shadow points North at noon (in the northern hemisphere) you can now tell directions.

At night, do the same using the North Star in place of the sun. Set the pointer in the direction you are heading, and then sight the North Star with the "shadow stick". Then turn the dial so that North points toward the star. Bon Voyage!

Structures

Structures

A Six-week or One-week Format

For our six-week sessions on structures, we used some of the same activities at three or four locations, and some different ones. At the one-week camp, our focus was on bridges and so the centers were all about different types of bridges and the various strengths and weaknesses of each. There are many books and web sites that address bridge building activities. Just search with a phrase such as “model suspension bridge”. A wonderful web site for bridges is www.pbs.org/wgbh/buildingbig. They have a series of activities on bridges, dams, tunnels, and domes based on their televison series called “Building Big”. You can access what you need online or buy the educators’ guides through the mail. Another great site belongs to the Society for Women Engineers. They even have Girl Scout modules that correspond to earning badges. Their site is www.swe.org. They have very good activities in a number of areas. Here’s what our typical SYSTEM program on structures might look like.

Week one: Set up three centers for the girls to explore at their own pace. Choices could be 1) file card bridge, 2) toothpicks and raisins, 3) tile tower, 4) any one of a number of commercially available sets of math “manipulatives” - could be borrowed from school district or sets like Tinkertoys, Zometools, and K’Nex are all good. 5) straws and paperclips, 6) building 3-D shapes from paper

Week two: Since most people will not have exhausted the possibilities from last week, set up the same centers again, or some new ones.

Week three: Newspaper Engineer or Playdough Playground (*see Chemical Engineering chapte*r).

Week four: Build and test a container that can protect an egg from a fall. Or study the porous properties of the ingredients in adobe bricks and make a first batch of bricks.

Week five: If working on the egg packaging, continue that, and have the culminating challenge. If working on adobe bricks, examine the bricks made the week before and make a large batch of the best recipe. Plan with the kids for next week, when the parents visit.

Week six: Parent day - You may want to do another activity during the fourth week instead of beginning the egg packaging, so that the final egg drop falls on week six. If they have made adobe bricks, they can build a structure with them this week. You will have to mix up more “mud” to use as glue for the building.

Career Options for those who enjoy building include architect, construction site supervisor, landscape designer, civil engineer, toy designer or tester. What else can you think of?

EXPLORING STRUCTURES - DIFFERENT SHAPES, DIFFERENT STRENGTHS

Concepts: You can discover which shapes make the strongest structures! Dead load, live load, compression, tension, and force are terms that can come up during building. See glossary for definitions.

Introduction: We chose to set up all three centers for about an hour to an hour and a half, two weeks in a row so that girls could rotate freely among the centers at their own pace. You may choose to do these on the same day as centers; or one at a time on different days, depending on your time constraints. A child could spend as little as 15 minutes at one center or as much as 45 minutes. Center two takes the least amount of time. Centers one and three tend to hold one's attention longer.

<u>Center 1</u>

Materials:
- straws or coffee stirrers and gumdrops OR
- toothpicks and mini-marshmallows, gumdrops or raisins

Objective:
Can you build a geometric shape with toothpicks and gumdrops (or what have you), that will stand on its own, and resist pressure? Try holding up a book with your shape.

Procedure:
Have a table set up with a couple of boxes of straws or toothpicks, and bags of marshmallows, raisins, or gumdrops. If the food items are new, not reused, give each child a small amount to eat, right off the bat, then tell them the rest are for building! If you do reuse them, be sure and tell the kids. It's a sure deterrent to eating them! As for the activity, a simple explanation is best; the task is to see what geometric shapes they can build, and which ones are sturdier. Chances are, they will just start building. You can suggest that they look for repeating patterns, perhaps, or shapes they may have seen on playground equipment or in bridges. (Hint: the secret word is: "triangle".) At the end of the session, see if that's what they determine to be a strong shape.

<u>Center 2</u>

Materials:
- at least two books of equal size
- stack of index cards
- several dollars worth of pennies, in or out of rolls.

Objective:
Can you make an index card bridge between the books that will hold up three or four dollars in pennies?

Procedure:
Have this table set up with several books of the same size, a package of index cards, and the pennies. Ask them to design a strong bridge from one stack of books to the other with one index card. It should be able to hold up several penny rolls. You can make an arch bridge or a beam bridge. Sometimes, one child sees immediately some of the best things to do. Secret information: the best shape for this is an accordion fold, but let them figure it out!

Center 3

Materials:
a stack of scrap paper, about 25 bricks or ceramic tiles, scotch or masking tape

Objective:
How can you get one regular 8 ½ by 11-inch sheet of 20-lb. paper to hold up a stack of bricks or ceramic tiles?

Procedure and Comments:
Put the scrap paper, tape and weights on carpet if possible, so you have fewer broken tiles, because as the kids build, the tiles or bricks will fall! They will probably start with a simple cylinder of paper. They may try rolling several sheets together. Let them try anything. If they are completely stumped, ask them what they might do with the paper that would change its shape. That should lead them to folding, without giving them answers.

After a while you could ask which structure has held the most weight so far? If someone has used more than one sheet of paper in layers and they name it as being the strongest, you can now prompt them to accomplish a similar design with one sheet of paper. Height is also a factor in the structure's stability. They may be stumped on how to accomplish making a thicker structure with one sheet of paper. Gentle direction is best here, to avoid giving them answers. Someone will most likely come up with folding, which will strengthen the shape as well as lower the height, making it sturdier and able to hold about 25 4" ceramic tiles, a considerable weight for one sheet of paper!

The pride of accomplishment you see on their faces is well worth the trouble you may have restraining yourself from telling them too much too soon. As they begin to get the idea, however, feel free to help them center the load evenly, so it doesn't tip over. When the structure does collapse, inspect it for the reason. Sometimes it could have held more weight, but crushes on one side due to uneven load. Secret information: the best shape will probably be a short cylinder made by folding the paper over and over from top to bottom, down to a height of a couple inches, rolled into a cylindrical shape and taped. Triangles work well, too. The crucial part is the folding down into many layers for strength.

PATTERNS FOR BUILDING 3-D SHAPES FROM PAPER

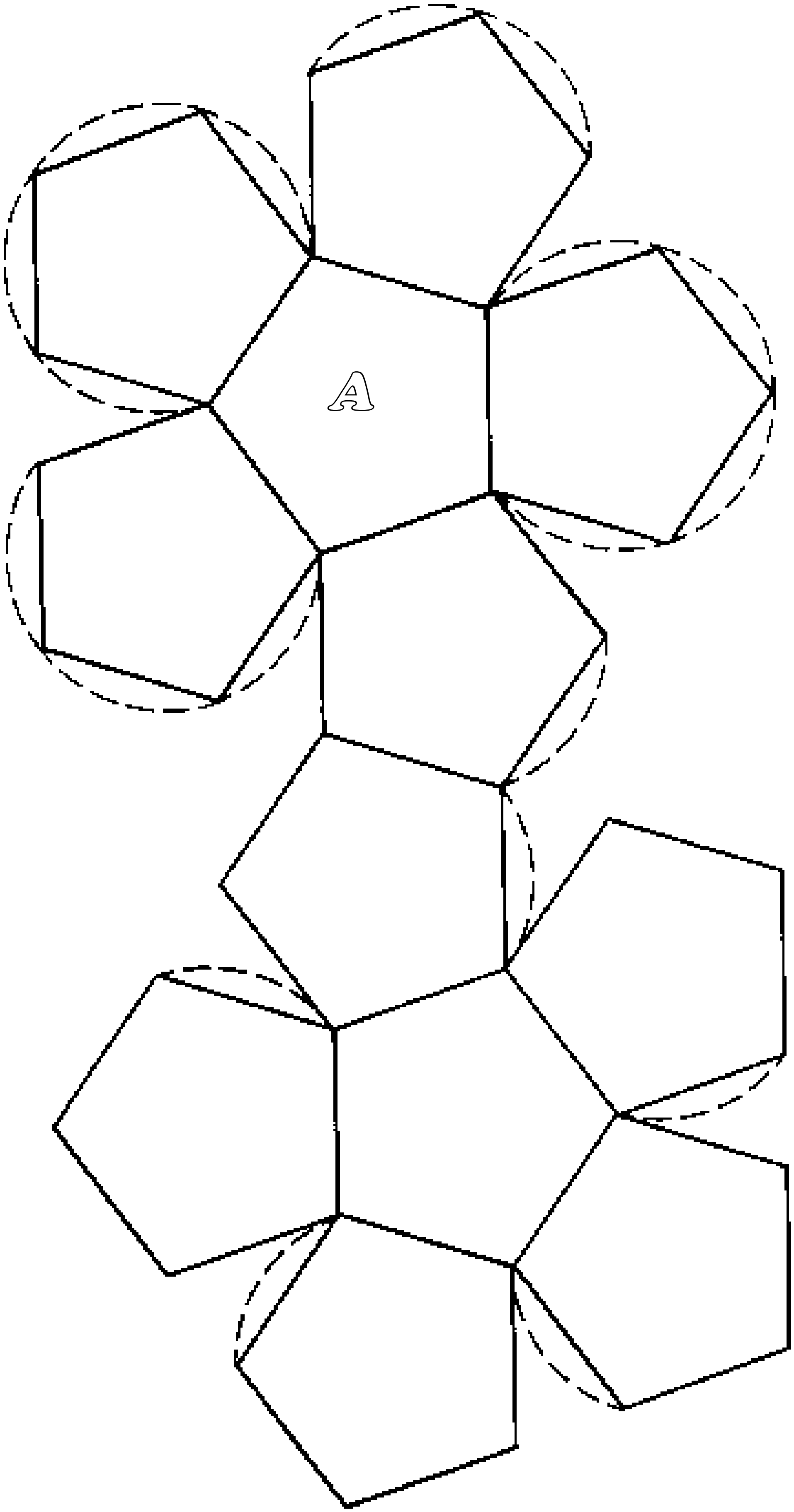
Category:
Structures

Objective:
Discuss two dimensional vs. three-dimensional objects. See what a 3-D object looks like flattened out.

Materials:
- patterns
- scissors
- tape
- glue

Procedure:
On the following pages are patterns you can photocopy and use as an activity on structures. They are to be cut out by the kids and folded on the solid lines. Where there are dotted lines, fold and glue or tape them to another side of the object.

Comments:
We used them at the beginning of a series on structures. This was one of several centers set up around the room. We photocopied several of each shape so the children could choose the shapes that interested them. This may be difficult for kids under 10, but you can help a little if this is the case.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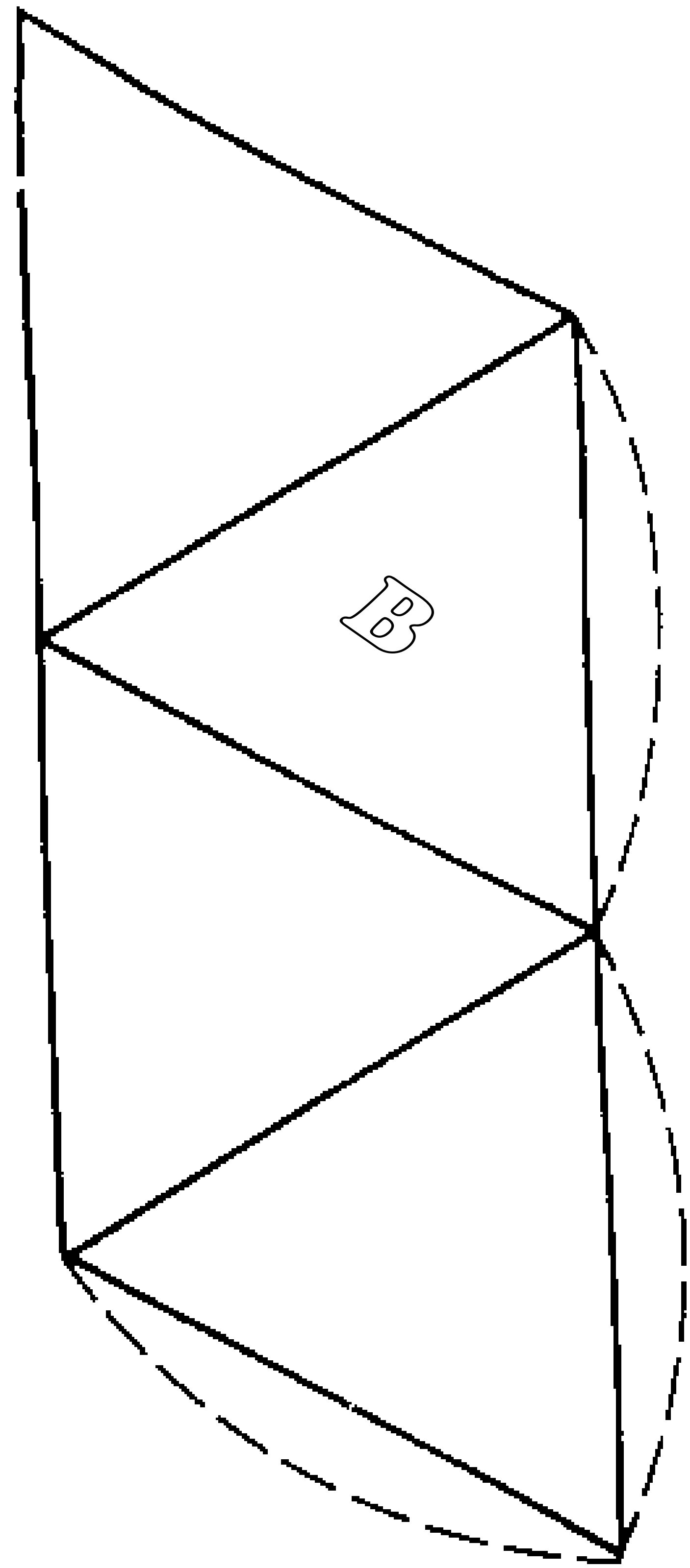
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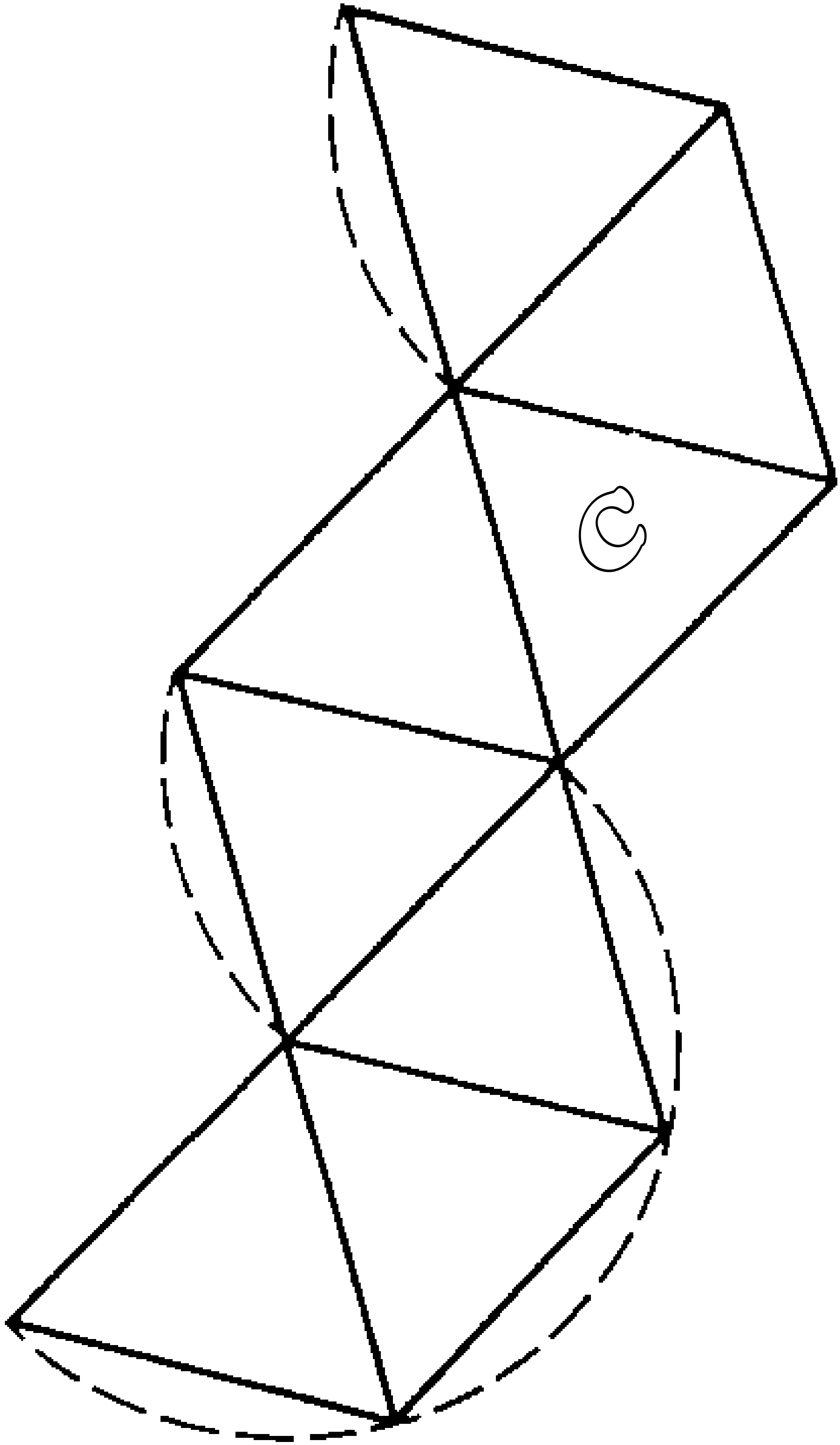

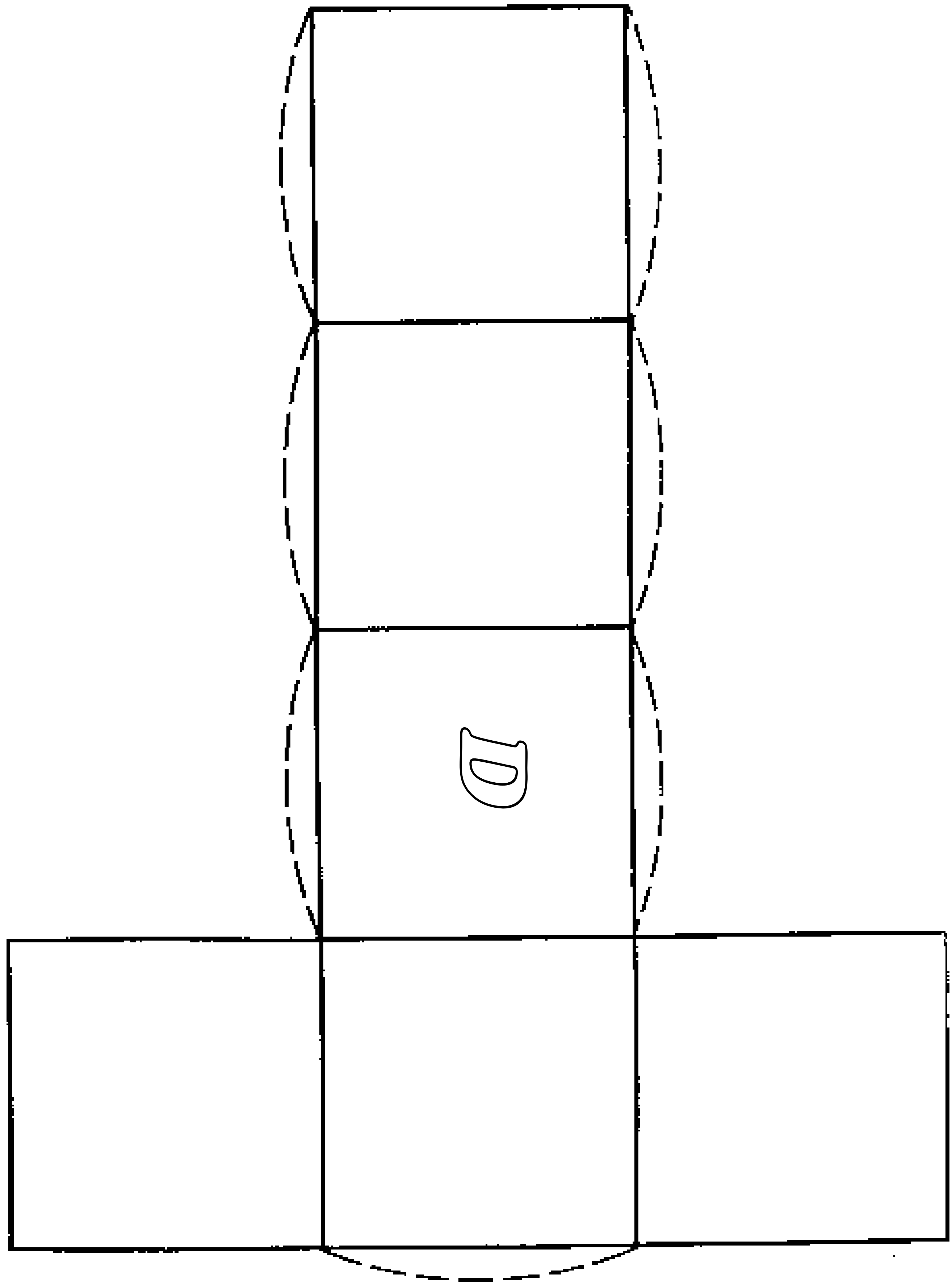
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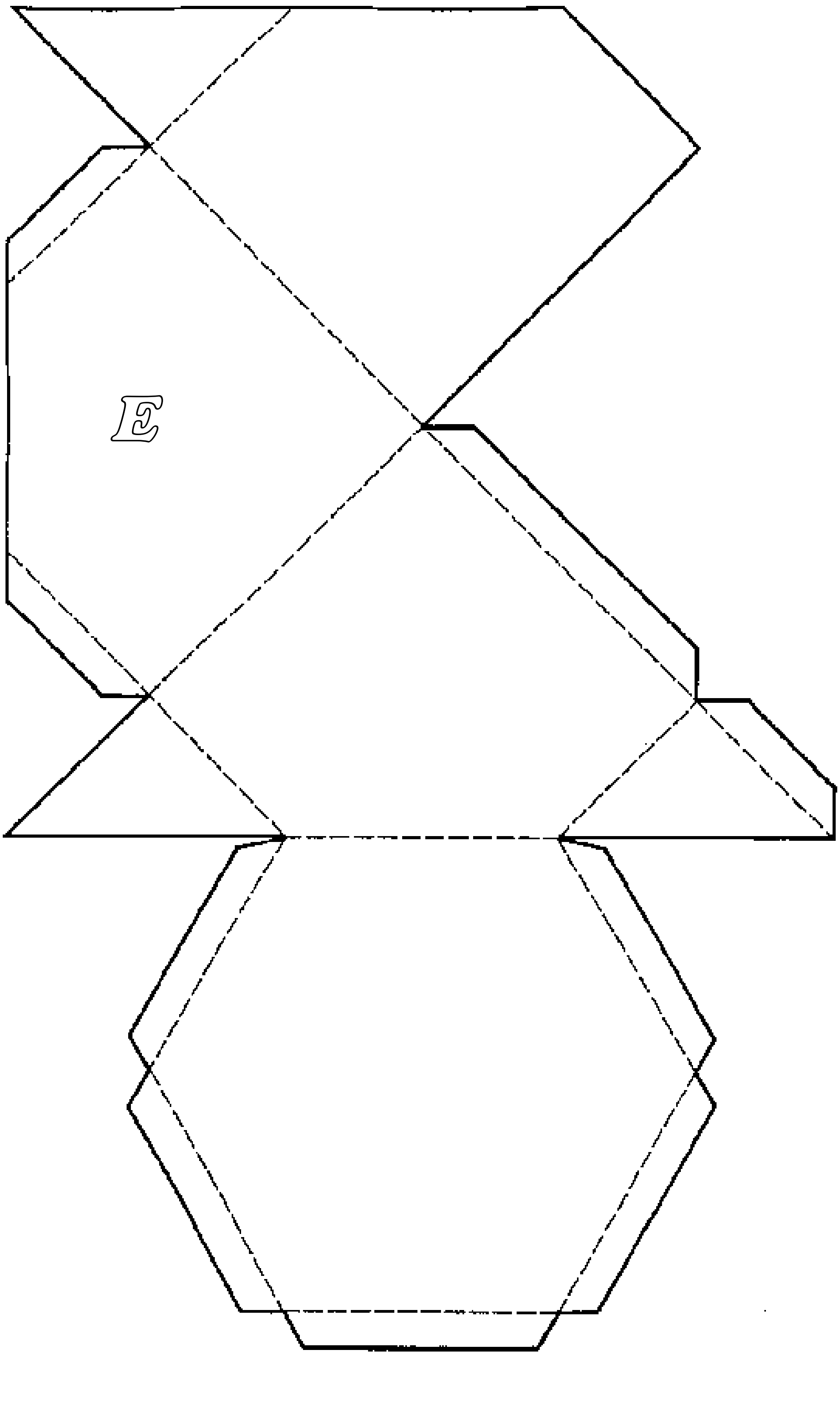
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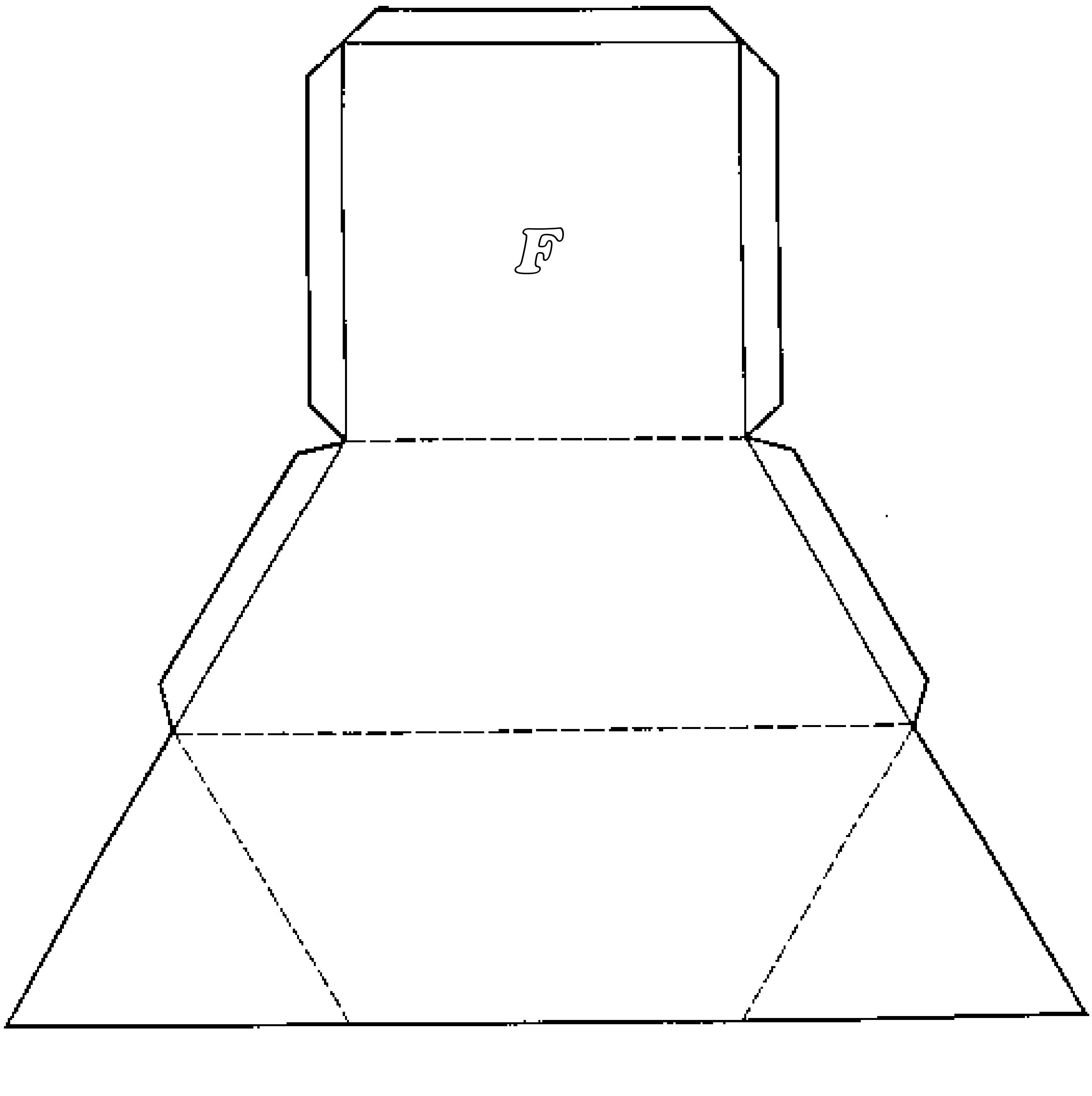
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NEWSPAPER ENGINEER

Category:
Structures

Introduction:
This is a really fun activity that requires little, if any, input from adults. There are just a few rules listed below.

Materials:
This is easy; stacks of newspaper and lots of masking tape!

Procedure:
Be a paper engineer. In teams of two to four kids, design a structure that the team can fit under. It must be 1) free-standing, 2) have a roof, and 3) be made of only newspaper and masking tape. So don't attach it to or lean it against the wall or desk, make sure some sort of roof goes across the top, and only use newspaper and tape.

Comments:
The above directions are enough for the first round. When everyone has finished, in about 30 - 45 minutes, discuss some of the difficulties they may have had. Ask them if any shapes seemed stronger than others.

Extension:
Their next task is to refine their structure, or build a new one. This time, they must keep in mind some of the constraints imposed on real structural design engineers. Ask them what some of the issues might be for an engineer designing a building for a customer who is buying it. They will probably think of several, including cost, time, and appearance. Others may be intended use, handicapped access, and safety. What would their structure be like if tape cost $10 per foot, or newspaper, $1 per sheet?

THE YOLK'S ON YOU

Category:
Structures

Objective:
To build a package that will protect an egg, drawing on knowledge of structural strength and weakness gained from previous activities, such as the file card bridge, tile tower and from making geometric shapes. The protected eggs are then dropped ceremonially from a great height, and the survivors are much celebrated!

Materials:
Have a variety of materials available to work with. Include such things as straw or the plastic grass from Easter baskets, Styrofoam peanuts, or scraps of material, toothpicks, straws, wooden skewers, strips of cardboard and wood lath (include tiny nails and hammers). Include whatever you have or can think of using.

- at least 2 uncooked eggs per person
- tape
- glue
- gumdrops
- scissors
- string (you may want to limit the amount each person can use, or stipulate that it can only be used for tying, not for wrapping around and around)
- paper towels, sponges, towels, water or spray cleaner for dropped egg clean-up.

Introduction:
Ideally, this activity is introduced after the kids have done other structural activities and participated in casual discussion about them. They need to have some picture in their minds about strong shapes.

Comments:
When we did this, we had spent 3 weeks on the several centers focusing on structural integrity. We'd hoped for them to have figured out that the strongest shapes are triangles and cylinders from doing the activities mentioned above in "objective". However, when presented with the challenge, almost all of them tried to build a box out of flimsy poster board! Perhaps we didn't have a good variety of materials, or we hadn't discussed the shapes enough. Maybe it is just hard for 8-12 year olds to transfer some information from one activity to another. Whatever the case may be, I think it's a valuable experience.

Culminating Activity:
We had a great time - a fire truck came and the firefighters took the packages up in the cherry picker one at a time and dropped them from about 3 stories! If you have a two-story building, you can station people in an upper window and others on the ground, and drop from there. You could go to the top of a slide or climb a tree for that matter! Have fun! Award prizes or certificates for zany categories: Safest Carrier, Cheapest, Most Colorful, Most Breakage, or the teams with the best team work, best design, the If At First You Don't Succeed award, etc.

ADOBE BRICKS

Category:
Structures

Time:
two or three one-hour sessions

Group size:
10-15

Objective:
To explore the permeability of several substances used in making adobe bricks. To make bricks and use them to build a miniature structure.

Procedure for Session One, 2 activities:
1) Observe and record the speed of water passing through 3 substances - sand, soil, and straw.

2) Use these substances to make adobe bricks.

Materials:

For whole group
- 1 25 lb. bag of sand
- 1 5 gallon bucket (or less) of straw, cut into 2 inch or smaller lengths (you can pick up enough straw off the floor of a feed store for about fifty cents)
- 1 5 gallon bucket of local soil
- 3 ring stands, funnels, and filter papers
- 3 one quart containers for water
- 3 to 6 1-cup measuring cups
- clock with a second hand
- newspaper

For each student
- 1 pencil
- 3 index cards
- small mixing bowl
- stirrers
- bottom halves of 3 half-pint cardboard milk or juice containers
- sheets of newspaper to work on

Introduction:
1. Lead the group in a short discussion of first, permeability of different materials, and then structural engineering by asking:

A . If we pour water into the clay (sand), (straw), in this filter, do you think it will go through it? How quickly? Do you think we'll get all of the water back out of it, or just some of it? How much? Set up the three ring stands with funnels, filters and each of the three materials and try them one at a time, pouring a specified amount, (such as 1 cup) into each material. You can have someone time how long the water takes to get through.

B. What do you need to think about, if you're building a house?

C. Do you think any of these materials would make a good house?*

***Note:**
In the right combination they will make a beautiful house that has a fairly constant indoor temperature due to the thickness of the walls. In the Southwest, adobe buildings last for many years. In addition, straw bale buildings are becoming increasingly popular. So the straw alone can be used for a very cost-efficient and pleasing structure, but it is built by stacking bales and covering them with chicken wire and a coating of adobe or plaster to protect it from the elements. The three little piggies were on the right track.

2. Tell your children they will become structural engineers during this meeting. Explain the work of a structural engineer, and maybe ask them to brainstorm related careers in building and design. Tell them they're going to explore creating their own recipes for adobe bricks.

Go over measuring with them. Maybe ask how many have used measuring cups in cooking at home or at school. Just as a cookbook author writes a recipe to cook something, they will be writing a recipe to build something. Give an example and write it on a card, (such as one cup of soil and 2 cup of water). Set each child up with the above-mentioned materials. They have 3 milk carton molds, so they can make three different recipes. They should write each recipe and tape it to the container after they pour the mixture in, so there's no confusion with batches. Leave enough time for them to clean up; at least 10 - 15 minutes.

Drying the bricks:
If you're doing this in a classroom where you'll be meeting every day, the kids can be responsible for turning their own bricks out of the carton, when they're dry enough to stay together, and turning them daily in the sun, so they dry evenly. If you only meet once a week , then an adult can take them home and care for them until the next meeting. They will take longer than a week to dry in a humid climate, but you can try drying them in or near a warm oven.

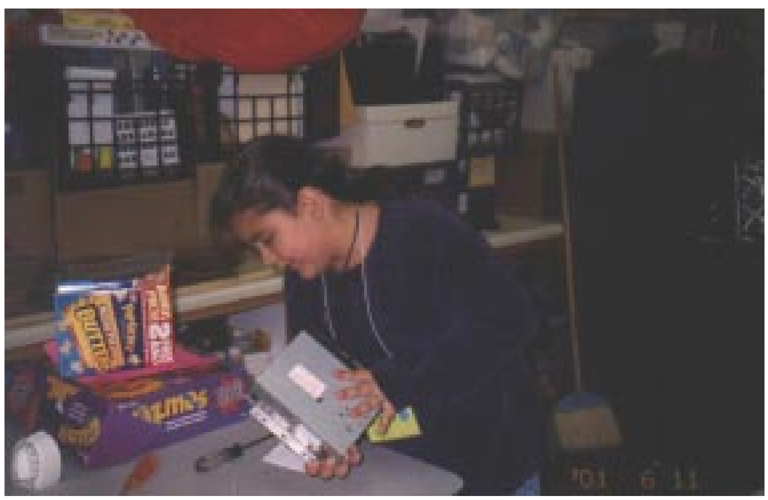
Comments:
One actual recipe is ½ bucket clay, ¼ bucket sand, ⅛ bucket straw, and enough water to make a stiff dough. However, to encourage exploration, don't introduce this until session 2, AFTER a discussion on how everyone's bricks turned out, so to speak.

Session Two:
Hand out the dried bricks in their molds to their builders. Have the kids examine their bricks and think about whether or not they turned out well. It may be very obvious! After examining the bricks, you could take the best batch and write the recipe so all can see it. Next, you can go in one of two ways. They could refine their recipes on their own and make another batch of bricks, based on their experiments and observations, or you can share the actual recipe and mass-produce a good batch for the next session's building activity.

Session Three:
In this session, we got back into our small groups, divided the dried bricks evenly and built with them. One dedicated adult had made a bunch more bricks at home and dried them, since we hadn't had time for another building session. It came out to about 40 bricks for each group of 4-5 girls. You need to mix up some mud to use as a bonding medium. Now comes the fun part. Design a small building, bridge, wall, or fireplace that you can build with your bricks. We made fireplaces, all of which were a little different. Using the mud as the glue to hold your structure together makes them look like chocolate ice cream sandwiches! Have fun!

Comments:
Let me say here that your life will be a lot easier if; 1) you mix the mud **outside**, and 2) you mix up **enough** mud the first time. I suggest one five gallon bucket per group of 4 -5 kids. 3) Build on a moveable platform like a plank or cookie sheet, so you can move the structures to a storage area for the mud to dry.

Technology



Technology

Anthropologically speaking, technology is “the body of knowledge available to a civilization that is of use in fashioning implements, practicing manual arts and skills, and extracting or collecting materials”. Applied to an ancient civilization, the term ‘technology’ might mean tools such as projectile points (or arrowheads) for hunting and crude digging sticks for tilling soil.

Applied to the 21st century, our thoughts immediately jump to computers. With computers we fashion implements (design tools, houses, mining pits and more), we practice manual arts and skills (type, draw, compose), and we extract or collect materials (do research on the Internet, buy on E-bay).

There are so many careers today that involve computers and they are capable of so much more than many of us use them for, we included one computer camp and two six-week Girl Scout troop sessions on computers. All three involved programming, which the girls picked up on quickly and they accomplished a lot. In addition, at other summer camps where we had access to computers, we included activities that I’ll mention a little further on.

I was amazed at the level of interest and concentration. With one group of 3rd through 6th graders we met once a week for six weeks (on a week night), from 5:30 to 7:00 p.m. We took a break around Christmas holidays and then met again for six or eight weeks. I was surprised that after being in school all day, and then possibly doing homework, that they were willing to come and put in the effort that they did week after week. They were enthusiastic and loved seeing their efforts come to life on the computer screen with animation and music!

In that group, we programmed with LOGO Writer during the first six weeks, and with Micro Worlds (a newer, more colorful, advanced version, see www.lsci.ca) during the second six weeks. Other than spending about one hour learning LOGO commands prior to introducing it to the kids, we were learning right along with them.

For the summer computer camp, we used Legos Mindstorms. These are Lego sets with which you build robots and program them with the computer to move about the floor.

During some of the other summer camps, we had access to school computer labs. For Simple Machines camp, we loaded about seven of the computers with the software “Even More Contraptions” and allowed kids to play during puzzle and game times. One of the free choices on Thursdays was web surfing with a purpose. Before camp began, we looked up several girl-friendly science web sites. For each one we created a question, and the girls got to cruise the web sites searching for the answers. Included here is the blank form we sent home with staff members before camp started, and a form complete with the questions we used at camp.

WEB SURFING

"Your Passport to FUN and KNOWLEDGE"

pg 1

Site	Question	Answer
www.girltech.com		
www.engineergirl.org		
www.discoverengineering.org		
http://pbskids.org/zoom		
http://jfg.girlscouts.org		
www.lego.com		

WEB SURFING

"Your Passport to FUN and KNOWLEDGE"

pg 2

Site	Question	Answer
http://school.discovery.com/brainboosters/		
www.blackholegang.com		
www.beakman.com		
http://kids.msfc.nasa.gov/		
www.wsu.edu/DrUniverse		
www.yucky.com		

WEB SURFING: Sample Questions

Site	Question	Answer
www.girltech.com	1) Go to "Girl Galaxy." Go to "Girls at Work." a) Who is the Walt Disney Executive VP? b) What costume is she wearing as a little girl? 2) Go to "Girl Galaxy." What job does Fanny Zuniga do at NASA?	1) a) ____________ b) ____________ 2) ____________
www.engineergirl.org	3) What year was the cellular phone invented? 4) Go to "Gallery." Which engineer has a sister who is also an engineer?	3) ____________ 4) ____________
www.discoverengineering.org	5) Go to "Cool Stuff." What type of engineer helps to design water slides? 6) Go to "Cool Stuff." What type of engineer works to preserve the underwater world?	5) ____________ 6) ____________
www.lego.com	7) Go to "Build." Go to "Building Careers." Check out the "Photo Gallery." Which is your favorite work of art?	7) ____________
http://school.discovery.com /brainboosters/	8) Who ate the last piece of pizza? 9) How can you throw a ball as hard as you can and have it come back without it striking anything or being attached.	8) ____________ 9) ____________

Site	Question	Answer
www.blackholegang.com	10) Which member of the Blackhole Gang is the chess expert? 11) What kind of microscope does A. J. have?	10) ____________ 11) ____________
www.beakman.com	12) Click on "Brains." Click on "Earth." Which venomous creature is the deadliest around?	12) ____________
http://kids.msfc.nasa.gov/	13) Play some of the puzzles or games. Which one is your favorite? 14) What does "QUASAR" stand for?	13) ____________ 14) ____________
www.wsu.edu/DrUniverse	15) What kind of animal is Dr. Universe? 16) Is Dr. Universe male or female?	15) ____________ 16) ____________
www.yucky.com	17) How big is the world's largest roach? 18) Can you make your stomach gurgle? Why or why not?	17) ____________ 18) ____________

LOGO, COMPUTERS, TURTLES, AND ANGLE MEASURING TOOLS

Concepts:
Problem-solving, logical thinking, constructive methods, and the opportunity to interactively create and manipulate mathematical processes.

Introduction:
Logo Writer is an early DOS-based computer programming language, also available as a MAC version, designed for use by learners, including children. By typing in commands, you “talk” to and direct the movements of an on-screen turtle, using just the keyboard. This is one theme for which I think a two-hour meeting would be beneficial. When you work on computers, the time flies and we seemed to barely be getting started when it was time to go home.

Session one:
As an opener to working with Logo Writer, the girls made turtle glyphs - name tags representing some things about themselves. We made a picture of a turtle, copied it onto colored poster paper, cut them to large-sized name tags and distributed them with yarn, a hole puncher, crayons and the following directions:

Turtle Glyph

1) Write your name across the middle of the turtle’s shell.

2) Color in sections of the shell at the bottom to show your grade.

3) Color the top middle section of the turtle RED if you attended SYSTEM summer camp last summer. Color the top middle section BLUE if you did not attend.

4) Give the turtle a smiley face if you like working on computers. Give the turtle a sad face if you do not like working on computers. Give the turtle a neutral face if you are so-so about computers.

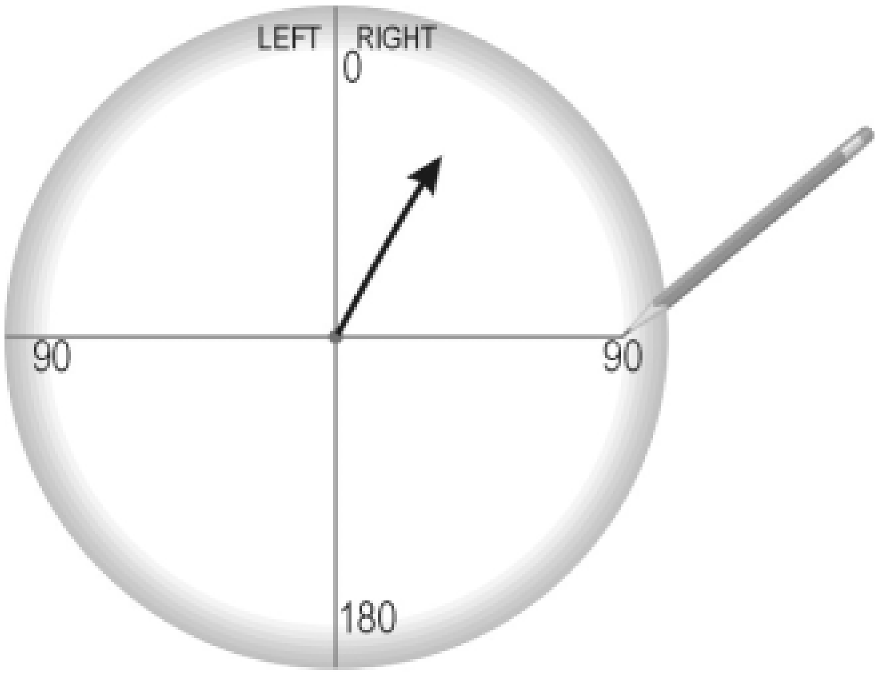
5) Color the turtle’s toenails your favorite color.

6) Give the turtle a hat if you like doing puzzles and games.

Question of the Day: Why a TURTLE??

See the section on rocket glyphs for more information on what you can do with glyphs, once they are made.

Angle Measuring Tools (AMT)
Next we made simple directional compasses or angle measuring tools. We wanted to start them off with a concrete and visual activity of what we would be asking the turtle to do more abstractly in Logo Writer.



Materials:
- 7” paper plates – one each
- brightly colored pipe cleaners – one each
- pencils
- markers
- scissors

Procedure:
Measure across the center of the plate and draw a pencil line through it from edge to edge. Measure from top to bottom and draw another line through the center to the edges. The plate should now have lines dividing it into quarters. Make a small hole in the center of the plate where the lines meet. To designate one line segment as the top, put an arrow on it and darken it with a marker. Mark it as 0 degrees. Write “left” to the left of the line, and “right” to the right. Mark 180 degrees at the bottom line segment and 90 degrees on both sides. Place the pipe cleaner through the hole in the center and twist the end on the back of the plate, so it stays in place. Cut off the extra length. Now you have the directional arrow. (It should extend about to the edge).

Ask if they know the number of degrees in a circle (360), discuss 90 degree angles, etc. Explain how to use the AMT. I think it’s easiest if they listen to the direction, turn the pipe cleaner to that direction, then turn yourself that way, and then move the plate and/or pipe cleaner so that it is lined up at 0 degrees in front of you again. When they have that figured out, they can pair off and take turns being the robot and programmer. “Move forward 5 steps. Turn right 90 degrees. Go forward 10 steps”, etc. So, for week one, we did not use the computers.

Materials:
- one computer for every two children
- one Logo Writer disk for each computer (There are several Logo-based programs that could be substituted, some of which may be downloaded at no cost.)
- paper
- pencils

Session Two:
We sat down with the girls and told them they would be exploring in a program called Logo Writer. We handed out a sheet with the basic commands and went over them before going to the computers. We also got the computers set up with Logo Writer before the girls sat down.

They worked in pairs and experimented, first trying to see what the turtle would do, and after a few minutes, trying to duplicate some of the shapes in the handout. At least one pair of girls hit on the wrap around feature by accident and had a lot of fun with that, putting in commands like FD 1010 and seeing the patterns resulting.

Session Three:
Again we sat on the floor in a circle for some beginning instruction, before going to the computers. Using butcher paper so all could see, one of us drew a turtle and asked the girls for some directions you would give the turtle so it would make a square. After we established that, she introduced the “repeat” command, and the girls went off to try using it on the computers. Because of a comment that came up, she also challenged them to make a circle! Some of the girls were shown the “flip side” where you actually program the turtle, and shown how to save their work. The time went by too fast – all were very engaged in the project and they (we) are always thrilled at the figures that show up on the screen. It’s a very satisfying activity, because you can see instant results, and also you can easily start over if it’s not what you want.

Session Four:
The “flip side” was introduced to the rest of the girls and I think they caught on quickly to the concept that what it enables you to do is use one word commands instead of the lengthy commands necessary on the other side. See instruction sheets for ideas (pp. 231-234).

Sessions Five and Six:
Again, see instruction sheets for ideas. You probably won’t get to all the pages unless you have more time than we did. Use what seems appropriate, and if some are learning more quickly than others, introduce more commands or projects to them.

MicroWorlds

Introduction:
When we came back to the same group of girls for another six-week round of computer exploration, we introduced this newer, flashier version of a Logo-based language. MicroWorlds encourages the development of problem-solving strategies, critical thinking skills and creativity. Key features are that projects can be saved as HTML code to be displayed directly on the World Wide Web, Macintosh projects can be transferred to Windows computers and vice versa.

Materials:
- one computer for every two children
- one MicroWorlds disk for each computer
- paper
- pencils

Procedure:
We started with a review of the commands for Logo Writer, since they are the same for MicroWorlds. Next, we handed out the Scavenger Hunt instructions to get them to explore with some direction.

Welcome to MicroWorlds Scavenger Hunt

Let's explore this program and see what we can find!

1) Make a geometric shape using commands you already know.

2) Figure out how to change the turtle into something else.

3) How can you make more turtles appear on the screen?

4) Find out how to make music and create a little song.

5) Can you write a message that will appear on the screen?

6) Explore some more!

Subsequent Sessions:
That will keep most people busy for the first session. After girls became a little familiar with the options available, we asked them to create a media display about themselves or something they were interested in, using as many features as possible. They had the next few weeks to complete it. On the last night, we invited parents to come watch as each girl displayed her presentation on a big screen, via laptop, explaining some of the features she included, or challenges she had .

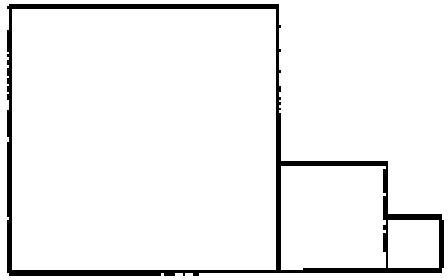
Some of the features you can include are: animation, importing videos and music, creating melodies, recording your voice and playing it back with a command, etc. In just a few weeks, you will not get too elaborate, but we were very pleased with the accomplishments and variety of the girls' projects, despite the time limitations!

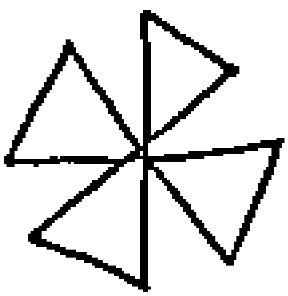
WELCOME TO LOGOWRITER
BIENVENIDOS A LOGOWRITER

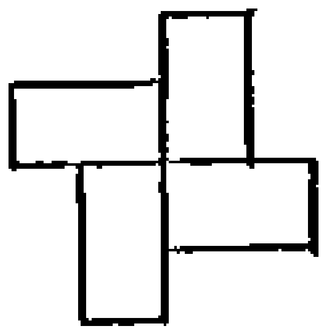
Here are some useful commands to communicate with the turtle
Aquí tiene algunas instrucciones útiles para que se puedan comunicar con la tortuga

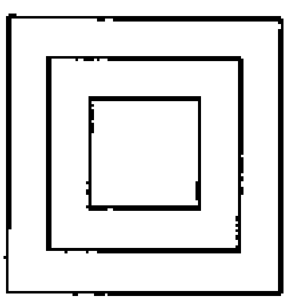
FD (forward)	for example, FD 40 tells the turtle to move forward 40 turtle steps por ejemplo, FD 40 le dice a la tortuga que adelante 40 pasos de tortuga
BK (back)	for example, BK 30 tells the turtle to move bakcwards 30 turtle steps por ejemplo, BK 30 le dice a la tortuga que ande para atrás 30 pasos
RT (right)	for example, RT 90 tells the turtle to turn 90 degrees to the right por ejemplo, RT 90 le dice a la tortuga que gire 90 grados a la derecha
LT (left)	for example, LT 180 tells the turtle to turn 180 degree to the left por ejemplo, LT 180 le dice a la tortuga que gire 180 grados a la izquierda
PU (pen up)	this command lifts the pen so that you can move the turtle without drawing esta instrucción levanta la pluma para que puedas mover la tortuga sin dibujar
PD (pen down)	this commands puts the pen down so that the turtle can draw esta instrucción baja la pluma para que la tortuga pueda dibujar
PE (pen erase)	this command lets you erase what you just drew with the turtle esta instrucción te permite borrar lo que acabas de dibujar con la tortuga
CG (clear graphics)	this commands clears (erases) the graphics and resets the turtle in the middle esta instrucción borra todos los gráficos y pone la tortuga en el centro

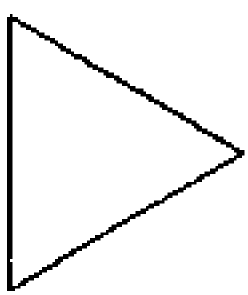
FREE EXPLORATION - TIEMPO PARA EXPLORAR

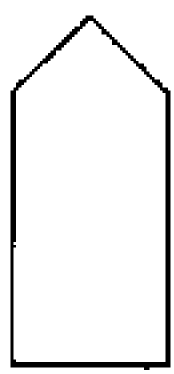












Your name: ______________

Exploring the REPEAT command

By now you probably know how to make the turtle draw square. Let's look at a command that would make it really easy for your turtle to draw a square:

Try it out by typing:

REPEAT 4 [FD 40 RT 90]

[Don't forget to press Return or Enter after you are done typing it]

→ What does the turtle do?

Let's explore what we can do with REPEAT… try different numbers and record what you tried and what you got.

For example, try **REPEAT 6 [FD 40 RT** ?????]

(Try different numbers for the Turn and see what happens)

Or try playing around with the number of repeats, or the number of turtle steps (the distance that the turtle walks)….

Drawing Regular Polygons

Let's continue our explorations with the REPEAT command. We are going to find out how to make the turtle draw specific shapes. These shapes are quite popular in mathematics. They are examples of Regular Polygons.

Fill in the blanks

1) For example, to draw a square of side 40, you could type:

REPEAT ___ [fd 40 rt ___]

2) What about to draw a regular hexagon (of side 40 too)?

REPEAT ___ [fd 40 rt ___]

3) What about a regular octagon?

REPEAT ___ [fd 40 rt ____]

4) How about an equilateral triangle?

REPEAT ___ [fd 40 rt ____]

5) Make up your own

REPEAT ___ [fd 40 rt ____]

6) Free exploration
Use what you have learned so far to make any design you want.

Properties of Water

Properties of Water

A Six-week or One-week Format

There are so many fun things you can do with water that we chose this theme at several locations throughout our project. You can easily address subjects such as surface tension, displacement, buoyancy, mass, weight, density, convection, and the three states of matter - liquid, solid, and gas, all while playing in water, building and racing boats, eating ice cream and sinking submarines!

Most of the activities are appropriate for a wide range of ages. However, the convection and liquid density activities are best done with ages 10 and up. Those under 10 years old may lack the deductive reasoning skills and hand-eye coordination necessary.

Career options are many. You could be anything from a marine biologist to a water treatment plant manager to a hydrologist, advising miners or builders on protecting water supplies. You could raise fish, be a commercial fisherman, design boats, be an engineer, or work for a state or city water utility. Can you think of five more jobs related to water?

Here are some ways to set up your week-long camp or six-week after school program. Remember, each week of a six-week format corresponds to one center, whole group activity or free choice activity at a one-week camp.

Week one: Sink or Float (clay and foil boats and pennies) and Floating Paper Clips

Week two: Convection or Hot and Cold and Buckets of Balloons

Week three: Plankton Race

Week four: Density and Convection or Aquifers and Edible Aquifers

Week five: Properties of Water (Water Drops on a Penny and /or Freezing Point Depression, which is found in the Chemical Engineering chapter)

Week six: Boat and Submarine Building and Junk Box Wars (see, http://school.discovery.com for these projects)

Check out the http://pbskids.org/zoom/sci/experiments.html web pages for more easy and fun water (and other) activities. You'll find activities that are similar to what we have done and more, in many categories. The best thing about this site's activities is that they are simple, and yet allow for creativity and scientific experimentation.

SINK OR FLOAT

Science Content: (Concepts)
Buoyancy, weight, mass. The concept of why some things float and others sink is hard to grasp, even for adults, but it is one of the most entertaining things to explore and ponder.

Objective:
To understand the relationship between weight and mass, and how buoyancy is affected.

Materials:
- Modeling clay (We use the kind that doesn't dry out and comes in a pack of 10 sticks for $.99 at craft stores)
- Dishpans or tubs for water
- Lots of small items for testing, such as paperclips, erasers, feathers, thumbtacks, candles, oranges, rubber bands, small cups, nails, crayons, Ivory and another bar soap.
- One roll of pennies (or more)
- Baggies, one per child or pair (optional)
- Paper
- Pencils

Procedure:
1) Kids can work in pairs or by themselves. Distribute a number of items (in baggies if you have them) and a paper and pencil to each child or team.
2) Have students take one item at a time and predict whether it will sink or float. Place the items into separate piles according to the prediction. Record the prediction.
3) Test each item and record what actually happens.
4) Give each student a stick (or small ball) of clay. Ask them to predict whether that will sink or float. Try it.
5) Challenge students to make their clay float. They must use the entire piece they were given.
6) Once they have successfully made their clay float, let them test to see how many pennies the clay can hold.

Comments: Here are a few questions you can ask as you circulate among the groups. Does the weight of the object determine floating or sinking? Does the shape? Why does a huge ocean liner, weighing many tons, float? Why does a rock sink? If you have tried floating an orange, peel it and try again. Try floating the peel.

Extensions:

1) Spend more time with the paper clip. It will float!
2) Give each person a 4" square of aluminum foil to float. See how many pennies it will hold.

CONVECTION *

Category:
Water

Concepts:
Convection - heat transfer by fluid motion between regions of unequal density that result from non-uniform heating. In meteorology or weather, the transfer of heat by massive motion in the atmosphere, especially upward motion.

Introduction:
This is a good experiment to tie in with a study of either weather or water. In this, you observe the patterns of movement of food coloring when it is dropped into water of different temperatures. We used blue food coloring for the no heat trial, and red for the heat trials. You could use a different color for each of the four trials.

Materials:
- four clear plastic containers, about 6" across and 2-3" deep (plant pot liners are good)
- 15 Styrofoam cups
- package of food coloring
- eyedropper(s)
- 4 sheets white paper
- water and a way to heat it (electric tea kettle or nearby microwave or stove)

Procedure:
Set up the equipment as shown in illustration. To provide the heat in the center of the container for Trials B, C and D, place a Styrofoam cup of very hot water under the center of the pan.

We didn’t have access to the original instructions, only the illustration, so my apologies to GEMS. I don’t know how the experiment was supposed to be done. We tried to use the same container and did one trial after another. It didn’t work very well. I think it would be advantageous to set up all four trials in a row. If you have a large group, they could work in small teams, and each could do one trial and then if there’s time, they could keep trading places and do all four trials.

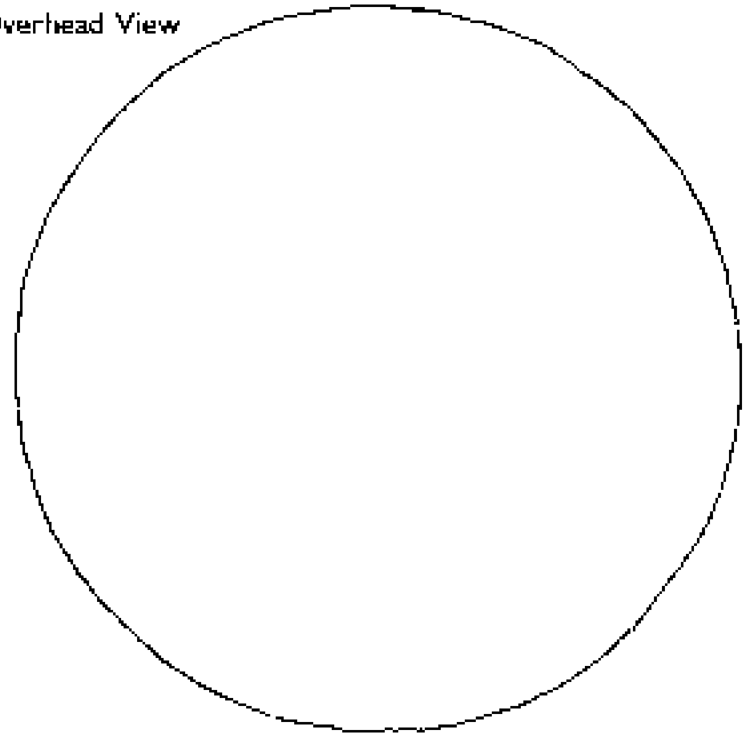
Comments:
It’s fun to have water colors, brushes, and white paper available so you can draw the patterns followed by the dye as it moves in the container. See what patterns you can observe. How does this correlate to weather patterns, high or low pressure systems or the movement of wind on a cool or warm day?

*This activity was adapted from the Great Explorations in Math and Science (GEMS) teacher’s guide entitled Convection

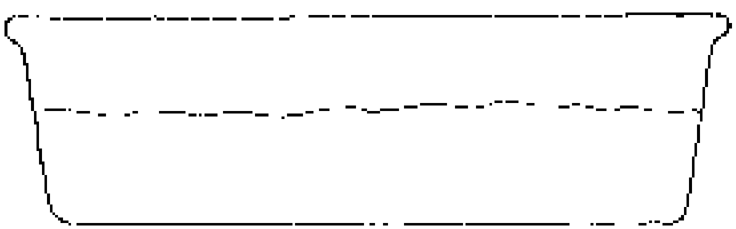
Convection Observations

Name

Overhead View



Side View



Circle which trial you are doing:

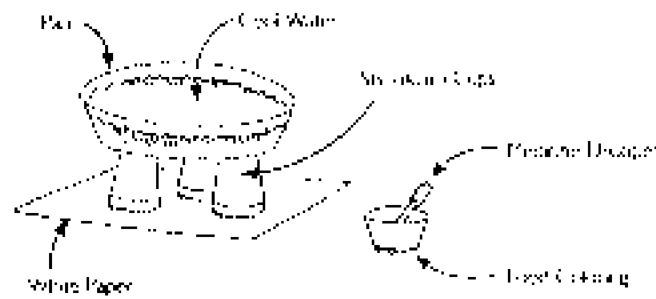
Trial A: No heat - Drop in center

Trial B: Heat in center - Drop in center

Trial C: Heat in center - Drop halfway to edge

Trial D: Heat in center - Drop in center and halfway to edge

Equipment Arrangement:



Describe (in words) what is happening:

HOT AND COLD
Two Activities

Category:
Water

Concept:
Density

ACTIVITY ONE
Materials:
- test tubes
- eye droppers
- red and blue food coloring
- source to heat water
- ice
- cups for hot and cold water on each table
- paper towels

Procedure:
The first activity was layering hot and cold water in test tubes. In order to see what happens, color the hot water red and the cold water blue. The kids can put several drops of food coloring into the cups of water, and then use eyedroppers to gently transfer the water into the test tubes. Let it dribble down the side into the test tube. They can try hot first, then try to layer cold on top of it and then try cold first, putting hot water on top. Does it blend or separate? If it separates, which water is on top, hot or cold? Continue to think about your results as you do the second activity.

ACTIVITY TWO
Materials:

- Three 5 gallon buckets, filled with ice water, room-temperature water and hot water
- Several water balloons, some filled with ice water, some with room-temperature water and some with hot water
- Large sheets of paper for girls to record results
- Red and blue marking pens and a third color

Procedure:
This activity explores whether water-filled balloons will float or sink, depending on the temperature of the water in the balloon and the water in the buckets. As each balloon is tested, draw pictures of where in the bucket the balloons floated. Did they rise to the top, did they sink, did they suspend in the middle? Label pictures with letters that make sense to you, such as an H in the picture of the hot water bucket, and a C in the cold water balloon. Or use colored markers to distinguish temperatures.

Comments: Begin the session by seeing if they are able to make any predictions about the results of the second activity based on the results in the first activity. Also, I would write up instructions and post them in a prominent place, so as girls began, there would be an order and logic to their inquiry.

For example:

1) Start with the bucket of hot water.

2) Place a hot water-filled balloon in it. Wait for 30 seconds.

3) Write or draw where it went in the bucket. Did it sink part way down and then float to the top? Did it float partially submerged? Did it sink?

4) Now, using the same bucket, place the room-temperature balloon in it. Do the same observation and drawing.

5) Try the cold water balloon.

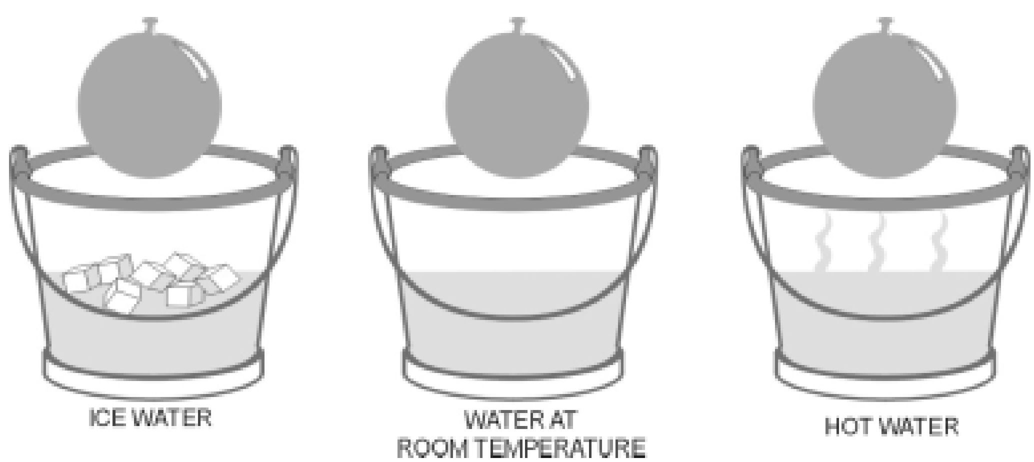
6) Next go to the bucket of room-temperature water. Place first the balloon with the same temperature water in it. Observe and record your results.

7) Then try hot and then cold balloons until you are finished, or run out of time.

Organize it in whatever way makes sense to you. But I strongly suggest doing it systematically!

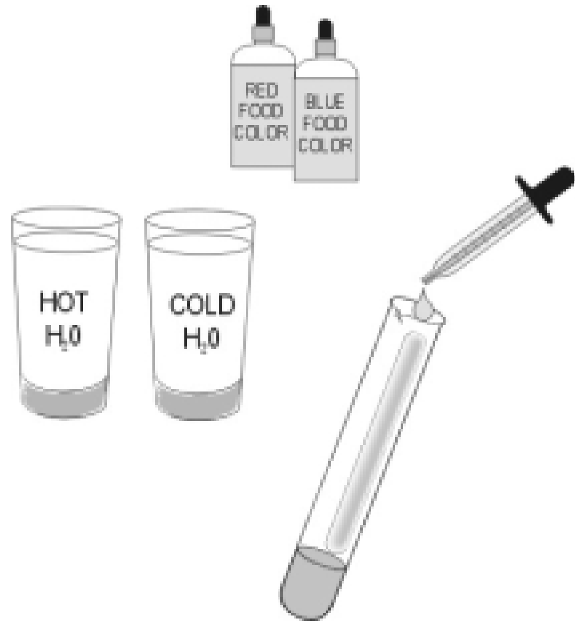
More comments:
If this helps: Theoretically, the hot water should layer, or float on the cold water. In cold water, the molecules are more densely packed together and slow-moving. In hot water, the molecules spread apart and move rapidly. If girls are having trouble seeing the results, or drawing any conclusions, you might ask some questions. In the summer, is it hotter near the floor or near the ceiling. (Or is it hotter on the first floor or second floor of your house?)

Adapted from the Great Explorations in Math and Science (GEMS) teacher's guide entitled Discovering Density, copyright by The Regents of the University of California, and used with permission.



PLANKTON RACE

Category:
Water



Concepts/skills:
Density, surface area effect on sinking rate, surface tension, biology of life in water, one-celled organisms, life cycles of organisms (many larvae are planktonic), photosynthesis, marine ecosystems, interdependence of land and ocean life, trial and error.

Materials:
- aquarium or clear plastic tub of water
- cork, either small pieces of sheet cork or small bottle-stopper type corks
- fun foam or Styrofoam pieces
- feathers
- buttons, washers
- wire
- string
- balloons
- other small items, some that float and some that sink

Procedure:
Tell the kids their mission is to create their own plankton, one that will fall more slowly than the others to the bottom of the tank. After some design and construction (15 or 20 minutes) they can begin to test their creations in the water. They can time them and then decide whether to add or remove items, or make major changes. When everyone is ready you can have timed plankton "races" to the bottom of the tank.

Plankton race rules:
1) Cannot float above the surface

2) Set a size limit*

3) Start timing after the plankton begins to sink

Which plankton sank the slowest, and why?

*Give everyone a washer or button that must be the body of their plankton, or set a size limit. If too big, won't fit into the aquarium you are using (unless it is a swimming pool!). Also a smaller size encourages lots of trial and error before the race.

Background information on plankton

The surface water of the ocean is teaming with microscopic plankton, tiny animals and plants (actually mostly one-celled protists) that form the base of the food chain in the ocean. The plant-like plankton are the phytoplankton; they photosynthesize using the sun's energy. The animal-like plankton are the zooplankton; they eat the phytoplankton and each other. Some plankton are the tiny larval forms of corals, sponges, fish and shrimp. Many animals depend on plankton for food, such as corals, shrimp, whales. The largest fish, the whale shark, lives only on plankton. This shows how abundant plankton are. The ocean seems clear, but it is a soup of invisible organisms.

Plankton include any organisms that drift passively in the water, using currents for most of their movement. They mostly are microscopic, but can be large such as jellyfish or floating kelp. Plankton comes from the Greek word for drifter, or wanderer.

Ocean organisms have many adaptations to live in water. They may be streamlined for moving through water, or small, irregularly shaped or round, or bell-shaped, to float or sink slowly. Plankton shapes are an attempt to maximize surface area to reduce sinking rate, and to maximize photosynthesis, and to uptake nutrients most effectively.

Primary production through photosynthesis requires light and nutrients. It is in the top 100 meters that most of the primary production takes place in the ocean because that is where light penetrates.

Adaptations of plankton for life in water include spines and other projections to increase surface area (to reduce sinking rates and to increase surface area for absorbing nutrients and sunlight), flattened or bell-shaped bodies, transparency for camouflage (no place to hide in the open ocean!), and skeletons made of limestone for protection from being eaten.

Examples of plankton

Dinoflagellates (cause red tides)
Diatoms (diatomaceous earth, and form the White Cliffs of Dover, England)
Foraminifera (very diverse fossil history used to date rocks and other fossils)
Jellyfish
Floating kelp or sargassum

Human uses of plankton

Plankton produce much of the oxygen in the air we breathe (as a byproduct of photosynthesis, they may exceed or rival that produced by tropical rainforests)
Fossil fuels (oil) come from fossil microscopic plankton layers
Limestone is made from fossil skeletons

How physical and chemical properties of water affect life:

Because water floats when it freezes, it rises and forms a cap on the surface allowing organisms to live in water through the winter and insulating water below from freezing. Density differences in water due to temperature lead to factors such as thermoclines and upwelling – nutrients at bottom rise to the surface and feed the surface animals.   Very deep water still holds lots of oxygen because it is so cold. Early explorers to the New World knew they were near land before seeing it when they saw and tasted a slick of fresh water running over the sea (from where and why does it float?)

How does adding salt to water affect its freezing and boiling? **

Which of these factors might affect floating and sinking?

Type of liquid (alcohol, oil, glycerin, salt or fresh water)
Water temperature
Material bucket is made of
Volume of water
Amount of air in water
Amount of forced gas (bubbles) in water

Archimedes' Principle explains the nature of buoyancy.
An object immersed in a liquid, either wholly or partially, receives an up thrust equal to the weight of the liquid displaced by the object.

Using Archimedes' Principle, the buoyancy of a submerged object can be calculated by subtracting the weight of the submerged object from the weight of the displaced liquid.

The buoyant force of water is dependent on its density, that is, its weight per unit volume. Sea water is more dense than fresh water, therefore a diver in seawater will be more buoyant than in fresh water, hence the need for a heavier weight belt when diving in the sea.

Lung capacity can have a significant effect on the buoyancy of a submerged person. A diver with full lungs displaces a greater volume of water and therefore is more buoyant than the same diver with deflated lungs.

**Salt water boils less readily (takes longer with the same amount of heat) and freezes less readily than fresh water. Salt in water causes surface tension to increase, boiling point to increase, freezing point to decrease.

DISCOVERING DENSITY

The colors must be intense enough for the liquid layers to be easily distringuished.

Getting Ready

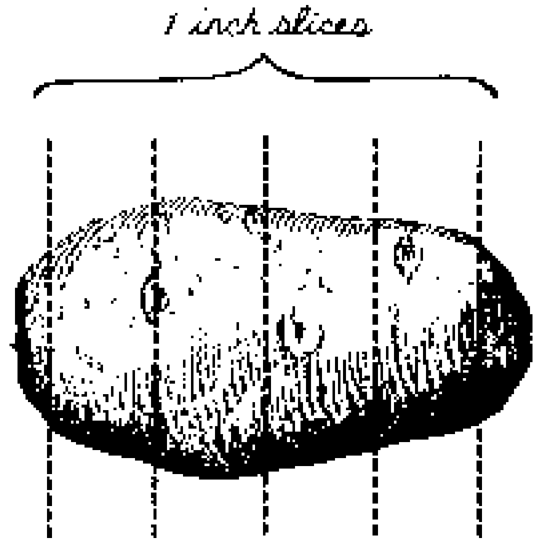
1. Purchase materials. If you cannot find clear plastic straws in the supermarket, try a fast-food restaurant. Make sure that they are not the super-thin straws with a small diameter. Glycerin and alcohol are available in drug stores. Kosher or pickling salt can be purchased in many supermarkets. These are pure salts with no additives to keep them free-flowing. They dissolve easily and make a clear salt water. Table salt can be substituted, but it makes a cloudy mixture.

2. Prepare the four stock solutions before class:

- Glycerin - add about 25 drops of blue food coloring to 16 ounces (about 1 /2 liter) of glycerin and shake well in a container. (Note: If you've purchased a 16 oz. quantity of glycerin, you can add the color directly to the container of glycerin. If you have a larger amount, measure 16 oz. of glycerin into a mixing container and add the color in the mixing container. Test a drop in a straw to be sure it flows to the bottom. If the glycerin is too thick, add a little water to thin it a bit. It should be the consistency of syrup.)
- Salt water - Add five level tablespoons (about 50 g) of kosher salt to 16 ounces of tap water, add 20-25 drops of green food coloring and shake until all the salt dissolves.
- Water - Add 20-25 drops of yellow food coloring to 16 ounces (about 1 /2 liter) of tap water and shake.
- Alcohol - Add 30-35 drops of red food coloring to 16 ounces (about 1/2 liter) of alcohol in a bottle

3. Cut the straws in half with scissors or a paper cutter. You can cut 10 to 15 straws at a time if you bundle them with a rubber band. (*Note:* Leave the paper wrappers on the straws when cutting them to prevent slipping. Remove the wrappers before distributing the straws to your students.) If you are concerned that the straws may be too small in diameter, try adding several liquids to see if they will flow in the straws.

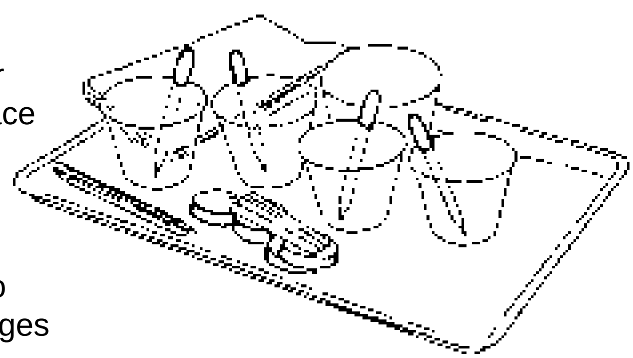
4. Shortly before class, cut the raw potatoes into one-inch thick slices. (You'll need two slices per pair of students, plus two slices for the demonstration, and about five extras.) Cut the potatoes shortly before class so they do not turn brown.



5. Make one copy of the "“Liquid Layers” data sheet (master on page 252) for each pair of students.

6. Prepare one tray per group of four to six students with:

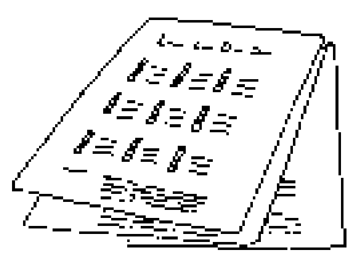
- 4 plastic cups
- 4 medicine droppers
- 2-3 pieces of potato
- 4-6 straw halves
- 2-3 paper towels
- 1 waste container
- 2-3 data sheets
- 2-3 pencils



7. Fill the four cups on each tray about 1 /4 foil (or slightly less), with a different liquid in each cup. Place one medicine dropper in each cup of liquid. Keep extra liquids on hand in case of spills or accidental contamination of a cup of liquid.

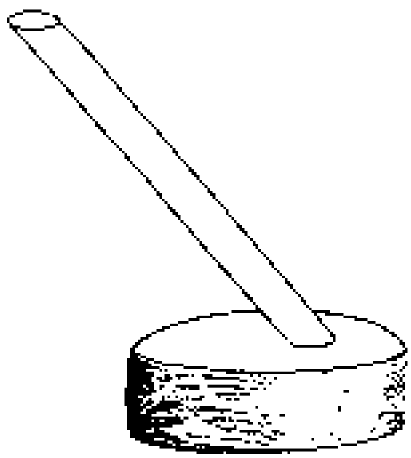
8. Try the demonstration so you will know what to expect. (See “Demonstrating the Procedure” on pages 247-248).

9. Select a central location to demonstrate the layering technique to your class. Set one of the equipment
trays and a data sheet in this demonstration area.



10. Arrange the tables or desks so two or three pairs of students may work together at one station. Since students will be working with liquids, the work surfaces should be made as level as possible.

11. Place the rest of the equipment trays, the extra straws, and extra liquids in a central location.



Referring to eyedroppers as medicine droppers is a safety precaution. Calling them eyedroppers may improperly suggest to students that these liquids may be put into their eyes.

Introducing the Challenge

Do not hand out the trays to the class until you have completed the demonstration.

1. Hold up one set of four colored liquids and ask the students to describe them.

2. Tell the students that today they will each work with a partner to attempt to layer these four unknown colored liquids in the same straw so none of the colored liquids mix.

Demonstrating the Procedure

1. Caution the students not to taste any of these unknown liquids.

2. Insert the straw into a slice of potato at a 45 degree angle. Explain that the reason the straw is placed at this angle is so the liquid can run down the inside of the straw. If the straw is pushed in too far, liquid may leak out of the bottom. If that happens, the straw should be inserted into a different spot on the potato.

3. If some of your students have not had experience using medicine droppers, demonstrate the technique:

   a. Squeeze the bulb to expel the contents; continue squeezing while you insert the tip of the dropper into the liquid.

   b. Release the bulb so the liquid is drawn up into the dropper.

   c. Carefully squeeze the liquid out into the straw, one drop at a time.

Younger students may need to practice using the droppers when they first get their trays. They can practice by taking liquid out of and putting it back in the containers, but they must not mix the liquids.

4. On the board, show how to record predictions on the data sheet. Mention that, before each test, partners should predict the order in which liquids might layer. They should write the first letter of each color on the lines to the right of each straw pictured. (“Y” for yellow, “R” for red, etc.). Start with the first liquid on the bottom, the second liquid above it, and so on. For your demonstration, write the prediction, G, R, Y, B (bottom to top layer).

5. Gently add some green liquid, drop-by-drop, down the inside of the straw, until about one-half inch of liquid accumulates. Then add some red liquid to the straw. Point out that when students do this, they should put in about a finger’s width (1/2 inch) of liquid so all four liquids can fit in the straw.

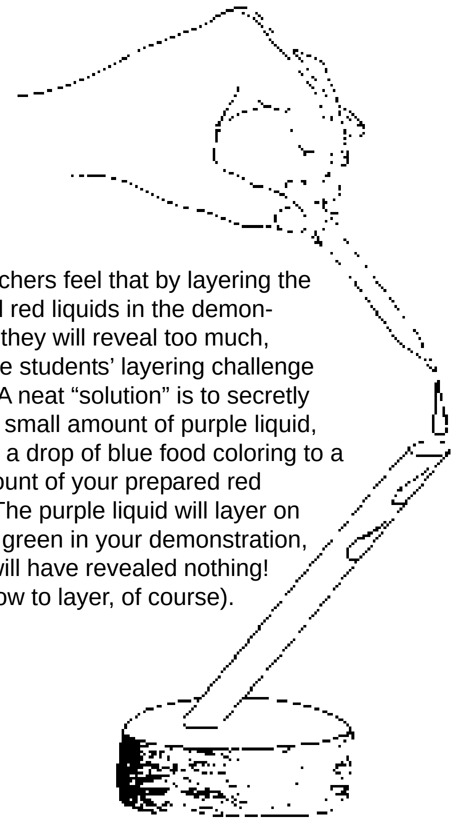
6. Hold a piece of white paper behind the straw so students can see the layering more easily. Tell the students that they can use their data sheets to make a white background.

7. Show how to empty the contents of the straw by removing it from the potato over the waste container, and allowing the liquid to spill into the container. (If a piece of potato plugs up the bottom of the straw, students can gently squeeze out the plug or, if necessary, discard the straw and get a new one.)

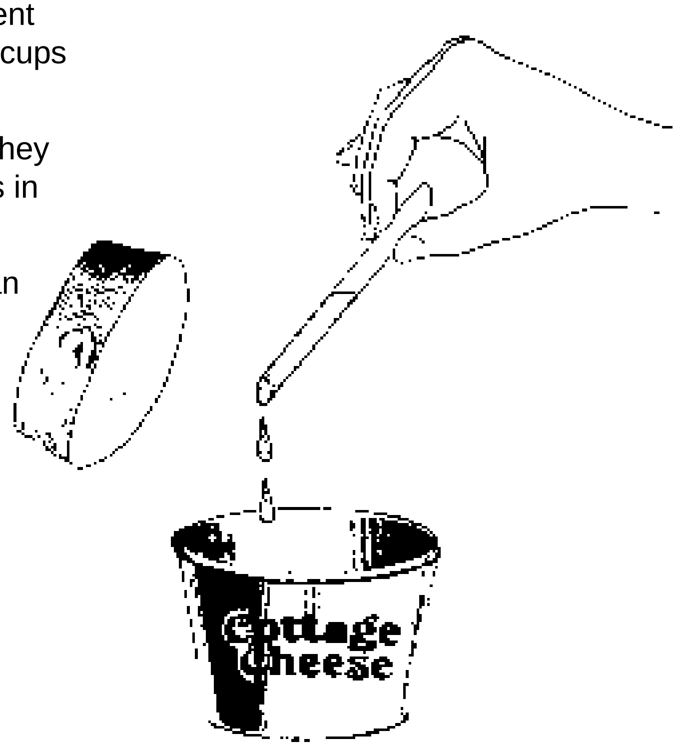
8. Caution students not to mix liquids in the different cups and to keep medicine droppers in the same cups so as not to contaminate the solutions.

9. Before letting your students begin, make sure they understand their challenge: to layer all four liquids in the straw so none mix together.

10. Demonstrate how, after each test, partners can refer to their written predictions and circle the sequences in which the liquids layered successfully.



Some teachers feel that by layering the green and red liquids in the demonstrationn, they will reveal too much, making the students’ layering challenge too easy. A neat “solution” is to secretly prepare a small amount of purple liquid, by adding a drop of blue food coloring to a small amount of your prepared red solution. The purple liquid will layer on top of the green in your demonstration, and you will have revealed nothing! (except how to layer, of course).



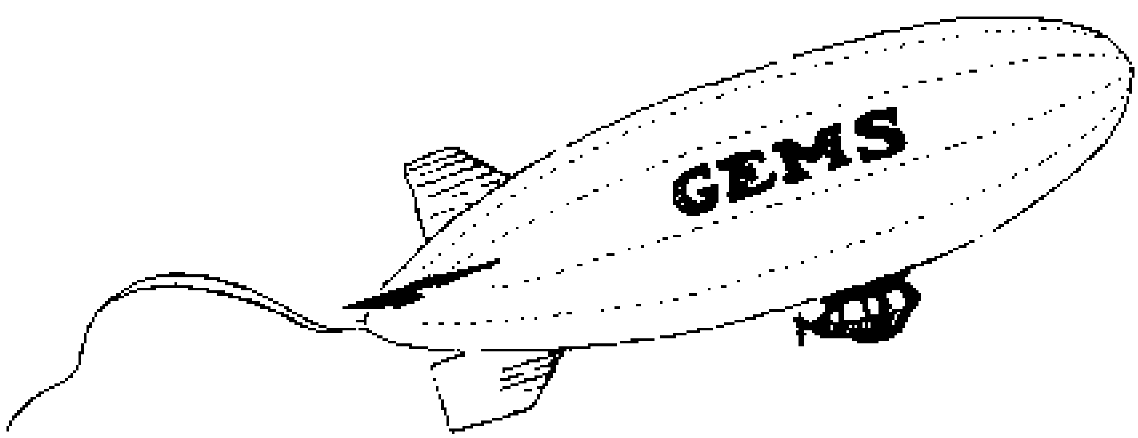
Experimenting

1. Divide the class into teams of four to six students per work area. At each work area students should be divided further into two or three groups.

2. Distribute one equipment tray to each team, and have the students begin. Circulate around the room, lending encouragement or assistance as needed. You
may need to remind the students to record their predictions and circle the results of their layering trials. Students may complain that the blue liquid (glycerin) is too thick to move down the straw. Tell them that it will move down the straw, but slowly.

3. As students finish, have them repeat their experiment, carefully layering the liquids in the expected order to see if they can get very clear separations between the layers.

4. When most of the students have successfully layered the four liquids, have the teams place their materials on the trays, and have one student from each table return the tray to the equipment area.



Discussing the Results

(Note: If it appears that you will not have time to discuss the results, it is best to have the students clean up right after their experiments, store their data sheets in a safe place, and discuss the activity during their next science class.)

1. Draw several large columns on the board like those on the data sheets. Ask the students to report how they ordered the layers, starting with the bottom layer (color 1). Sometimes, one or two groups of students find another order that worked. If so, list those results as well.

2. Ask the students if they can guess what some of the liquids are. Reveal the identity of the liquids to the students. Write the names of the liquids alongside one of the columns on the board.

3. Ask your students why they think the liquids layered the way they did. Some students may mention that some liquids were heavier or thicker. Others might mention differences in density. If they do use this word, ask them to explain what they mean by it. Encourage alternative explanations and discussion. Refrain from defining density yourself at this time. Tell the students that in the next activity they will have an opportunity to discover if their explanations for the layering effect are accurate.

4. If teams have different results, ask the students why they think different teams came up with different ways to layer the liquids.

5. Ask the students to predict what might happen to the layers in the straw if it is turned upside down. Add the liquids to a straw in the order that most students determined would result in layering. Holding your finger over the open end, invert the straw for the class to see what happens. [Some liquids will mix easily and some will stay separate. Even with time the original layers will not settle out again.] Ask your students if they can think of any liquids that separate after they have been mixed together. [Oil and vinegar, or water and oil.]

6. Have your students write their names on their data sheets. Collect these so they will be available for use again in Session 2, and for reference during the discussion in Session 3.

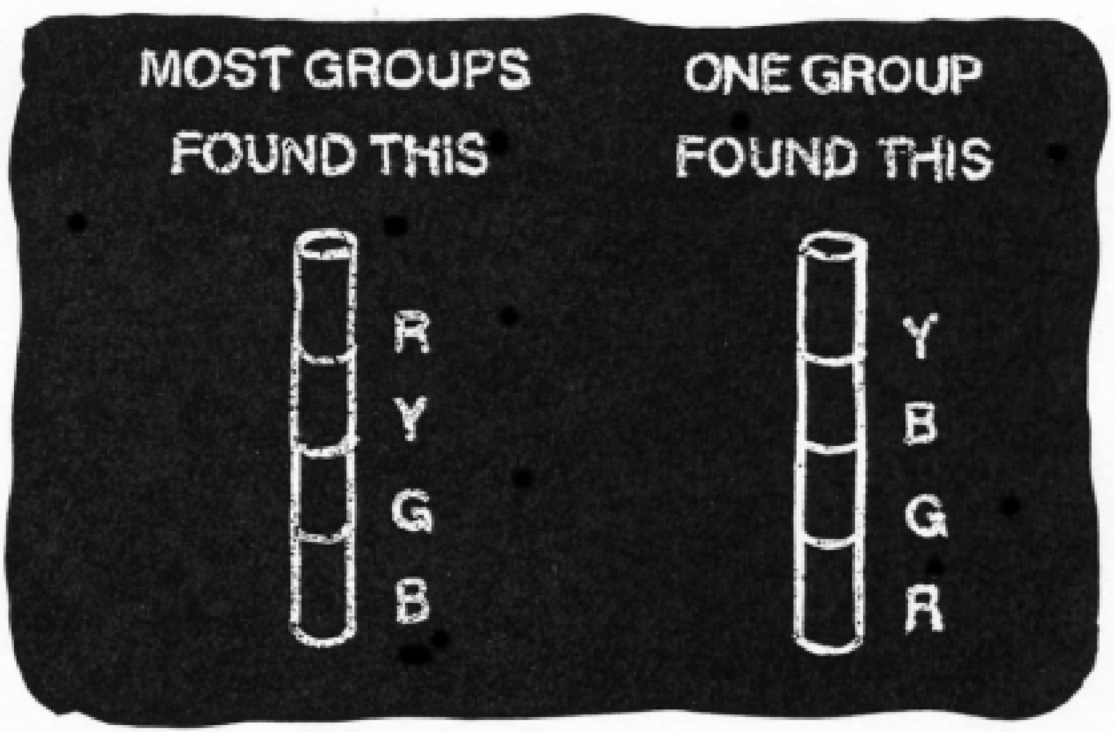
Cleanup

1. Return leftover uncontaminated liquids to their containers.

2. Wash out all of the empty containers with warm soapy water, rinse, and set them out to dry.

3. Remove the rubber bulbs from the medicine droppers, place both parts in a container of warm soapy water to soak, then rinse thoroughly and spread them out to dry.

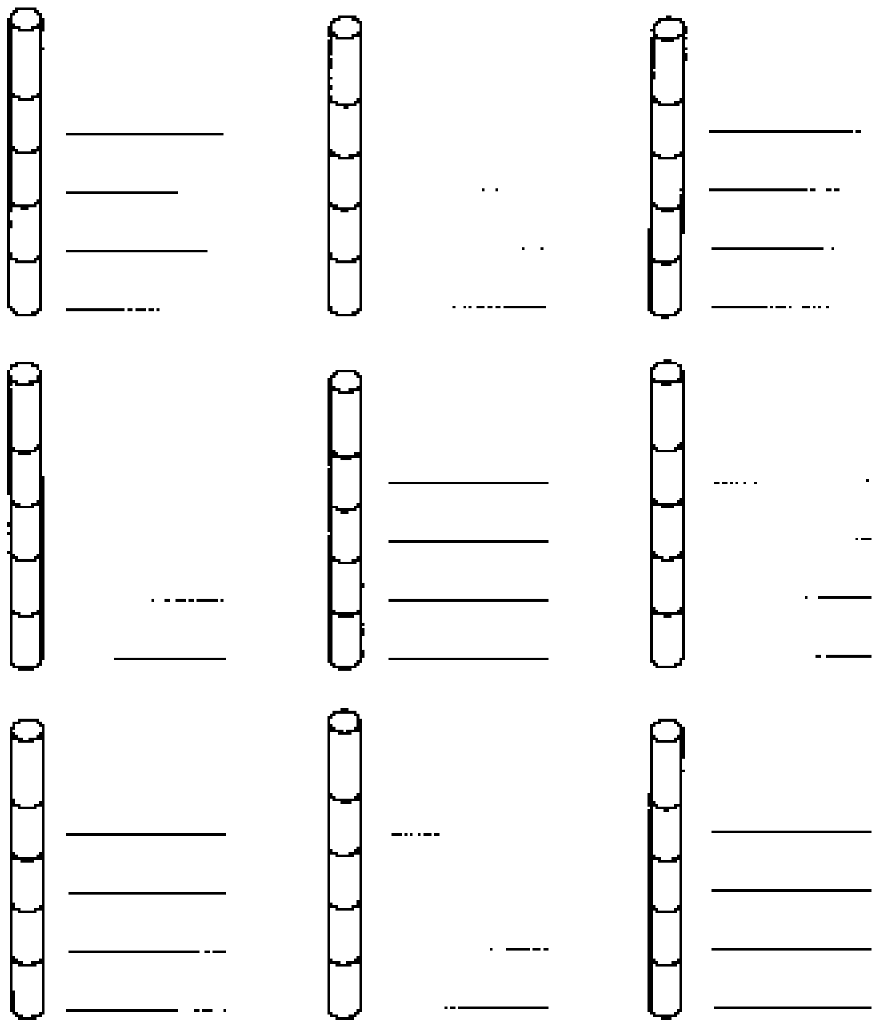
4. Discard the potato slices and throw out the used straws.



Names ________ ________

Liquid Layers Data Sheet

Your challenge is to layer all four liquids in the straw so none of the liquids mix.



KEY

Y = Yellow
R = Red
B = Blue
G = Green

Circle color combinations that layer successfully.

Helpful Hints:

1. Insert the straw in the potato slice at a 45 degree angle.

2. Before adding the liquids, decide with your partner which color you'll add first, second, third and fourth. Write the first letter of each color on the lines near the picture of a straw.

3. Gently add the first colored liquid, drop by drop, until there is about one finger's width of liquid in the straw.

4. Add the next three liquids in the same way, following the order that you wrote down.

5. Circle the colors that layered.

6. Empty the straw over the waste container by removing it from the potato. Decide on your next order of colors, and write it on the next set of lines.

7. Keep trying new combinations until you make four layers that do not mix.

ENVIRONMENTAL EDUCATION: BUILD YOUR OWN AQUIFER

United States Environmental Protection Agency | Office of Water 4601 | EPA 810-F-95-005 October 1995

BACKGROUND: Many communities obtain their drinking water from underground sources called **aquifers**. Water suppliers or utility officials drill wells through soil and rock into aquifers for the groundwater contained therein to supply the public with drinking water. Home owners who cannot obtain their drinking water from a public water supply, will have their own private wells drilled on their property to tap this supply. Unfortunately, the groundwater can become contaminated by harmful chemicals, including improper disposal of household chemicals such as lawn care products and cleaners and any number of other pollutants. These chemicals can percolate down through the soil and rock and into the aquifer - and eventually the well. Such contamination can pose a significant threat to human health. The measures that must be taken by well owners and operators to either protect or clean up contaminated aquifers is quite costly.

NOTE: This demonstration should follow a class discussion on potential sources of pollution to drinking water supplies.

OBJECTIVE: To illustrate how water is stored in an aquifer, how groundwater can become contaminated, and how this contamination ends up in the drinking water well. Ultimately, students should get a clear understanding of what happens above the ground can potentially end up in the drinking water below the ground.

MATERIALS NEEDED:

1 6" x 8" clear plastic container that is at least 6-8" deep (shoe box or small aquarium)
1 lb. of modeling clay or floral clay
2 lbs. of white play sand
2 lbs. of aquarium gravel (natural color if possible) or small pebbles
(As any small rocks may have a powdery residue on them, you may wish to rinse them and dry on a clean towel prior to use. It is best if they do not add cloudiness to water.)
1 drinking water straw
1 plastic spray bottle (be sure the stem that extends into the bottle is clear)
1 small piece (3 x 5) of green felt
1/4 cup of powered cocoa
red food coloring
1 bucket of clean water and small cup to dip water from bucket
scotch tape

PROCEDURE:

1. To one side of the container place the small drinking water straw, allowing approximately 1/8 of an inch clearance with the bottom of the container. Fasten the straw directly against to the long side of the container with a piece of tape. Explain to the students that this will represent two separate well functions later in presentation (if not placed at this time, sand will clog the opening).

2. Pour a layer of white sand completely covering the bottom of the clear plastic container, making it approximately 1" deep. Pour water into the sand, wetting it completely, but there should be no standing water on top of sand. Let students see how the water is absorbed in the sand, but remains around the sand particles as it is stored in the ground and ultimately in the aquifer.

3. Flatten the modeling clay (like a pancake) and cover of the sand with the clay (try to press the clay into the three sides of the container in the area covered). The clay represents a "**confining layer**" that keeps water from passes through it. Pour a small amount of water onto the clay. Let the students see how the water remains on top of the clay, only flowing into the sand below in areas not covered by the clay.

4. Use the aquarium rocks to form the next layer of earth. Place the rocks over the sand and clay, covering the entire container. To one side of your container, slope the rocks, forming a high hill and a valley. Now pour water into your aquifer until the water in the valley is even with your hill. Let students see the water around the rocks that is stored within the aquifer. They will also notice a "**surface**" supply of water (a small lake) has formed. This will give them a view of both the ground and surface water supplies which can be used for drinking water purposes.

5. Next, place the small piece of green felt on top of the hill. If possible, use a little clay to securely fasten it to the sides of the container it reaches.

6. Using the cocoa, sprinkle some on top of the hill, while explaining to students that the cocoa represents improper use of lawn chemicals or fertilizers, etc.

7. Use the food coloring and put a few drops into the straw, explaining to students that often old wells are used to dispose of farm chemicals, trash and used motor oils. They will see that it will color the sand in the bottom of the container. This is one way pollution can spread through out the aquifer over time.

8. Fill the spray bottle with water. Now make it rain on top of the hill and over the cocoa. Quickly students will see the cocoa (fertilizer/pesticide) seep down through the felt and also wash into the surface water supply.

9. Take another look at the well you contaminated. The pollution has probably spread further. Now remove the top of the spray bottle and insert the stem into the straw, depress the trigger to pull up the water from the well. (Water will be colored and "polluted.") Explain that this is the same water a drinking water well will draw up for them to drink.

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COOL GROUNDWATER ACTIVITY: EDIBLE EARTH PARFAITS

Background:
This activity is a fun and easy way to understand the geology of an aquifer. You will build your own edible aquifer, learn about confining layers, contamination, recharge and water tables.

Key Topics: Geology, Groundwater, Wells

Subject Area: Science

Grade Levels: all ages

Duration: 25 – 30 minutes

Materials Needed:

- Blue or red food coloring
- Vanilla ice cream
- Clear soda pop
- Crushed ice
- Variety of colored cake decoration sprinkles and sugars
- Drinking straws
- Clear plastic cups

Objective:
To teach about the geologic formations in an aquifer, how pollution can get into groundwater and how pumping can cause a decline in the water table.

Activity Steps:

1. Review What is groundwater? and Groundwater ABCs
2. Begin to construct your edible aquifer by filling a clear plastic cup 1/3 full with crushed ice (represents gravels and soils)
3. Add enough soda to just cover the ice
4. Add a layer of ice cream to serve as a "confining layer" over the water-filled aquifer
5. Then add more crushed ice on top of the "confining layer."
6. Colored sugars and sprinkles represent soils and should be sprinkled over the top to create the porous top layer
7. Now add the food coloring to the soda. The food coloring represents contamination. Watch what happens when it is poured on the top of the "aquifer." Keep in mind that the same thing happens when contaminants are spilled on the earth's surface.
8. Using your straw, drill a well into the center of your aquifer.
9. Slowly begin to pump the well by sucking on the straw. Watch the decline in the water table.
10. Notice how the contaminants can get sucked into the well area and end up in the groundwater by leaking through the confining layer
11. Now recharge your aquifer by adding more soda which represents a rain shower
12. Review what you have learned as you enjoy eating your edible aquifer

Edible Earth Parfaits was adapted from *Making A Bigger Splash*, co-published by The Groundwater Foundation and the US EPA, Region VII. If you are interested in more activities based on environmental issues, see our online catalog or contact The Groundwater Foundation at **1-800-858-4844**.

WATER DROPS ON A PENNY

Category:
Water, Math

Objective:
To estimate the number of water drops you can fit on a penny, experiment to find out, and gain an understanding of surface tension.

Materials:
- pennies; one per child
- eyedroppers; one per child
- containers for water; enough so all can easily reach them
- paper towels
- other coins (optional)
- pencils
- paper

Introduction:
This activity is engaging, and can be adapted for ages 7 and up. Young children can become familiar with using an eyedropper and counting. Older children can practice estimating, predicting, and recording or graphing results. All can see the wonderful property of water called surface tension.

Procedure:
Begin by asking the group if anyone has done this activity before. If so, ask them to help you out by not answering this question right away. Ask the rest of the group how many drops of water they think can fit on a penny. Have someone record the guesses on a large sheet of paper or a blackboard. After all have guessed, then the ones who have done it before can share their numbers and have them added to the sheet. Note and explain that those students will be estimating, not guessing, as they have some prior experience.

Next, hand out the paper, pencils, paper towels and the pennies and eyedroppers. Set out cups of water for every two or three kids, or centrally located containers that all can reach. Keep the extra paper towels nearby.

Let them play around with the eyedroppers, practicing lifting water and dropping it onto the pennies. They can now test their guesses or estimates and see how close or far off they were.

There will be a large variance in numbers of drops. Ask the kids what some of the variables might be. Hint: size of drops, height of dropper, speed, whether the dropper is touching the pool of water on the penny (or the penny itself). You all may want to reach a consensus about how to cut down the number of variables (such as each holding the eyedropper a certain distance above the coin, or dropping at a certain rate of speed).

Have them look sideways at the water drop on the penny and describe or draw its shape. (It will look like a dome). Science explanation: water molecules have a tendency to stick together at the surface (see glossary). If you have some soap, try touching a soapy finger to the dome of water. What happens?

Now that they have some experience, they can estimate the number of drops they could fit on another coin, such as a dime, nickel or quarter.

Girls in the SYSTEM
Glossary

Girls in the SYSTEM Glossary

Absorption: The act or process of taking in or soaking up something.

Aerodynamics: Atmospheric interaction with moving objects.

Area: The measurement of a planar (flat) region, or the surface of a solid. Found by multiplying length times width.

Bernoulli's Principle: As air travels faster (than surrounding air) across a surface, the air pressure against the surface is reduced. So by curving the upper surface of an airplane wing, you cause the air to have to travel farther than the air beneath the wing to get across it. The result is lower pressure on top of the wing and more underneath, causing "lift". It's as if someone were pushing up from below, and pulling from above, allowing a plane to fly.

Buoyancy: The force that keeps an object from sinking into liquid in spite of its own weight. Buoyancy depends on the difference between the density of the object and the liquid.

Dead load: The fixed weight of a structure or piece of equipment, such as a bridge on its supports. Also called "dead weight".

Density: The quantity per unit length, unit area, or unit volume: as the mass of a substance per unit volume.

Displacement: The weight or volume of a fluid displaced by a floating body, used especially as a measurement of the weight or bulk of a ship.

Drag: The frictional force slowing an object moving through the air.

Energy: The capability of an object to perform work. The energy can have different forms: potential energy, kinetic energy, thermal energy (heat). Units of energy are kilowatt hours, calories, Joules.

Force: A push, pull, or twist that makes an object move or change direction. For example, throwing a ball is exerting force on the ball, which makes it move. (Units are Newtons in metric system and pounds-force in English system).

Friction: A force that results from two surfaces rubbing against each other. It always slows movement and brings motion to a stop if no other force is applied to overcome it.

Gravity: The pulling force of the Earth that makes things fall, and gives things weight.

Heat: The amount of energy transferred from a warmer to a cooler body.

Lift: see Bernoulli's Principle, above.

Live load: A moving, variable weight added to the dead load of a structure or vehicle. For example, the live load of a bridge is the weight of the objects crossing the bridge at a given moment.

Mass: Amount of matter in an object. (Units of kilograms and pounds). Mass is independent of gravity.

Polymer: Sometimes called a plastic, a polymer is a compound made of many strings of simple, linked molecules. When you mix certain household items together, such as Borax, glue, and water, you get a polymer. This is a substance with very different properties than the original items on their own.

Power: The rate at which energy is used to perform work or the rate at which energy is changed from one form to another. It is measured by the amount of energy per unit time (e.g. Watts, Joules/sec, horsepower).

Proportion: A relation of equality between two ratios or a relationship between things or parts of things in regard to comparative size.

Ratio: The relative size of two quantities expressed as the quotient of one divided by the other. The ratio of 1 to 3 is written 1:3 or 1/3.

Reflection: If an object does not emit its own light, then it must reflect light in order to be seen. Light particles or waves bounce off objects so the objects are visible. When light strikes a mirror, it bounces off. When you look at an object in a mirror, you are seeing the reflection of light from the object.

Refraction: Light can be bent when it passes through water or another substance and back through the air. The bending of the light is refraction. This makes an object under water appear magnified and slightly distorted.

Surface tension: The force that makes a liquid surface minimize its surface area. (This property arises from unbalanced molecular cohesive forces at or near the surface.) For example: fill a glass to the brim and it doesn't spill, but curves above the rim.

Three-dimensional or 3-D: Existing or appearing to exist in the three dimensions of length, width, and depth.

Thrust: The forward-directed force developed in a jet or rocket engine as a reaction to the rearward ejection of fuel gases at high velocities.

Two-dimensional: Flat, or having only two dimensions, especially length and width.

Volume: The size or capacity of a 3-D object or container.

Weight: Mass times gravity. Your weight is different on the moon than on Earth because the moon has less gravitational pull. Your mass stays the same.

Science Sites on the Internet

Science Sites on the Internet

I use www.google.com to search for sites.
Just type in a key word or two and countless sites pop up.

General Science Activities
www.pbskids.org/zoom/too <http://www.pbskids.org>

www.exploratorium.edu/snacks <http://www.exploratorium.edu>

www.madsci.org

www.swe.org/SWE/StudentServices/CareerGuidance/GirlScoutModules

www2.csource.net/bridgeview. Then click on "links" and go to curriculum links and/or teacher resource links.

www.fi.edu/qa97/spotlight3/spotlight3.html. The Franklin Institute (famous museum in Philadelphia) has this website with great definitions of **simple machines** and links to related web sites. Worth the trip!

www.learningkids.com/experiments.html. This is another good site consisting of links to many experiments including **levers, pulleys**, **Beakman's electric motor** and more. We did the motors - they are cool!

Balloon Rocket
<http://www.planetary.org/learn/activities/BalloonRocket.html>

Glurch, **ice cubes & salt** and more.
http://student.biology.arizona.edu/sciconn

Paper-making, recycled
http://www.beakman.com/paper/paper.html

Paper Helicopters and airplanes; here are just a few sites that came up.
http://www.paperairplanes.co.uk
http://www.paperairplanes.co.uk/heliplan.html
http://www.exploratorium.edu/science_explorer/roto-copter.html
http://www.faa.gov/education/resource/helicopt.htm

Slime
www.plastics.com/slime.php

Solar food dehydrator and Solar oven - more elaborate than what we made but cheap and easy! Try them!
www.i4at.org/surv/ Once you get there, just click on **solar food dehydrator** or **solar oven**, (or type in soldehyd.htm and solarbox.htm).

Solar panels (cells) and small electric motors - to buy
www.siliconsolar.com

Solar stone or Viking bearing dial
When I looked, the directions weren't yet posted, but this is a great site! Every science activity features paper plates!
http://analyzer.depaul.edu/paperplate

Solar stone or Viking bearing dial; for a good drawing, see:
www.sjolander.com/viking/museum/Compass/rebobsun.htm

Sundial
This one is pre-marked, but if you don't have time to make one...it will do nicely
http://kids.msfc.nasa.gov/Earth/Sundials/SundialMake.asp

Sundial
www.eyeonthesky.org/lessonplans/14sun_sundials.html

Super absorbers (Here, you take the baby, ick!)
www.projectlabs.com/htmldocs/superdiaper.html

Careers in Science, Technology, Engineering, and Mathematics

Careers in Science, Technology, Engineering, and Mathematics

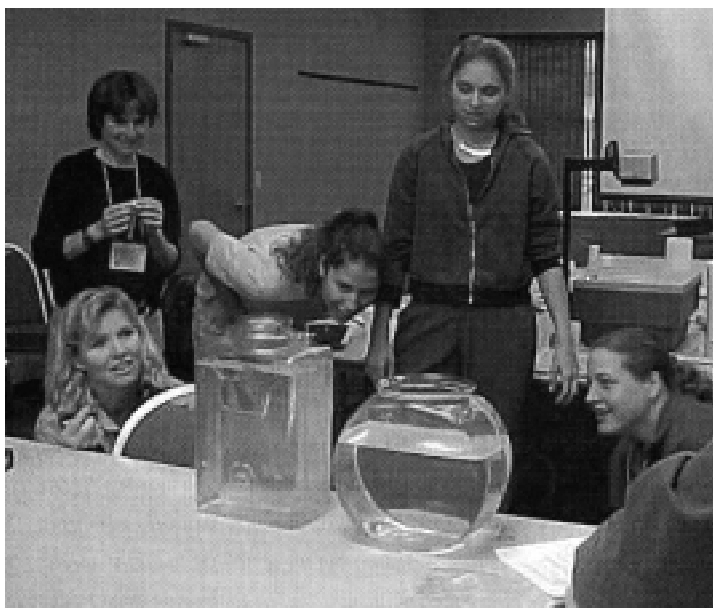
You may be wondering how to encourage girls to enter these fields if you don't know what kind of jobs are out there for them. Here are three sites to get you started. Again, I used www.google.com and typed in science, technology, engineering, math careers. Many great sites popped up.

1) This one is the Bureau of Labor Statistics site. It has a section called "Jobs for kids who like..." and then lists different subject areas from school.
Http://stats.bls.gov/k12/html/edu_over.htm

2) All kinds of careers, including math, engineering and science jobs are described at this site.
www.khake.com

3) Math careers can be found at: www.ams.org/careers/home.html

STEM Academy



STEM Academy

The STEM Academies were workshops providing opportunities for adult participants to work with innovative educational resources to increase their knowledge of science, technology, engineering and math, while providing instructional ideas for their work with youth, placing special emphasis on issues of gender equity.

People who were invited to attend STEM Academies were experienced teachers, preservice teachers, Girl Scout troop leaders, and parents. The academies consisted of nine to twelve hours of training, sometimes offered once a month for several months, or sometimes as a day and a half workshop, or two six-hour workshops offered in fall and spring. We tried to be accommodating!

During the workshops, we wanted not only to provide activities that were engaging and scientific in content, but to model the informal methods of teaching that we hoped to engender. To this end, our teaching staff consisted of women faculty from five departments at The University of Arizona and experienced K-8 teachers.

As we led the participants through the activities, we modeled the inquiry techniques and (teacher) hands-off approach that we wanted them to pick up. In other words, we would give the instructions on how to do the activity and then just step back and let them experiment and see what they came up with. At the activity's conclusion, we would ask how it went, what variables did they change, what worked and what didn't. They would present their findings to the group, often as a team. Then we would hand out the Criteria and Indicators and ask them how the activities and our teaching measured up to those standards.

If you want to provide training similar to this, make sure your staff includes scientists, gender equity trainers, and people who are familiar with innovative methods of "child hands-on, teacher hands-off", inquiry-based learning.

Three Years of STEM Academy Content

STEM Academy I Fall 1999 Three sessions of three hours each. Topics: math, engineering, biology, gender and communication differences. Sample activities: Crack the Code, Marine Discovery, tin can telephones.

STEM Academy II Spring 2000 Three sessions of three hours each. Topics: math, engineering, biology, gender. Sample activities: Communicating with a robot (giving compass directions), taking apart telephones, classification (birthday line-up).

STEM Academy III Fall 2000 Four sessions of three hours each. Topics: engineering and teaching, environment, biology, gender equity. Sample activities: Rockets (rocket racers, 3-2-1 Pop, altitude trackers), pinhole cameras, transformation of water and land formations, making ice cream, effect of temperature on balloons in liquid nitrogen, plankton races.

STEM Academy IV Spring 2001 Two sessions, one of six hours, one of three hours. Topics: structures, water, teaching, gender equity. Sample activities: building a suspension bridge, plankton races.

STEM Academy V Fall 2001 and Spring 2002 Two sessions of six hours each. Topics: structures, rockets, water, gender equity. Sample activities: building a suspension bridge, rocket racers, 3-2-1 Pop, helicopters, clay boats, floating a paper clip, plankton races.

We found, in reflection, that the first two STEM Academies were activity-intensive. They lacked content knowledge. We would present a fun activity, but we wouldn't explain the science behind it or how to address the science content for children. After that we became more aware that we needed to add a component addressing science or math content in the activities. Even though we had verbally addressed the issue prior to the first STEM Academy, i.e. we had discussed that there were basic concepts we wanted to keep clear throughout all STEM Academies; we perhaps didn't incorporate them as well or as much as we had wanted. We then came up with a glossary of definitions of general concepts to hand out. It included such definitions as energy, mass, weight, force, and drag. Going over these during the workshops and discussing how they applied to the actual activities added what we were lacking. STEM Academies III, IV, and V had specific science content integrated with activities, discussions of gender equity, and activities to emphasize pedagogical approaches appropriate for informal settings.