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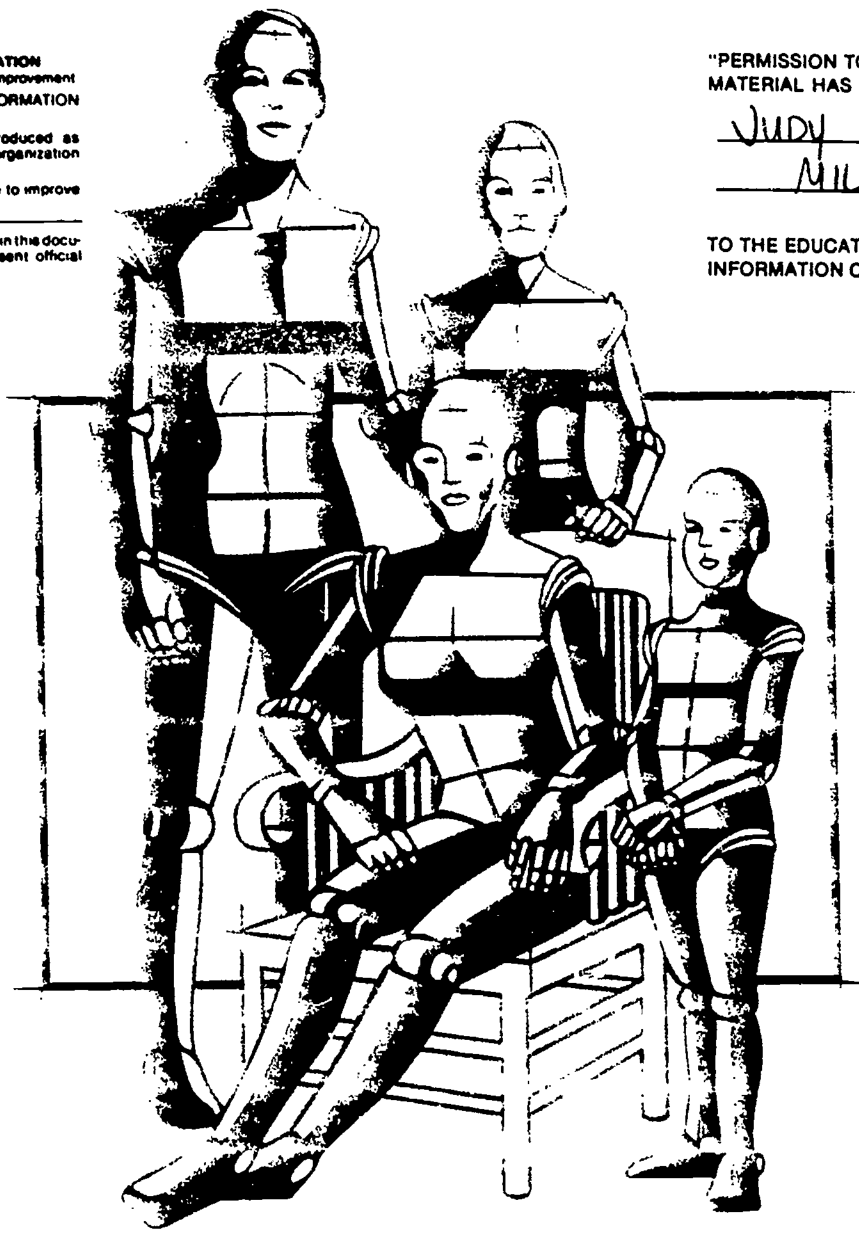
ABSTRACT

Preparing students to be successful in a rapidly changing world means showing them how to use the tools of technology and how to integrate those tools into all areas of learning. This booklet is divided into three sections: Design Activities, Experiments, and Resources. The design activities ask students to collaborate on design projects. In these cooperative learning activities, students brainstorm and discuss ideas before they design and construct. The activity titles and grade levels are: Billy Goat Launchers (K-6), What the World Needs Now--Contraptions (6-12), The M & M Cookie Company (K-6), The Toy Factory (6-12), This Way In: Designing an Entrance (6-12), UPS: The Ultimate Private Space (5-12), Ergonomics: Designing Products for People to Use (6-12), Reach Out With Robotic Arms (6-12), What's Inside: Container Design (6-12), Wind-and-Water Transportation (6-12), Getting From Here to There by Monorail (7-12), and The Auto Company (7-12). The Experiments section contains cooperative learning activities that call for research and discussion in preparation for the construction phases. The titles and grade levels are: Old MacDonald Had a Laser (K-6), Space Station: Recycled Waste (3-6), Space Station: Solar Collectors (1-6), Earth Station: Solar Collectors (7-12), Air Cushioned Vehicle: Hovercraft (9-12), Magnetic Levitation Transport (MAGLEV) (6-12), and Commercials (3-12). The final section is a resource list for equipment and information. (MKR)

ED 381 388

RoboResource

Technology Learning Activities



Compiled and Developed by Tom Keck

Written and Edited by Ellen Frye

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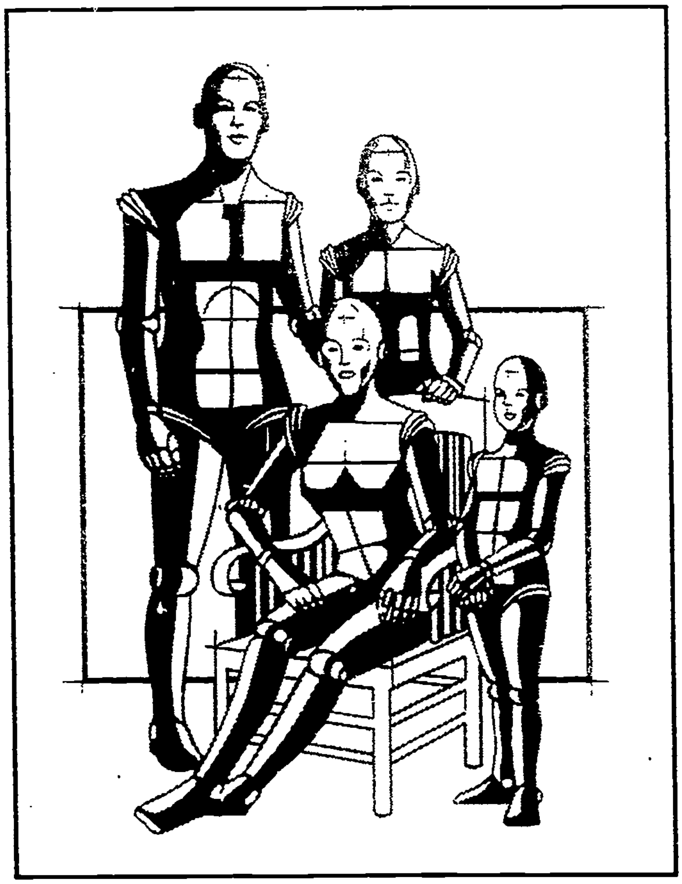

Compiled and Developed by Tom Keck

1992–93 Christa McAuliffe Fellow

Written and Edited by Ellen Frye

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The activities included in this book have been part of the technology education curriculum at U-32 Junior-Senior High School in East Montpelier, Vermont. Many of the activities have migrated to U-32 from other technology education sources. Every effort has been made to acknowledge these sources; we regret any oversights that may have occurred and will be happy to rectify them in future printings.

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Technology and Society

We live in an age of technology. We can fly across a continent in a matter of hours. We can send information to someone on the other side of the world, knowing that he or she will be reading it as we send it. The microelectronics industry, which did not exist 30 years ago, today provides us with digital computers, satellite communications, robotics, lasers, programmable ovens and space shuttles.

In this increasingly technical world, technological literacy is imperative. Students today live in a world that demands a technologically competent populace. From office workers to auto mechanics, technology influences how the job is done. Issues discussed in the media—genetic engineering, acid rain, organ transplants, military weaponry—require more than a superficial understanding of technology.

Technology is a human endeavor. Whether used to benefit or harm society, the development and application of technology is a human decision. Only a technologically educated population can assess and influence the impact of technology on society and the environment.

What is Technology Education?

Technology education is a hands-on, minds-in study of past, present and future technological systems. Through technology learning activities, students develop skills in problem-solving, creative and critical thinking, and decision-making. They research, design, engineer, and test devices and systems to solve practical problems. As they carry out their projects, they learn how to work cooperatively and how to be project managers and leaders.

With its hands-on emphasis, technology education lets students discover their own technical interests and capabilities. They work with a variety of machines, tools, work surfaces and materials; they learn how to investigate ideas and experiment with designs. As they proceed from the idea to the execution, they learn that creativity and innovation are often the keys to problem solving.

Technology education focuses on broad concepts and principles. In every field, technology changes so rapidly that no educational program can meet specific future needs. What students do need is a fundamental understanding of how technology works plus a set of skills they can adapt to changing world.

Technology education also establishes connections between theoretical concepts and their practical applications, thus providing a platform for genuine interdisciplinary study. All areas of learning—music, art, mathematics, the natural and physical sciences, social studies—have technological components.

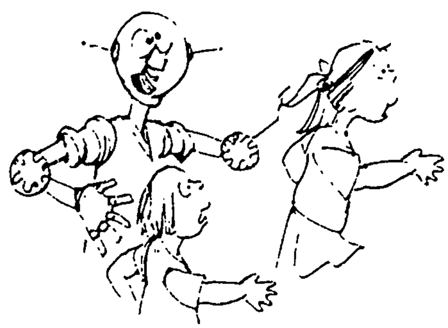
Goals of Technology Education

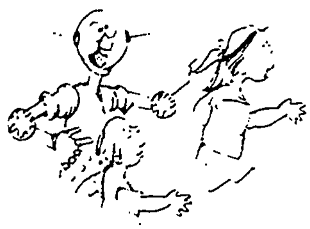
Preparing students to be successful in a rapidly changing world means showing them how to use the tools of technology and how to integrate those tools into all areas of learning. The goals are to give students the ability to interact successfully with technology, to assess the impact of technology on everyday life, and to apply conceptual knowledge to solve problems. A good technology curriculum begins with placing technology learning within the social context of school and community.

Through learning activities, students

- explore areas of technology to discover their own technical abilities and interests
- develop skill in the use of technological tools and systems
- gather, organize and evaluate ideas from different sources
- find and solve problems, think and reason logically
- recognize that technology can have consequences that are desired or undesired, expected or unexpected, so that they can exercise some control over the use of technology
- synthesize concepts of mathematics, the sciences, socials studies and the arts through technological activities
- acquire broad-based, transferable skills and knowledge which will be useful in future employment, further education and life's experiences

Technology education is for all students. The diverse nature of technological learning activities permits active roles for students with a variety of interests and abilities. Students who are less successful in traditional academic activities often reveal special problem-solving abilities in technical activities. The higher-level thinking skills—analyzing, synthesizing, evaluating—that students develop as they manipulate technological tools give them a solid platform on which to build their life's work.





Design Activities

The following activities ask students to collaborate on design projects. In these cooperative learning activities, students brainstorm and discuss ideas before they design and construct.

Group work lets students learn how to be effective leaders and productive team members. The best group work occurs when three or four students work together. In larger groups, productivity drops off drastically.

It is important for teachers to let the groups develop their own structure and decide for themselves how to tackle a problem. The key to learning lies in discovering a process that works.

Billy-Goat Launchers for the Billy Goats Gruff

This project asks students to design and construct a transportation system that will transport three billy goats across a river.

Grade Level: K-6

The Problem

The three Billy Goats Gruff want to get to the meadow across the river for a dinner of fresh green grass. There's a bridge over the river, but it belongs to a dangerous troll who lives under the bridge. He won't let anybody use his bridge. Can you design an alternative way for the Billy Goats Gruff to cross the river safely?

Brainstorm

With your team of three or four, discuss different ways the Billy Goats Gruff might get across the river. Would a raft work? How about a mobile goat launcher? A tunnel under the river? Balloons? A troll trap? Make sketches of your ideas and write down how they might work.

Develop the Best Idea

Think of all the good and bad points for each of your ideas. On the chart below, list your ideas and the criteria for evaluating your ideas. When you have finished the chart, choose the idea you think has the most good points and the least bad points.

Criteria	Mobile Goat Launcher	Raft/Boat	Tunnel	Balloons	Your Idea
Feasibility: Can we build this?					
Cost: Can we build it for a reasonable cost?					
Practicality: Will this idea really work?					
Reliability: Can we trust this idea to work every time?					

Design the System

Draw a more detailed picture of your chosen idea and explain how it works. You can create your design as a team with one person drawing and the others adding ideas. Or you can each make a drawing and then choose the best ideas to integrate into a final drawing. The design should include answers to the following questions:

What materials will be used?
How will the materials be connected to each other?
How will the Billy Goats Gruff get on the system?
How will the system operate once the Goats are loaded?

Label all the parts of the design and explain how the parts work. Use color to show the different parts.

Gather the Materials

Make a list of all the materials you'll need to build your transportation system. Here are some possibilities:

cardboard	paper towel rolls	wood scraps
string	fabric scraps	packing foam
tape	balloons	mouse traps
plastic soda jugs	plastic wading pool	hot air balloon
	rubber bands	

Build and Test the System

You'll need to decide who is going to do what. Can some parts of the system be built separately? How can you test your construction as you go along?

When you test your working model and it doesn't work the way you want it to, go back to your design drawing and make the necessary changes. You may have to make several tests and redesigns.

Evaluation

As a group, you will want to evaluate both the design and the model. Was the design drawing easy to follow? Is the final drawing still readable? Is your construction well crafted? Did the model work?

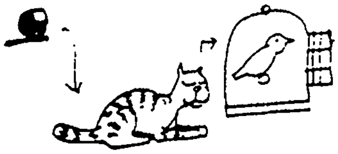
You'll also want to evaluate how well you worked together as a team. Did everybody contribute to the project? Did anybody try to do all the fun stuff?

Ask other teams to evaluate your design and construction model in terms of uniqueness of design and quality of construction.

Related Activities for an Integrated Curriculum

Place your system in its environment using a small wading pool for the river. Make troll and goat puppets and act out your version of "The Three Billy Goats Gruff."

Billy Goat Launchers adapted from *The Technology Teacher* (September/October 1991).



What the World Needs Now—Contraptions

This project directs students to create a *contraption*—a mechanical device in which one action sets off and turns into another action.

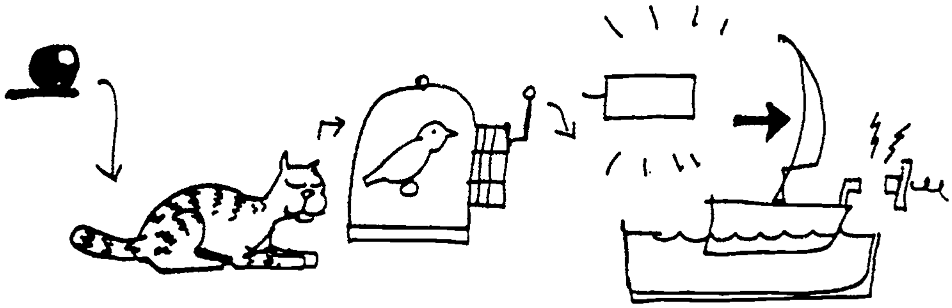
Grade Level: 6–12

The Problem

You are being asked to design a mechanical contraption that shows action *and* betters humanity. Each action should cause something else to happen. That is, the movement of one part should set off the movement of another part. The second part in turn will set off the movement of a third part and so on until each of the parts has been moved and has moved another part in turn. The last movement should have an end result.

Research

Before you start brainstorming, you'll want to look at some examples of contraptions other inventors have built. Rube Goldberg (1883–1979) was a cartoonist who created extremely intricate diagrams for machines that produced relatively simple results. Here is a Rube Goldberg type of contraption.



Ask your librarian to help you find pictures of real Rube Goldberg inventions.

You may also want to research the mechanical principles of simple machines. Think of an axe as a wedge, a see-saw as a lever and a clothes line pulley as a wheel. Then think of how a wedge, hand crank (lever) and wheel are used in a kitchen can opener. In your library or science room, look up information on levers, wheels, ramps, pulleys, hand cranks, screwing devices, gears and cams.

Brainstorm

Be wild and creative with your teammates. Sketch out as many different contraptions as you have ideas for. Use words and arrows to explain what is happening in each of your sketches.

Consider these ideas for your contraption:

- What happens in the end? Is it something useful, funny, silly, or absurd?
- What materials could you use from the kitchen? from a toybox? from a toolkit?
- What kinds of actions and movements can you create? Will parts of your contraption drop, roll, hit, push, pull, wind, bump, slide, stop, fall, fly, glide, rotate, spiral, jump, bounce or flip?
- Can you build a ramp? Could you create a series of rods and levers to push up or down other rods and levers? Can you build a hand crank? a waterwheel? a windmill? How could you make a lopsided ramp or a wheel that spins at an angle?

Develop the Best Idea

Look at all your sketches and decide which one you like and can actually build. Be realistic. Work together to create a detailed drawing of your contraption idea. Draw each action that is happening and show how it sets off the next action or how it turns into the next movement.

Keep in mind the end result of your contraption. Will it be functional or funny or both?

Your design should include answers to the following questions:
How will the parts be built?
What materials will be used to build each part?
How will each part be connected to the next part?

Gather the Materials

Here is a list of possible materials:

sheet cardboard
construction paper
wood scraps
dowels and broomsticks
acrylic plastic
sheet metal
aluminum foil
plastic bag material
cardboard boxes
PVC pipe and tubing
flexible electrical wire tubing
food and product packages
silverware and kitchen utensils
plastic and paper cups
pots and pans
plastic containers
mousetraps
pulleys, hinges, levers
motors, electric fans
weighing scales
books
marbles
plastic building blocks
garden hose pieces
push pins
staples, nails, tacks
masking and duct tape
white glue, hot glue
wire, string, rope
rubber bands
clocks and clock motors
toys, dollhouse furniture
toy train tracks
ramps and slides
radios, televisions

Design the Contraption

Label all the parts of the design and explain how the parts work. Use color to show the different parts. When you have a finished drawing, recheck your design. As you look at each part, ask yourself

Will this part be easy or difficult to build?

Is there an easier way to make this action or movement?

Change and redraw your design as needed.

Build and Test Your Contraption

You'll need to decide who is going to do what. Can some parts of the contraption be built separately? Will you need a pattern to transfer part of the design from paper to your chosen material? How can you test each part of your contraption as you go along?

Start with the important actions. Be careful not to get "contraption fever" and add too many details and actions. If you do want to add an action, go back to your drawing design and make sure it will fit into the whole design. Use craft to build everything, even the simplest parts.

When you have a working part, test it. If it doesn't work the way you want it to, go back to your design drawing and make the necessary changes. Keep a cool head while you are testing. If you begin to feel frustrated, take a deep breath and pause for a minute. Call in a teammate to help you troubleshoot the problem. Brainstorm. Then choose the best solution and start again.

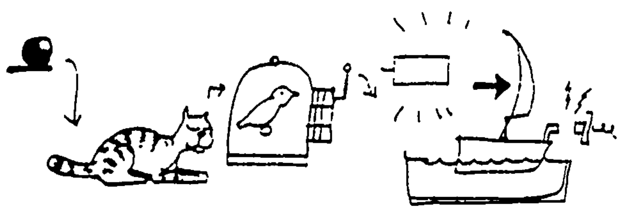
When you have finished your contraption and are sure that the whole thing works, make a title card that lists the name of the contraption, its designers and builders, how to start and reset the contraption and an explanation of what the contraption does in the end.

Evaluation

As a group, evaluate both the design and the construction. Was the design drawing easy to follow? Is the design still readable? Is the contraption well built? Does it work?

Evaluate how well you worked together as a team. Did everybody contribute to the project? Did anybody try to do all the fun stuff?

Ask other teams to evaluate your design and your contraption in terms of uniqueness of design and quality of construction.



Related Activities for an Integrated Curriculum

Write a technical report on how you designed and built your contraption. Compare your completed contraption with the sketches you drew when you brainstormed and the final design drawing. Explain how your contraption changed and why.

Make a formal presentation of your contraption to classmates, friends, family or a local business. Ask a local business to display your contraption.

Do a research project at the local library on the life and work of contraption cartoonist Rube Goldberg.

Plan an Invention Show.

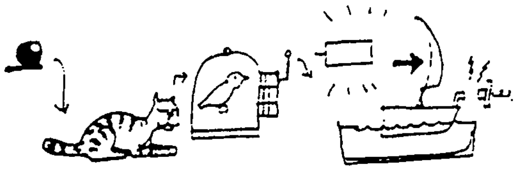
Study patent laws and write a patent for your invention.

Resources

Television: Smithsonian Discovery Channel, Invention Tapes 1–3 (very good with a variety of short topics)

Book: *What the World Needs Now* by Steven Johnson

Movies: "Goonies," (about kid inventions); "Gizmo," a newsreel of invention



The Contraption Planning Sheet

Name of Contraption ______________________

Team Members

____

____

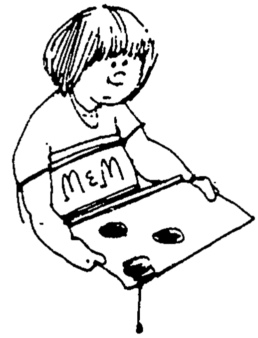
____

____

____

Name of Part	Sketch of Part	Materials Needed	Team Member Responsible

The M&M Cookie Company



This project directs students to form their own cookie company. Each of two student companies will organize, manufacture, test, market and consume their own cookies.

The Problem

You have a great idea to produce a new product—M & M cookies. But Kübler and Nabisco are not interested. Remember how Ben and Jerry started their own ice cream company? Could you form your own cookie company?

The First Step: Organize

Before you can think about making cookies, you have to organize your company. What are some of the jobs in a cookie company? Will you need a Chief Executive Officer (CEO) or Company President. Make a list of some of the other jobs needed and discuss what qualifications someone would have to have for each position. Here are some possibilities:

- M & M Sorters and Counters
- Cookie Designers
- Measurers
- Packers
- Quality Controllers
- Logo Designers
- Taste Testers
- Labor Union Representative
- Production Manager
- Bookkeeper

Brainstorm

You need to design the cookie. What will it look like? Where will the M&Ms go? Make some sketches of cookie designs and discuss the different designs. Which will be the most marketable? Your final design will probably be a composite of several designs.

Grade Level: K–12.
A system of competing teams may be desirable.

Discuss your marketing ideas. How will you tell people about your new cookie? What will your company logo look like?

Gather the Materials

- cookie dough or vanilla wafers
- M & Ms
- tubes of frosting
- aluminun foil
- rolls of butcher block paper
- rulers for measuring
- stop watch for timing
- plastic or rubber gloves
- felt tip pens
- cardboard
- SaranWrap

Organize the Tasks

Workers responsible for making the cookies will have to set up an assembly area. What will you wear when you are making the cookies to make sure you don't touch the cookies with your hands? How will you keep the assembly area clean?

Workers responsible for marketing the cookies will have to design the company logo and map out the advertising campaign.

Use the Task List on the M & M Cookie Company Planning Sheet (page 17) to list all the workers in the company and their tasks.

Evaluation

As a group, you will want to evaluate each task completed. Was the task well planned? Was it finished in time to dovetail with other tasks? Was the product attractive? Did it taste good?

Select as a group your evaluation standard; for example, a scale of 1 to 5. Then mark each task in the evaluation column on your Task List.

Ask other teams or other classes to evaluate your cookies both in terms of design and quality.

Related Activities for an Integrated Curriculum

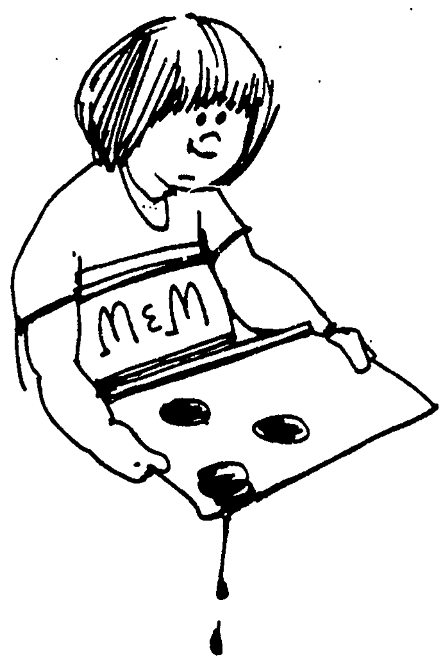
Create a Jobs Fair or Employment Clearing House. List each company job with its job requirements. Make up student résumés. Assign someone to be a Personnel Manager and match the résumés with the jobs.

Use math tools to perform cost analyses of the cookie production for school sales. Draw a graph showing daily cookie production and sales.

Organize a union to negotiate with management for better wages and working conditions.

Use art materials to design a logo for your cookie company and a good-looking package for the cookies.

Design a marketing survey to determine what kind of cookies might sell best and what price might bring the most sales. Perform market research to find out competitive cookie prices.



The M & M Cookie Company Planning Sheet

Task List

Tasks to do	Designated	Performed	Evaluation
logo design			
cookie design			
advertising plans			
assembly line setup			
cookie making			
taste testing			
packing			

This project directs students to design, build and test a toy for two- to five-year-old children.

Grade Level: 6–12

The Toy Factory

The Problem

You have been asked to design and construct a toy for preschool children. You want to build something that will be safe and long-lasting, something that will be fun to play with and yet will be educational. You want to build something that will stand the ultimate test: a preschool child's playtime.

Brainstorm

In your small group, discuss what kind of a toy you want to build. How big is a two-year-old? a five-year-old? What might be attractive to a preschooler? Will your toy be a large-muscle toy? a small toy? Will it have movable parts? What materials can you use that are non-toxic? What other safety features are necessary for a toy for preschool children? Draw sketches of all the different toys you might make.

Develop the Best Idea

Think of all the good and bad points for each of your ideas. Make a chart like the one below and list your ideas and the criteria for evaluating your ideas. When you have finished the chart, choose the idea you think has the most good points and the least bad points.

Criteria	Idea 1	Idea 2	Idea 3
Feasibilty: Can we build this toy?			
Cost: Can we build it for a reasonable cost?			
Practicality: Will this toy be attractive to preschoolers?			
Safety: Is this toy safe for preschoolers to use?			

Gather the Materials

Here are some possible materials:

wood	magnets	computers
metal	yarn	toy wheels
plastics	string	bells, rattles
cloth	velcro	dowels
paper	cardboard	food trays
foam packing	aluminum plates	aluminum stick-on paper

Design and Build the Toy

Make sketches of your different ideas. When you have chosen the best idea, collaborate on a detailed design drawing of the toy. As you design, make sure you've answered these questions.

What materials will be used?
How will the materials be connected to each other?
How will the child use the toy?
Are all parts of the toy safe for a child?

Label all the parts of the design and explain how the parts work. Use color to show the different parts.

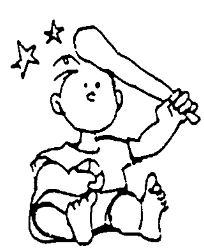
As you build your toy, make sure all its different parts work the way you designed them. If a part doesn't work, analyze the problem and then redesign that part of the toy. Keep in mind the age of the child for whom you are designing the toy.

Field Test Your Toy

With all the other teams working on this project, make arrangements to visit a kindergarten class or preschool in your area. Before you visit, discuss your objectives with the children's teachers. You'll want to be sure that a large open space is available and that the children will not be worn out or excited from a previous activity.

When you visit the kindergarten or preschool, be sure you take both your toys and your evaluation logs. Put all the toys in the middle of the children's room. Place the large-muscle toys away from the smaller toys. Leave plenty of space between each toy. Tell the children that they must walk around the room twice without saying anything and not touch a toy until one of you gives the signal. You might ask the teachers what signals they used to begin activities.

Just watch quietly while the children are playing. As evaluators, you do not want to influence the children's own curiosity. Let the children play for twenty to thirty minutes. Then ask each of them the questions on your Evaluation Log.



Evaluation

You'll want to evaluate yourselves as well as your toys. Was your design drawing easy to follow? Is the final drawing still readable and attractive? Is your toy well crafted?

You'll also want to evaluate how well you worked together as a team. Did everybody contribute to the project? Did anybody try to do all the fun stuff?

Ask the preschool teachers to evaluate your design and construction model in terms of appropriateness of design and quality of construction.

Related Activities for an Integrated Curriculum

Mass produce one of the most popular toys and offer it for sale.

Display your toys in your district office or a local business.

Ask some parents to evaluate your toy.

Visit a toy store.

The Toy Company Evaluation Log

You want to evaluate your toy in terms of its attractiveness to children, its durability and its educational value. As the children are playing with all the toys, focus on your own toy and collect the following data.

1. Is the toy attractive to its target population?

	Number	Percent of Total
How many children chose this toy to play with?		
How long did each child play with it?		

2. Is the toy durable?

(Is it in the same shape when a child leaves it as when she or he began?)

The Toy Company Evaluation Log (continued)

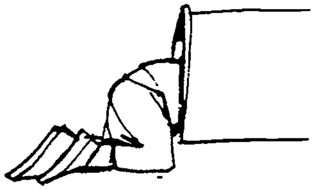
3. What is the toy's educational value?

(Describe each action a child performs with this toy and the number of times that action recurs.)

Action	Number of times action performed

4. Rate Your Toy on a Scale of 1 to 5.

	1	2	3	4	5
Attractive to target population					
Durable					
Educational Value					



This Way In: Designing an Entrance

This project directs students to design and construct an entrance to meet the needs of one of five architectural design problems. Students may choose a problem or problems may be assigned by the teacher.

Grade Level: 6-12

Some Problems

Problem A. Scotty has just beamed you into a structure in a hostile environment. The outside is coming in all around you. Design an entrance that will keep the environment out and still let you come and go as you need.

Problem B. You are an archeologist and you have stumbled across a building. You think it's a house of worship. The building is intact except for the entryway which was destroyed by a natural disaster. In order to get your money from National Geographic Society, you must build a new entry based on the available information.

Problem C. You stole the giant's magic harp and slid down the beanstalk. Now, as you reach your hut, you hear the giant sliding down behind you. You don't want to kill the giant; you just want to keep him in his beanstalk land. Design a door at the bottom of the beanstalk to keep the giant from reaching the ground.

Problem D. You have decided to follow in the footsteps of Walt Disney. You hired the world's most expensive architect to design your new recreational facility. Two hours before the grand opening, you realize that there is no way for the public to come in.

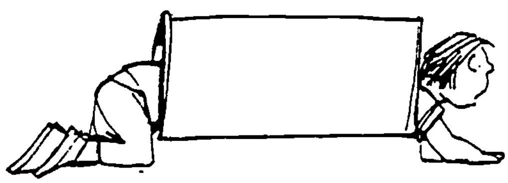
Problem E. It is the year 2050, and the environmental activists have succeeded. The animals are running rampant over the land. You are faced with a choice: you can either confine the animals or confine yourself. Design the connection between the two.

Brainstorm

With your teammates, discuss all the aspects of your problem. What makes a good entrance? How can an entrance let those inside go in and out but not allow those outside to come in?

Make a series of sketches of how you'd like the entrance to look. Use ideas from all the sketches to create your final design. As you discuss your ideas, keep in mind that

- you may use whatever raw materials you can think of but all parts must be manufactured by the group
- you may use hand tools, drill press, band saw and power sander
- you have ten class periods to complete the design and manufacturing



Evaluation

When your entrance is completed, discuss how well you accomplished the task. Assess yourselves on design and construction. Is your entrance design creative? Is it functional? Did you complete the construction within the time limit? Is your construction well executed?

Organize a panel of students who are not in your class to come in and evaluate your project.

Related Activities for an Integrated Curriculum

Research the design and scale of entrances to ancient temples.

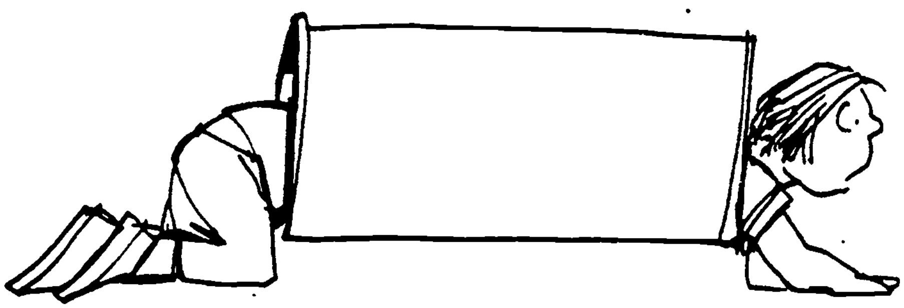
Discuss the psychology of gang membership. What do those in a gang fear?

Research recreational facilities. Review the Disney Theme Park entrance.

Compare and contrast the entrance designs in igloos, tents, a Japanese home, your own house, etc.

Resources

Book: *Mythology, Archeology and Architecture* (The Learning Works, 1982).

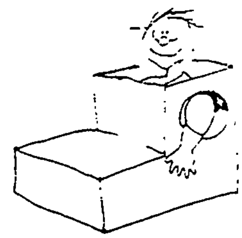


Designing an Entrance Planning Sheet

Preliminary Sketch

Final Drawing

UPS: The Ultimate Private Space



The Problem

You're sick and tired of the room you share with your brother or sister. You'd like your own private space. If you could create the room of your dreams, what would you design?

This project directs students to design and construct a private space model suitable for teenage habitation.

Brainstorm

Pair up with someone you think may share your dream and ask yourselves some questions.

What do you want to happen in your private space?

What kind of "look" should it have?

Make some sketches and talk about possibilities. What are some possible lengths and widths that will yield the 400 square-foot limit listed below?

Grade Level: 5–12.

Study the Parameters

Here are the parameters for your UPS design:

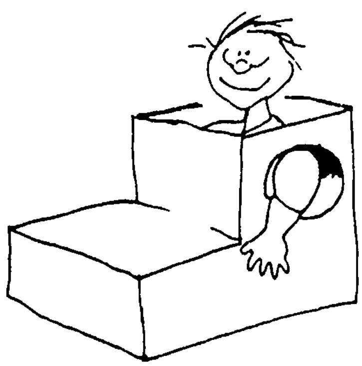
- Work with a scale of 1 inch = 1 foot.
- Maximum size of your UPS is 400 square feet. If you want to add a bathroom, you may add 100 square feet to the size.
- You may not use any ready-made materials; you must make everything yourself, even plumbing fixtures.

Pa-rá-me-ter: A term used to describe something arbitrary that restricts and thus determines the final expression.

Gather the Materials

For this task, you can use any common construction materials except materials that are radioactive. Some possible materials are

cardboard	plastic baggies	acrylic or latex paint
cloth	wood scraps	small speakers
acrylic Plastic	aluminum foil	straws
cardboard Tubes	reflective material	rocks or gravel
wall coverings	plexiglass	flashlight bulbs
electric wire	batteries/power supply	duct tape
popsicle sticks		



Organize the Tasks

Some of the tasks you'll need to do are in the list on the worksheet on the following page. You may want to add others to the list. Decide which of you is responsible for each task and which tasks you will do together.

Evaluation

As a team, evaluate each task completed. Was the task planned well? Was it finished in time to dovetail with other tasks? Was the final product attractive? Did it work?

Select your evaluation standard; for example, a scale of 1–10 or a grade of A–F. Then mark each task in the evaluation column on your task chart (see above). Give yourselves an overall mark that reflects how well you worked together as a team.

Ask other teams to evaluate your finished products in terms of design, quality of construction, accuracy of scale, neatness, details.

Related Activities for an Integrated Curriculum

Electrify your UPS.

Join with other teams to produce a home show. You'll need to advertise the home show and write stories for the newspaper.

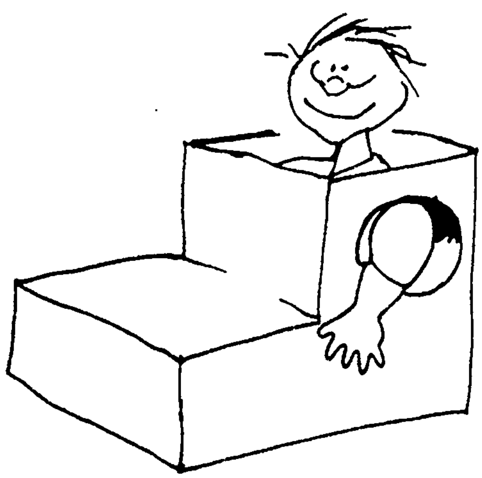
Use a computer to write a small book that shows the process you used to design your UPS.

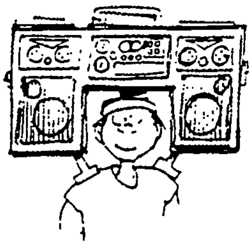
Translate your sketches and designs into scaled computer graphics.

Study the mathematics of measuring.

Visit an architect's office. Read a blueprint.

Ask a local psychologist to analyze your UPS in terms of design and color.





This project directs students to design an electronic appliance that will be easy to operate in the dark.

Grade Level: 6-12

Er-go-nó-mics: science concerned with the characteristics of people that need to be considered in safe and effective design.

Ergonomics: Designing Products for People to Use

The Problem

You are an electronic engineer working for a large company. You have an idea that will help the United States compete with Japanese electronic products. Your idea is to build a combination television–VCR–AM/FM alarm clock radio. Since each product would usually require a separate power supply and amplifier, your combination product will be cheaper and more versatile. Your research manager has just given you the go-ahead to design a prototype.

Brainstorm

With your team, discuss all the design possibilities.

How will you use symmetry and balance in your design?
Where will you place the important switches?
How big will the switches and buttons be?
How will your user distinguish the important switches in the dark?
How will you group the other controls?
How will you have your machine provide feedback for programming the alarm and any automatic recording?

Make sketches of all the different possibilities for arranging the controls and the different parts of the product.

Design Your Product

Each of you should make one or two sketches of an integrated product. Look at all the sketches and discuss their good and bad points. Take the feedback into consideration as you make your final design drawing.

Write the Product Manual

Each of you should write your own user's manual. The manual will describe the product in general and then give specific directions for its safe operation. Each aspect of the integrated product should be documented separately.

When you have finished your manual, trade both product design and manual with your partner. Without talking with your partner, follow the manual and check for any errors.

Make changes as needed in both the design and the product manual.

Related Activities for an Integrated Curriculum

Study some anthropometric charts. Then measure school furniture to determine how appropriate this furniture is for the age group using it.

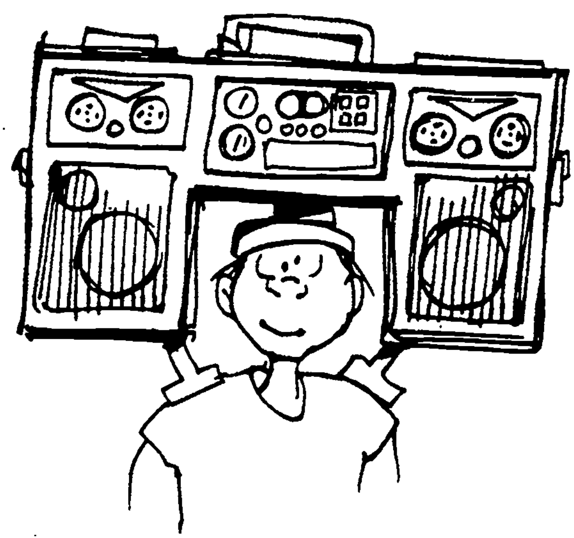
Use a large pair of outside calipers to measure your own body parts. (Boys should measure boys and girls should measure girls.) Transpose these measurements onto cardboard and make a student model. Add clothes, sunglasses, hair, etc.

An-thro-po-mé-tric: relating to the study of human body measurement.

Resources

"Ergonomics" slides from B.P.

Human scale charts published by MIT Press (available from Trans Tech-Creative Learning)

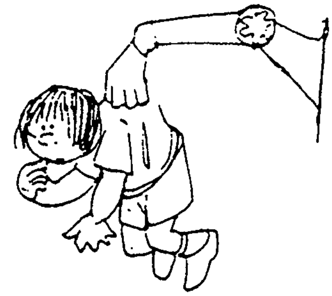


Ergonomics Design Drawings

Preliminary Sketch

Final Drawing

Reach Out With Robotic Arms



This project directs students to design and construct a functional hydraulic robot.

GradeLevel: 6–12

Hy-drau-lic: something operated by liquid under pressure.

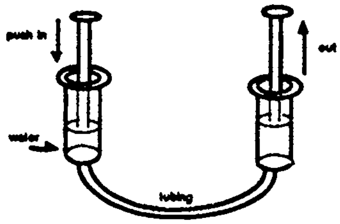
Pneu-má-tic: something operated by air under pressure.

The Problem

Your radioactive hen has laid a dozen radioactive eggs. You can't touch the eggs but you must get them into an egg carton so that they can be sent to the laboratory for analysis. All you need is the arm of a robot. Can you design one that will do the job?

Research

You'll need to do some research so that you understand both pneumatics and hydraulics. Study the diagram below and discuss how a hydraulic or pneumatic system made from two syringes and a piece of plastic tubing might be used to lift an egg.



Organize

Form a team and decide who will do what. All of you will work together on the design of the robotic arm, but you may want to specialize for some of the other tasks. You may need, for example,

- a reader who reads and supervises directions
- an engineer who puts together the modules for the experiments
- a documenter who records the experimental data
- a mathematician who writes down the data and calculates

Brainstorm and Design

Discuss with your teammates how you want your robotic arm to work. Figure out how the different parts of the arm move and how to control the up-and-down motion. Each individual team member should make a rough design sketch. As a group, discuss your rough sketches. Try to integrate all the ideas into a single preliminary design drawing.

Gather the Materials

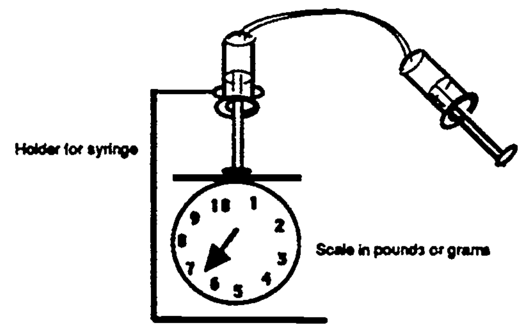
You may use any of the following materials:

wood scraps	scale measuring in grams or pounds	junk including broken toys, axels, toy DC motors, hinges, etc.
metal scraps	clear tubing, 1/8" diameter	
plastic scraps		
syringes		

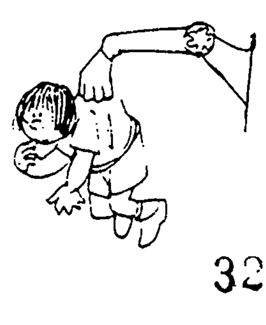
Construct and Test a System

Before you build your robotic arm, you'll need to build and test your pneumatic or hydraulic system. Read these directions through completely and discuss each task before you begin. Some tasks you will do individually, some you will do together as a group.

1. Construct a pressure tester by building a holder for one of the syringes over a scale.



2. Place one of the syringes in the holder.
3. Construct a pneumatic system by connecting the syringe in the holder to another syringe with plastic tubing. When you connect the tubing, the plunger of the syringe in the holder should be all the way in while the plunger of the other syringe should be all the way out.
4. Pressure test your pneumatic system by pushing the plunger of the syringe in your hand all the way in. As you depress the plunger, the plunger of the syringe in the holder comes out and pushes down on the scale.
5. When the scale is fully depressed, read the number of pounds or grams. This is the measure of the pneumatic pressure. Enter the data onto your data sheet.
6. Construct a hydraulic system by disconnecting the plastic tubing and filling the syringe in your hand with water. As you connect the tubing, the plunger of the syringe in your hand should be all the way out and the plunger of the syringe in the holder should be all the way in.
7. Pressure test your hydraulic system by pushing in the plunger of the syringe in your hand. As you depress the plunger, the water moves from one syringe to the other and the scale is pushed down by the plunger in the holder.
8. When the syringe in the holder is full of water, the scale tells you how much pressure in grams or pounds has been applied. Enter the data on your data sheet.



Construct and Test a Robotic Arm

1. Construct your robotic arm using the materials you gathered.
2. Test the robotic arm. Make it pick up a wooden egg from the nest and transport it to an egg carton.
3. Refine your engineering design.
4. Repeat Steps 2 and 3 as needed.
5. Create a finished design drawing.
6. Time test the robotic arm. Measure the distance the egg travels and enter the data on the data sheet. If your pressure tests were in pounds, measure the distance in inches. If the pressure tests were in grams, measure the distance in centimeters.
7. Use the work formula to calculate the amount of work your robotic arm accomplished over a given time period and enter your calculation onto the data sheet.
8. Write a technical report on the design and testing process and the results.
9. Assemble your experiment portfolio. It should include
   - your preliminary research sheet
   - one of your preliminary design drawing
   - your finished design drawing
   - your data sheet with the results of the pressure tests, the results of the robotic arm tests and your math calculations of work done
   - your technical report signed by all members of the team

Evaluation

As a group, you will want to evaluate each task completed. Did each task dovetail with the other tasks as needed? Did you work well as a team? Did you complete the robotic arm? Did it work?

Ask other teams to evaluate your project on the basis of both the construction and disassembly of the robotic arm and your experiment portfolio.

Related Activities for an Integrated Curriculum

Investigate the labor, production, and safety issues relating to the automobile industry and/or the nuclear power industry.

Acquire a five-axis robotic arm with joy sticks and simulate picking up items.

Acquire a robotic arm which interfaces with a computer and learn how to program it.

Resources

Book: *Usborn Introduction to Robotics*

Robotic Arm Data Sheet

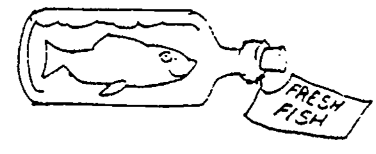
Research Results

	Definitions
Work	
Pneumatics	
Hydraulics	
Axis	
Syringe	

Pressure Test Results

NOTE: Be sure that the pneumatic pressure and the hydraulic pressure is measured in the same unit, either pounds or grams.

	Pressure in pounds or grams
Pneumatic Syringe	
Hydraulic Syringe	



What's Inside: Container Design

This project directs students to design and construct a container for a chosen product. The problem given is for an export container. A similar project could be developed around the design of a fast-food container.

Grade Level: 6–12

Pa-rá-me-ter:
A term used to describe something arbitrary that restricts and thus determines the final expression.

The Problem

You are part of a packaging company. You have been invited to put in a bid for designing the container for a specific product for a foreign exporter.

Brainstorm

With your teammates, study a world map and identify several developing countries. Use pins to identify them by name and by major products.

Choose one of the countries and research all of the products it might export. Pick one of those products that might be packaged in a simple container. Some questions you'll need to ask yourselves:

What kind of container might best suit this product?
Will this product be sold by weight or by volume?

Make some sketches and talk about possibilities.

Study the Parameters

Here are the parameters for your container design:

It must be able to support 5 kilograms of weight.
When it is empty, it must have an airspace of 1000 cubic centimeters ± 100 cubic centimeters.
The assembly must not require additional materials such as glue, tape or staples.
The container must identify the contents in at least two languages.

Gather the Materials

For this task, you can use any common construction materials. Some possible materials are

cardboard   acrylic plastic   wood

Organize the Tasks

Some of the tasks you'll need to do are in the list below. Decide who is responsible for each task and which tasks you will do together. Use the task list on page 38 to keep track of each task.

Design the container
Construct a prototype
Test for strength and refine design
Design a company logo or product logo
Design marketing materials
Create assembly instructions without using any words
Design and build a display to market the export product
Determine the cost of construction for 100 pieces, 1000 pieces and 10,000 pieces

Evaluation

As a team, you will want to evaluate each task completed. Was the task planned well? Was it finished in time to dovetail with other tasks? Was the container attractive? Was it cost-effective? Could the containers be stacked? Was it an economical and appropriate usage of materials?

If your container was designed for food, evaluate the product in terms of usage with hot food. Was there difficulty in getting the food in or out? Were there any structural changes from usage? Did the box hold heat? Did it color the taste or smell of the food?

Select your evaluation standard; for example, a scale of 1–10 or a grade of A–F. Then mark each task in the evaluation column in your task chart (see above). Give yourselves an overall mark that reflects how well you worked together as a team.

Ask other teams to evaluate your finished products in terms of design of container, design of marketing materials, product display, professional appearance of product.

Related Activities for an Integrated Curriculum

Use a computer to create a brochure for your packaging company.

Translate your sketches and designs into scaled computer graphics.

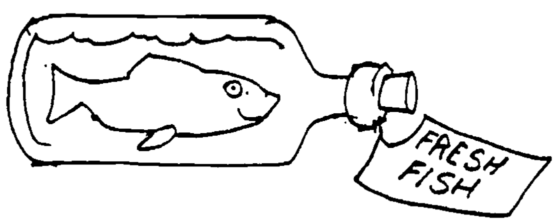
Study the mathematics of volume. Use algebra to determine the greatest possible volume of a rectangular container.

Evaluate the packaging of a variety of products on your local supermarket shelves. Bring in 5 containers and describe the merits and faults of each.

Interview older friends or relatives who have immigrated to America from other countries. Write foreign embassies for economic information.

Contact the Vermont Public Interest Resource Group (VPIRG) for information about the packaging bill under study in the Vermont Legislature. Discuss the ramifications of the bill for fast-food marketers and for the environment.

If your project was for fast food, organize a cookout with the living arts or home economics department. Sell the extra food during lunch as a fund raiser.

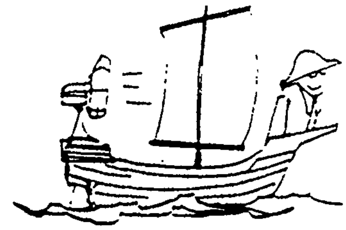


Container Design Planning Sheet

Task List

Tasks to do	Designated	Performed	Evaluation
Container Design			
Prototype Construction			
Strength Test			
Logo Design			
Marketing Plans			
Assembly Instructions			
Display Design			
Cost Analysis			

Wind-and-Water Transportation



This activity challenges students to design and build model sailboats.

The Problem

What if you were a sailor who lived in Spain in the fifteenth century and you thought you could find a new trade route to the Orient by sailing west instead of east? Suppose your queen had given you the go-ahead to build three ships. Wouldn't you want to build a model first to discover the best design for a sailing ship?

Brainstorm and Research

What did Europeans know about the world in 1492? How did people travel from one country to another? How big were the ships that sailed the Mediterranean? How fast did they sail? How did they know where they were going? Discuss Columbus' trip in the 90-foot Santa Maria. If you had been Columbus, how would you have made things different?

Grade Level: 3–6

In your group, talk about how a boat floats on the water and how wind can push a sail to make the boat go forward. Discuss what kinds of materials would be best for the boat hull and what kind would be best for the sails. How will you hold the sails up? Do you want one sail or two?

Decide how the materials should be joined together. You'll want your boat to be buoyant, to be capable of using the wind to move it at least twelve feet and remain sturdy enough for another voyage.

Gather the Materials

For your test ocean, you'll need to build a 4′ x 12′ wooden frame out of these materials.

- 3 twelve-foot two-by-fours
- 2 four-foot two-by-fours
- stopwatch
- 1 T50 stapler with quarter-inch staples
- 1 pound eightpenny nails
- 1 roll of 4-mil plastic
- water source
- wind source (hair dryer or electric fan)

You can use any of the following materials to make your ship model:

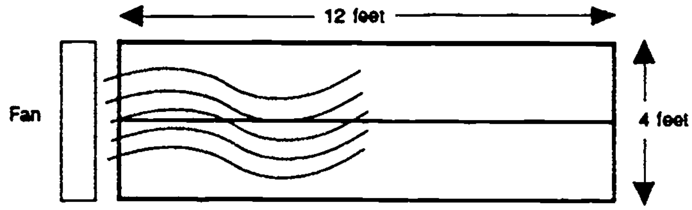
- plasticine
- styrofoam
- wood scraps
- plastic containers and lids
- fabric scraps
- plastic wrap
- popsicle sticks
- yarn
- cardboard
- dowels
- string
- rubber bands

Build the Test Ocean

Follow these directions to build your ocean.

1. Lay the three twelve-foot two-by-fours parallel to each other and fasten the two four-foot pieces at either end as shown in the diagram below. Each two-by-four is resting on the 2" side.
2. Drape the plastic over the frame to form two troughs.
3. Staple the plastic securely to the outside and the middle of the frame.
4. Fill each trough with water.
5. Place an electric fan or hair dryer at one end of the ocean to create wind.

WARNING. Electricity and water can be dangerous! Make sure the electric cord is well away from the water in the frame. Be careful not to allow splashed water to reach the fan or the electric cord.



Design and Build the Sailboat

Select your best idea and draw a detailed design of the boat. Designate the materials for the hull, the mast and the sails. Indicate how each part goes together. When your design is done, build and test your boat in the water. If it fails, troubleshoot what went wrong and modify your design. Retest until the sailboat can sail the entire length of the ocean.

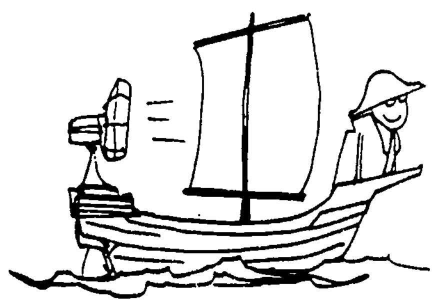
When your sailboat is seaworthy, speed test it against a sailboat built by another team. Make sure the fan directs the wind evenly over the test area.

Record your test results in your test log.

Evaluation

Evaluate your project both in terms of design and construction. Was the original design easy to work from? Were you able to make the necessary changes to make the system work? Is the finished product well crafted?

Compare your sailboat to the sailboats other teams made in terms of design and construction. Ask other teams to evaluate your sailboat.



Related Activities for an Integrated Curriculum

Research the different kinds of sailing ships (sloop, brigantine, schooner, bark, etc.). Research the names of the sails and parts of the ship.

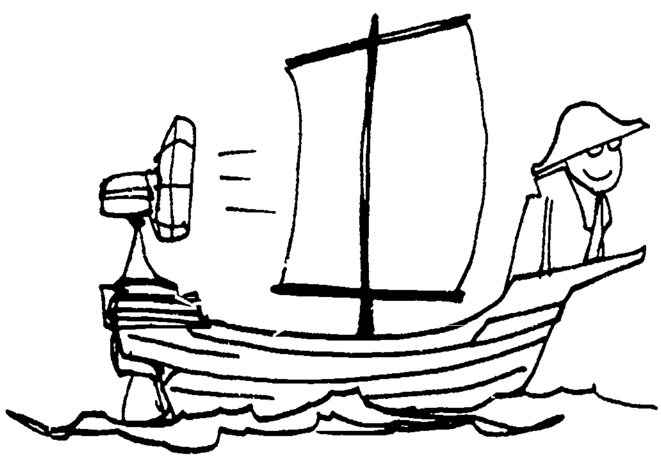
Locate the path of Columbus' trip using maps and globes. Research other explorers such as Cabot, Magellan, Hudson, Champlain.

Obtain a nautical chart and locate landmarks, longitude and latitude, and depth markings. Chart a course from one point to another. Graph the results of your time and distance trials.

Research the navigation aids that are in use today.

Practice seamanship by learning how to tie different knots such as the sheepshank or the bowline.

Use a computer to create a timeline that shows the development of sea vessels from log rafts to paddle-wheels to tankers.



Wind-and-Water Transportation was adpated from The Technology Teacher (November 1992).

Sailboat Planning Sheet and Test Log

Name of Sailboat Model ______________________

Team Members

____

____

____

____

____

Materials List

____

____

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____

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Test Log

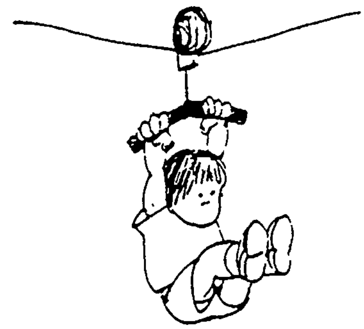
If your sailing model travels less than the entire length of the test ocean, measure its traveling distance with a tape measure.

Use a stopwatch to determine the time.

Use the formula, *Rate equals Distance divided by Time,* to calculate the speed at which your sailing model travels on each test.

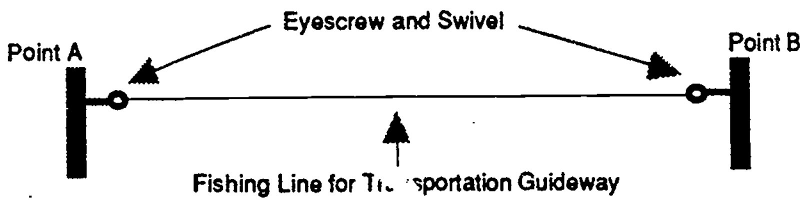
	Test 1	Test 2	Test 3	Test 4
Distance				
Time				
Rate				

Getting From Here to There by Monorail



The Problem

You are being asked to design a fixed route transportation system which will transport a single clothespin between two points. A transportation guideway between Point A and Point B is provided.



This project directs students to construct a model self-propelling monorail system from common everyday materials.

Brainstorm

List all the transportation systems you know about and discuss how each one works. Then, with your team, brainstorm ideas for your own system. Make a list of all the ideas suggested, no matter how "weird." Make rough sketches of several of the ideas.

Grade Level: 7–12

Study the Parameters

You may only use the materials listed below.

2 long-style balloons	4 popsicle sticks	1 strip of aluminum foil
2 large rubber bands	20" of masking tape	
2 paper clips	2 pipe cleaners	2 napkins
2 large drinking straws		1 clothespin

Scissors, stapler, razor, knife, etc., may be used as needed.

Pa-rá-me-ter:
A term used to describe something arbitrary that restricts and thus determines the final expression.

The power source must be part of the system. No external sources, such as human muscle power, throwing or blowing may be used. Your system must operate without assistance. Human hands may touch the system only before vehicle departure and after arrival.

Design and Build the System

Select your best idea and draw a detailed design of the entire system. Your drawing should include materials used and how each part goes together. When your design is done, build and test your prototype. If it fails, troubleshoot what went wrong and modify your design. Retest until the system works. Record your test results in your test log.

Once the prototype has had several successful runs, build a production model and demonstrate it to the rest of the class.

Evaluation

Evaluate your project both in terms of design and construction. Was the original design easy to work from? Were you able to make the necessary changes to make the system work? Is the finished product well crafted?

Did your system fail to get to the end of the line on any of its tests? Were you able to troubleshoot the problem quickly and efficiently?

Ask other teams to assess your system in terms of design and construction.

Debriefing

Discuss the essential features of any transportation system. Does every system need

- power and transmission
- support and cover
- guidance and control

How does your system compare with jets and rockets? With trains and ski lifts?

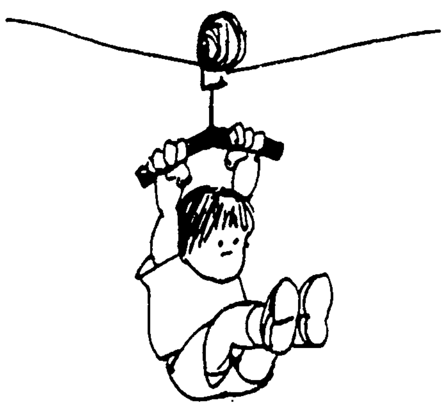
Discuss what occurred during the project. Did any group steal an idea from another group? Does that kind of piracy occur in the industrial world? What is a copyright? What is a patent?

Discuss Newton's Third Law of Motion: "For every action, there is always an equal and opposite reaction." Does this law apply to your system? How?

Related Activities for an Integrated Curriculum

Weigh your entire system to the nearest gram.

Run several tests to determine the average speed of your system. Use a tape measure to measure the distance traveled. Use a stopwatch to measure the time it took to travel each distance. Calculate the total distance traveled and the total time (for all tests combined). Then use the formula *Average rate equals total distance divided by total time* ($r = d/t$) to calculate the average speed of your system.



Getting From Here to There was adapted from Technology Activities, Idea Book 1.

Monorail Planning Sheet and Test Log

Name of System ______________________________

Team Members

____

____

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____

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Materials List

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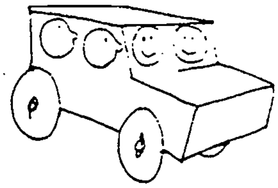
Test Log

	Test 1	Test 2	Test 3
Distance Traveled			
Reason for Failure			



This project directs students to form their own automobile corporation. In teams of four or five, they will organize a company, design and construct a car, and prepare marketing materials.

Grade Level: 7–12

Pa-rá-me-ter:
A term used to describe something arbitrary that restricts and thus determines the final expression.

Pa-rá-me-ter: Arbitrary limitation.

The Auto Company

The Problem

You've got a great idea for a car. Nobody has ever seen one like it. But General Motors isn't interested; Ford and Chrysler won't return your calls. Why not start your own company? Why not design and market your own car?

The First Step: Organize

Create a company structure. List the skills of each person in the group. How do those skills fit with the traditional positions in a company? Are there positions you want to create in addition to the ones below?

Chief Executive Officer (CEO) or President
Design Engineer
Production Engineer
Director of Marketing

If your company has the four branches shown, in which branch is your position located?

Research and Development	Sales and Marketing	Production/ Manufacturing	Administration and Finance

Brainstorm

Some questions you'll need to ask yourselves:

Who is your target audience?
What is unique about your design?
What about your design is the same as cars you know about?

Make some sketches and talk about their possibilities. Collect auto brochures and analyze them. What can you do better? Make up a catchy name for your company that will reflect your ideas.

Study the Parameters

Here are your parameters for your car design:

- Draw a rectangle that measures 4" by 12" (10 cm x 30 cm). Your car must fit into this box.
- Your car must have at least two working axels; it may have more than two.
- Anything you use to color the car may not add to its structural strength.
- Your license plates must identify your company.

For this task, you are limited to the following materials:

aluminum offset printing plates
hot glue
duct tape
wooden dowels (used for axels only)
sheetrock knife
latex paint
writing materials as needed
scissors

Organize the Tasks

Some of the tasks you'll need to do are in the list below. You may want to add others to the list. Decide which officer of the company is responsible for each task.

Vehicle design
Wheel design
Display design
Engineering Drawing
(two-view drawing)

Pattern Layout
Wheel Layout
Assembly
Prototype Production

Logo design
Media Plans
Ad Layout
Pictorial View

Evaluation

As a group, evaluate each task completed. Was the task planned well? Was it finished in time to dovetail with other tasks? Was the product attractive? Did it work?

Select as a group your evaluation standard; for example, a scale of 1–10 or a grade of A–F. Then mark each task in the evaluation column in your task chart (see above). Give yourselves an overall mark that reflects how well you worked together as a team.

Ask another team to evaluate your finished products (both the automobile prototype and the marketing displays) in terms of uniqueness of design and quality of construction.

Related Activities for an Integrated Curriculum

Join with other teams to produce an automobile show. Advertise the car show and write stories for the newspaper.

Use a computer to write a design pamphlet that shows the process you used to design your car. Translate your sketches and designs into computer graphics.

Use the Car Builder software to design and construct an automobile. Test your design for coefficient of drag, handling and speed.

Research the mathematics of gear ratios. Research alternative energy sources such as solar-powered motors or electric autos. Research solutions to car pollution. Study Consumer Reports Auto Section.

Discuss the social impact of cars as a country moves from an agrarian to an industrial economy. Discuss the effects of car exhaust fumes on the environment. Discuss mass transportation systems.

Resources

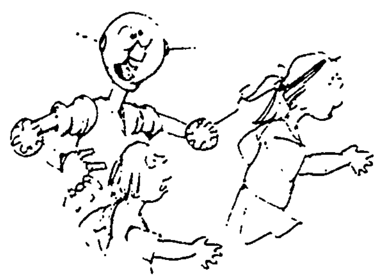
Software: CarBuilder.

Videos: "Tucker: the Man and His Machine"; "Sunracer"

The Auto Company Planning Sheet

Task List

Tasks to do	Designated	Performed	Evaluation
logo design			
vehicle design			
wheel design			
display design			
media plans			
two-view drawing			
pattern design			
wheel layout			
ad layout			
pictorial view			
assembly			

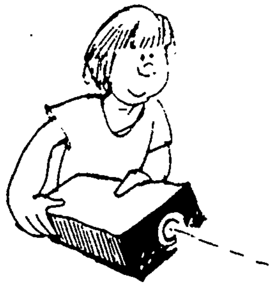


Experiments

The following activities ask students to collaborate in an experiment. These are cooperative learning activities that call for research and discussion in preparation for the construction phases.

Group work lets students learn how to be effective leaders and productive team members. The best group work occurs when three or four students work together. In larger groups, productivity drops off drastically.

It is important for teachers to let the groups develop their own structure and decide for themselves how to tackle a problem. The key to learning lies in discovering a process that works.



This activity directs students to build a fence using a laser beam to set the lines straight. Younger students may want to turn this into a barnyard complete with barn and animals.

Grade Level: K-6

Old MacDonald Had a Laser

The Problem

You have a laser and you want to know how it works. What can it do in your world that is useful? Could you build a fence with it?

Research

Look up laser in a dictionary or world book. Ask your teacher to show you the "Laser Information Guide." Watch the video "Lasers Unlimited." Discuss some uses of lasers that you have seen or heard about.

Study the Safety Rules

A laser beam is safe so long as you obey some basic safety rules.

1. Post WARNING signs whenever you are using the laser.
2. Make sure the overhead lights in the room are on.
3. Wear goggles or protective glasses.
4. NEVER look directly into the laser beam or into the reflection of the beam in a mirror.
5. NEVER point the laser beam into anybody's eyes.
6. NEVER operate the laser without permission.
7. NEVER leave the laser unattended.
8. Turn off the laser when you finish using it.

Gather the Materials

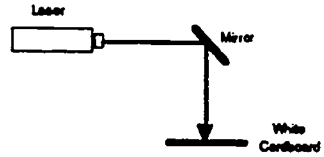
In addition to your laser, you'll need the following materials:

a laser	1 white cardboard square
6 mirrors	14 dowel rods for fenceposts (1/4" or 1/2" x 5")
2' x 3' cardboard box with sand	

Change the Direction of a Laser Beam

Before you build your laser fence, you need to know how to change the direction of your laser beam.

1. Set up the laser, one mirror and a white cardboard square as shown below.

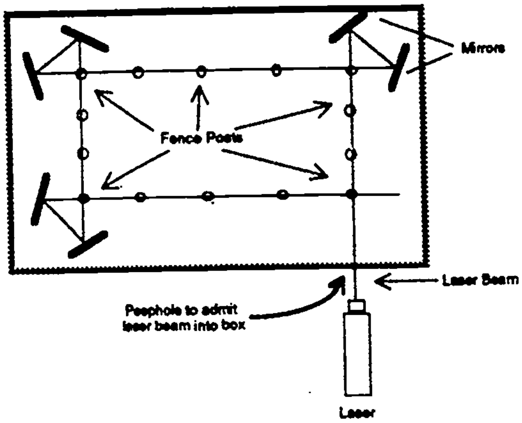


2. Move the mirror until you can see the laser beam on the white cardboard.

Why does the laser beam change direction? Does any of the laser beam pass through the mirror? How could you use two mirrors to make a right angle with the laser beam?

Build Your Laser Fence

Now you are ready to build a fence using the laser beam. Study the diagram and follow the directions below. Notice how the right angles are made with two mirrors instead of one.



1. Pour two to three inches of sand into your cardboard box.
2. Set the laser on the outside of the box as shown. The beam should be approximately 6" above the table height.
3. Punch a small hole in the outside of the box to allow the laser beam to penetrate the box interior.
4. Align two mirrors in the corner opposite the laser so that the laser beam turns the 90° angle.
5. Install the fence posts under the laser beam.
6. Repeat Steps 4 and 5 until all the fence posts are installed.

NOTE: A humidifier with a flexible hose or a water spray bottle will allow you to put water droplets in the path of the laser beam to make it more visible.

Related Activities for an Integrated Curriculum

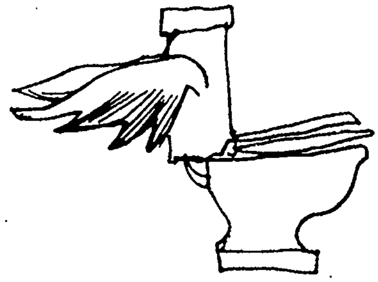
Measure the perimeter and area of the fenced-in area. Measure the angles. Change the dimensions until you have the length and width that will give you the greatest area.

Research the medical uses of lasers. Research how lasers are used in excavating and construction.

Resources

Video: "Lasers Unlimited"

Books: *The Hologram Book* by Steven A. Feller and Joseph E. Kasper; *The Laser Experimenter's Handbook* by Frank McAleese; *Laser Activities for the Classroom* by Harold P. Woods, Joseph R. Verboys and George A. Evans; *USBorne Introduction to Lasers.*



Space Station: Recycled Waste

This project directs the students to construct a water filtration system and purify fluids.

Grade Level: 3–6

The Problem

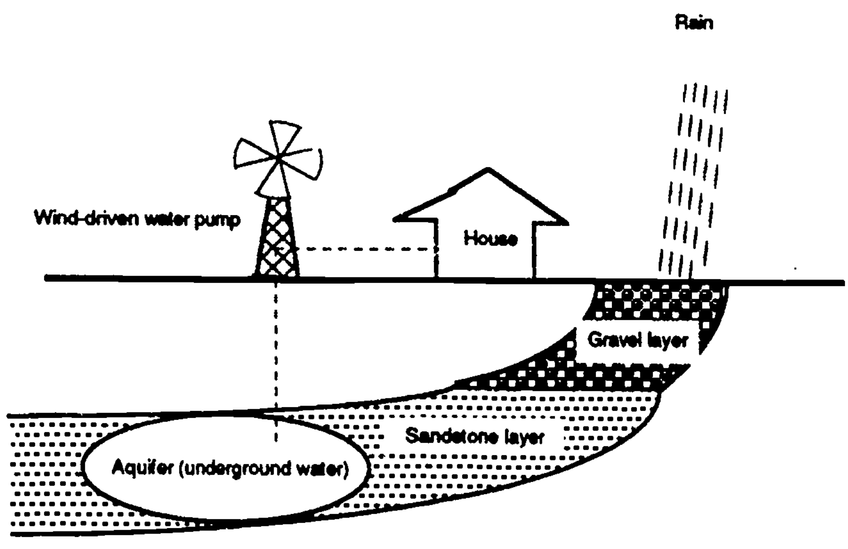
You have landed on Space Station Zebra. The project you are working on is going to take longer than you expected, and your clean water supply is running low. You have to design and construct a water filtration system so that you can reuse water.

Preliminary Research

With your teammates, research and discuss how water and other fluids are purified by passing through successive layers of filtering material. Some questions you'll want to ask yourselves include

- What is a closed environment? Is the earth itself a closed environment?
- Why recycle water?
- On a space station, does it make sense to have a large system of surplus water?
- What are the pros and cons of returning liquid waste to earth?
- What are the pros and cons of resupplying liquids by way of a space shuttle?

The diagram below shows how water is naturally recycled on farms in Vermont. How do you think the rain water gets purified? Where would you put the cow barn in this diagram? Why? Why is well water cleaner than river water?



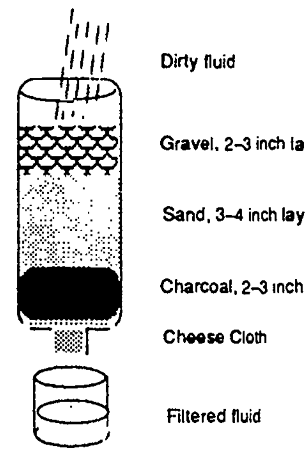
Research the weight and volume of a gallon of water. Do you think it is more practical for astronauts to recycle their water or to provide several gallons per person?

Gather the Materials

To make your own water purification system, you'll need the following materials:

one 2-liter plastic bottle	sand	pitcher
plywood	activated charcoal	a drinking glass
sharp-pointed scissors	cheese cloth	dirty dish water
rubber band	oxygen kit	pond water
gravel		urine

Build the System



The diagram in the margin shows a simple water purification system. Compare it to the natural system shown above.

Read the following instructions carefully. Discuss each step before you begin to build.

1. Cut the bottom out of the 2-liter bottle.
2. Place the cheese cloth over the mouth of the bottle and secure it with a rubber band.
3. Turn the bottle upsidedown and pour a layer of charcoal followed by layers of sand and gravel.
4. Construct a stand for the bottle out of two pieces of plywood. Use a large rubber band to attach the bottle to the stand.
5. Place the drinking glass under the neck of the bottle to catch the clean filtered fluid.
6. Measure one of the unfiltered fluids and record its volume on the data sheet on the following page.
7. Pour the unfiltered fluid into the bottle and wait for it to pass through the purification system and into the glass.
8. Measure the fluid in the glass. Record its volume on the data sheet.
9. Repeat Steps 7 and 8 for the other unfiltered fluids.

Evaluation

After you have completed your data sheet, discuss the results. Ask ourselves the following questions:

How well did your purifier purify?
What could you do to make it work better?

Related Activities for an Integrated Curriculum

Study and design a septic system or leach field.

Research the average daily water consumption per person in the state of Vermont or in the United States. How much is consumed by intake, washing, toilet flushing, etc.?

Research the use of litmus paper to measure pH. What is the pH of pure water? What is the pH of your filtered fluid?

Calculate the percentage of fluid retrieved from your purification system.

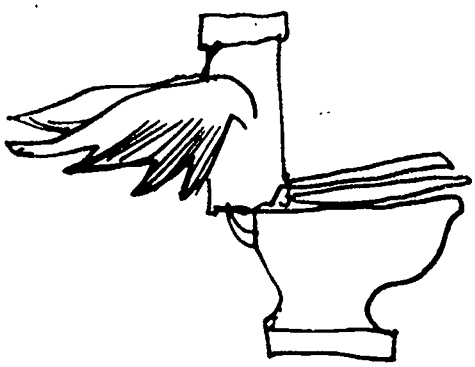
Recycled Waste Data Sheet

Table of Data

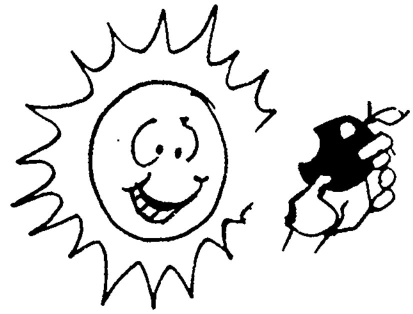
	Dish water	Pond Water	Urine
Ounces poured in			
Ounces received out			
Ounces consumed in filtering			
Change in clarity			
Different in odor			
Oxygen ??			

Observations

Write a summary of your team discussion about recycling water.



Space Station: Solar Collectors



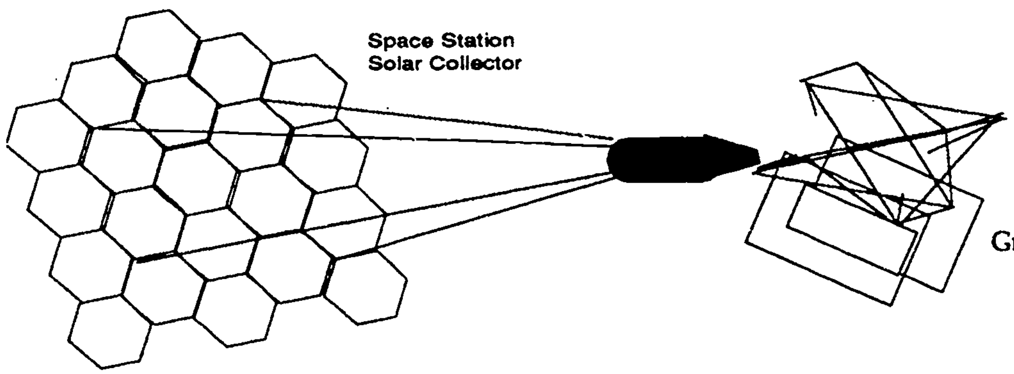
The Problem

You are on Space Station Zebra and you have decided to cook an apple but there's no stove and no cooking pot. You can't light a fire in space. The sun is your only source of energy.

Research

How do think light from the sun can be turned into energy? Look up photovoltaic and solar radiation in a dictionary or science book. What does solar collector mean? Could you cook an apple using only sunlight?

This project directs students to construct a simple solar collection device and demonstrate the generation of heat from the light of the sun.



GradeLevel: 1–6

Gather the Materials

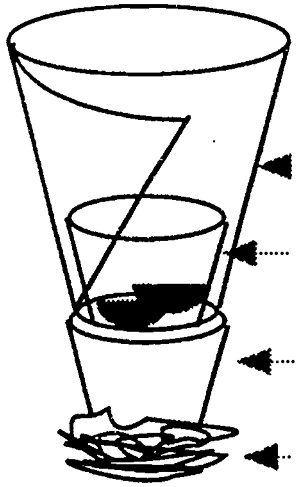
You need the following materials to make your solar collector:

cardboard	scissors	black paper
4 paper cups, unwaxed	newspaper	plastic wrap
white paper	tape	2 thermometers
aluminum foil	slices of apple	

Build the Solar Collectors

Read the directions carefully before you begin.

1. Line a paper cup with black paper.
2. Place a slice of apple in it.
3. Cover the top of the cup with plastic wrap.
4. Make a cone out of white paper and wrap it around of the cup.
5. Place the cone with the cup inside it into another cup. Make sure it can stand up by itself.
6. Repeat Steps 1 through 5 for a second solar collector. For this collector, make the cone out of white paper lined with aluminum foil.
7. Crumple newspaper around the base of both outside cups.



Test the Collectors

You can test your solar collectors on any sunny day, although a warm sunny day will provide the best results. Be patient and allow plenty of time to complete the testing.

1. Set your two solar collectors on a windowledge that gets plenty of sun.
2. Tape the thermometers to cardboard strips and lower one into each cone. The thermometer should be positioned between the cone and the cup.
3. Check the temperatures at different times. Record the time and the temperatures in your log.
4. Leave the solar collectors in the sun until the apples are cooked.
5. Taste the apple slices from each cooker. Record your impressions in your log.

Analyze the Results

Discuss the results of your test. Here are some questions you will want to ask yourselves.

1. Which solar collector cooked the apple slices the fastest?
2. Which apple slices tasted better?
3. How did the solar collector work? Explain why or how the aluminum foil worked.

In a space station solar collector, there are mirrors that reflect and concentrate the sun's rays. Can you think of any kinds of natural solar collectors here on earth?

Related Activities for an Integrated Curriculum

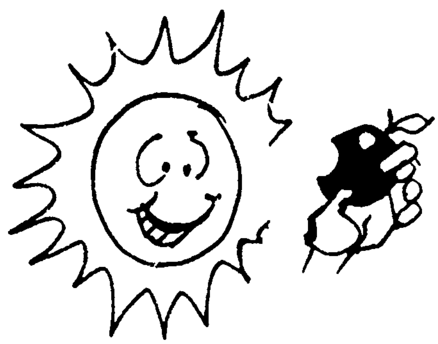
Solar Collectors adapted from Science Activities in Energy.

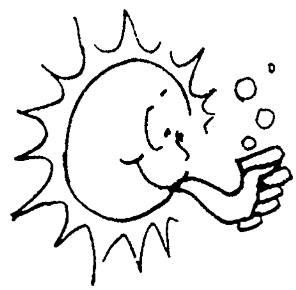
Calculate the difference in cooking time between the two solar collectors. What is the percentage of total cooking time saved by using the faster collector?

Design an experiment to test the importance of the cone size. What do you predict? How can you test your prediction?

Solar Collector Log

	Time 1 Temperature	Time 2 Temperature	Time 3 Temperature	Total Time for Cooking Apples
Solar Collector 1				
Solar Collector 2				





Earth Station: Solar Collectors

This project directs students to construct a flat-plate solar collector and use it to heat hot water. The objective is for students to learn how solar energy works and how to monitor the results of a solar heating system.

Grade Level: 7–12

The Problem

You have been hired to design and construct a hot water system using solar energy.

Research

You will need to know how solar energy works. Find a book on solar energy in your library or science room.

How is the sun's energy used naturally to heat water?
What is indirect solar energy and how does it work?
How could you collect the sun's energy?

Gather the Materials

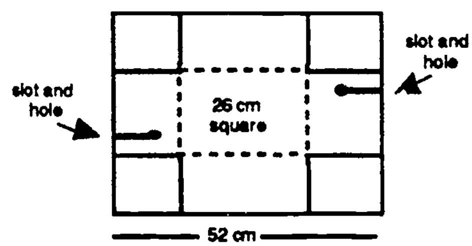
You'll need the following materials to build your active solar collector.

- cardboard box or piece of cardboard to make a box
- one 1-meter clear plastic tubing, 3/8" to 1/2" in diameter
- plastic funnel to fit inside plastic tubing
- protractor
- razor blade or utility knife
- tape or stapler
- rubber cement
- two styrofoam cups
- two 40-cm square pieces 3- or 4-m clear plastic or Saran Wrap
- flat black spray paint or latex flat black
- roll of heavy-weight aluminum foil
- food dye
- foam or fiber glass insulation
- thermometer ranged 32°–212° F

Build the Collector Housing

You can either use a recycled box or construct one from cardboard. If you use a recycled box, measure it carefully so you can compare the differences when using different sized boxes.

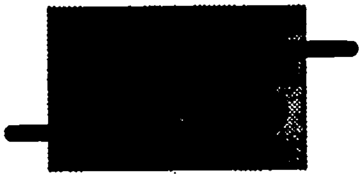
1. If you are making your own box, draw the pattern below on the cardboard square.



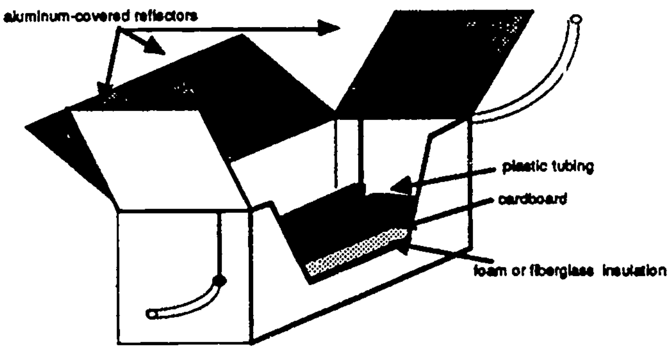
2. Cut on the solid lines, fold on the dotted lines.
3. Fold and staple or tape the cardboard to make the box.
4. Fit aluminum foil onto the flaps to create reflectors.

Assemble the Collector

1. Insert insulation into the bottom of the box so that it is one or two inches thick across the bottom area.
2. Fit a piece of cardboard on top of the insulation.
3. Insert the plastic tubing through the holes in the sides of the box and make an S-shape with the tubing inside the box.



4. Tape the slots tightly closed.
5. Fold and tape the plastic to make a tight but removable cover.



Test the Collector

A warm sunny day will provide the best results. Be patient and allow plenty of time to complete the testing.

1. Set your solar collector on a windowsill that gets plenty of sun. Make sure it is facing the sun.
2. Place one of the styrofoam cups directly below one of the extending pieces of plastic tubing.
3. Fill the other styrofoam cup with exactly 100 ml of water.
4. Record the temperature of the 100 ml of water.
5. Pour the water through the plastic funnel into the other extending piece of plastic tubing.
6. When the water is collected in the other styrofoam cup, record its temperature.
7. Using the same water, repeat Steps 5–6 until there is a ten-degree difference between the two temperatures. Allow 5 seconds between pourings.

Additional experiments

- Run the test using 50 ml of water.
- Vary the angles at which the collector faces the sun.
- Fill the collector tubing with water and allow it to stand for ten minutes before it flows out.
- Add 2–5 drops of different food colorings to the water before you pour it through. Pour each color ten times.
- Add colored salts (copper sulfate, chromium chloride or potassium permanganate) to the water before you pour it through.

Analyze the Results

Discuss the results of your test. Here are some questions you will want to ask yourselves.

How many pourings did it take for the ten-degree rise in temperature?
Which was the best angle for the collector?
Which color liquid absorbs the most solar energy?
What is the latitude of your state?
What is the angle of the sun at this time of year?
If you used different sized boxes, how did the different sizes affect the temperature increases?

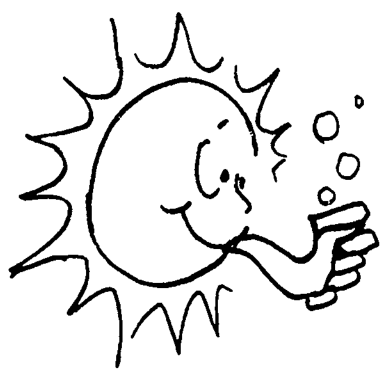
Related Activities for an Integrated Curriculum

Design and construct a parabolic reflector.

Study Vermont's latitude and the solar calendar. At what time and angle is the optimum sun?

Discuss how would you design a solar tracking system or a closed loop system using a storage tank.

Solar collectors adapted from Science Activities in Energy.



Solar Collector Data Sheet

Team members

____

____

____

____

____

Specifications of the solar collector

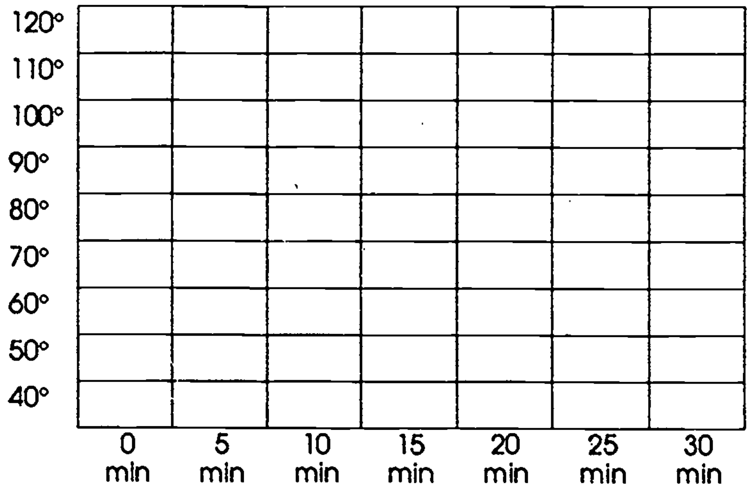
Area of bottom of box______________

Type of insulation used ______________

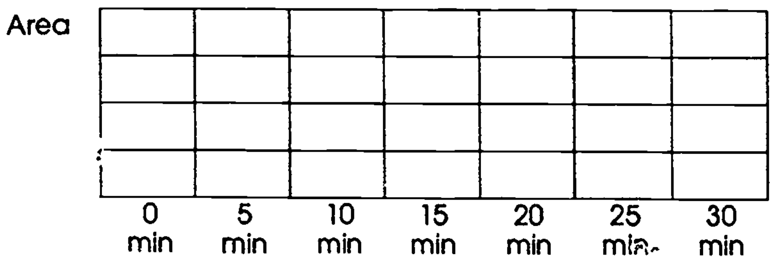
Temperatures

	1st pour	2nd pour	3rd pour	4th pour	5th pour	6th pour	7th pour	8th pour
100 ml H_2O								
50 ml H_2O								
50 ml with food coloring (color:__________)								
50 ml with food coloring (color:__________)								
50 ml with colored salts (type:__________)								

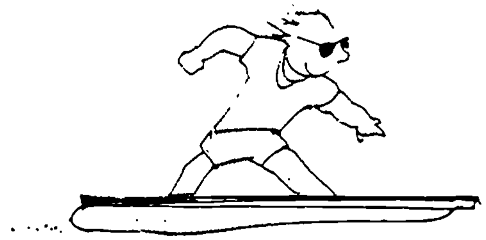
Graph: change in temperature vs the time it takes to change



Graph: time it takes for the temperature to change 10° vs area of the bottom of the box



Air-Cushioned Vehicle: Hovercraft



The Problem

The best blackberries in the country are on an island in a lake. You used to go there every summer, but now the aquatic weed milfoil has invaded the lake. The milfoil is so thick now, you can't swim or boat without getting tangled in the weed. The blackberries will go to waste...unless you can figure out a way to transport yourself across the water without touching down.

Research

With your teammates, discuss how something could travel on air without wings. How could you control such a machine? What would be its advantages? What would be its disadvantages? What would be the uses of an air-cushioned vehicle?

You'll need to research how to calculate the minimum pressure required to lift a given weight. The basic formula is given on the Air-Cushioned Vehicle Data Sheet on page 66. Look for more information in a science book or encyclopedia.

Make some preliminary sketches of what you'd like your air-cushioned vehicle to look like.

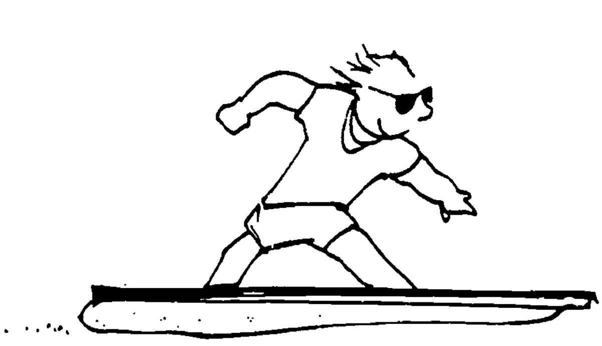
This project directs students to design and construct a vehicle that can travel on a cushion of compressed air. Air blown under the vehicle will create the pressure to lift the vehicle off the ground. An aircraft propeller attached to the vehicle will create the thrust that will move the vehicle forward.

Gather the Materials and Equipment

You'll need the following materials and equipment:

- 1 sheet 3/4" plywood measuring 4' x4'
- 1 blue reinforced tarp or 6-mil plastic measuring 56" x 56"
- 1 plastic lid from a 3-lb. coffee can
- one roll of duct tape
- one T-50 staple gun with 1/4" staples
- one 1" x 1/4" bolt and nut
- two 1/4" fender washers
- 1 string-and-pencil compass
- 1 portable vacuum cleaner or shop vacuum

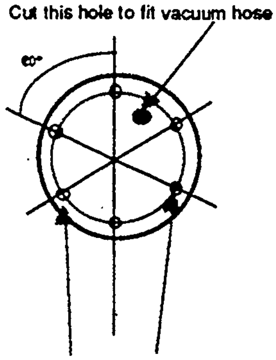
Grade Level: 8-12.



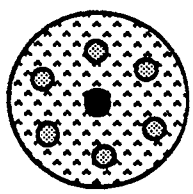
Construct Your Hovercraft

Read through the instructions carefully. Discuss each task before you begin.

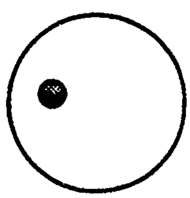
1. Use a string-and-pencil compass to draw a circle on the plywood for the base of your vehicle. Make it the maximum size you can get from the 4-foot square.
2. Under the guidance of your instructor, cut out the circle with a sabre saw.
3. Measure the diameter of the hose of your vacuum (usually 1 $^1/_4$" in diameter).
4. Use a sabre saw, a hole saw or spade drill bit of the appropriate diameter to cut a hole in the plywood circle exactly 6" from its center. The diameter of the hole should match the diameter of your vacuum.
5. Use your compass to draw a circle 8 inches inside the edge of the plywood circle. Draw three lines through the center of this circle so that the angles the lines form are each 60°. Then use the intersection of the lines and the inner circle to draw six circles with diameters of 6 inches. THESE CIRCLES ARE GUIDELINES ONLY. DO NOT CUT THEM OUT.
6. Turn the panel upsidedown and tightly stretch the 6-mil plastic across the bottom of the plywood circle. Staple it to the top and then seal it with the duct tape.
7. Use a sheetrock screw to fasten the coffee can lid to the center of the bottom (plastic-side) of the plywood circle.
8. Using the 6 drawn circles that show through the plastic, cut 6 equally spaced 4" holes in the plastic. Before you start cutting, remeasure the holes to make sure they are 60° apart and 8" from the outer edge of the circle.
9. Place the plywood circle on the floor with the plastic-side down.
10. Insert the vacuum hose into the hole on the top of the plywood circle.



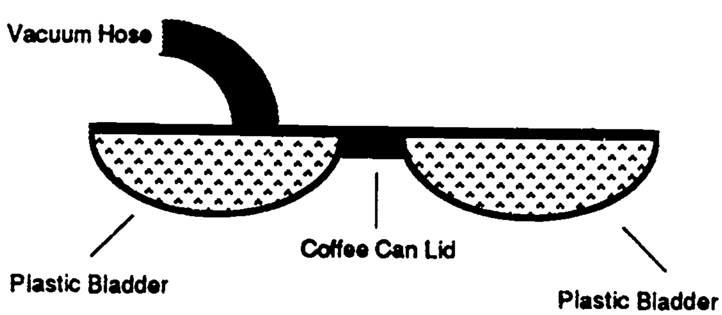
Mark these holes for guides for cutting the plastic



Bottom view with coffee can lid and 6 holes cut in plastic



Top view with hole cut in plywood to match diameter of shop vacuum



Cross-sectional view with vacuum hose attached and blowing air into plastic

Test Your Hovercraft

Test your air-cushioned vehicle by placing a chair on the plywood circle and turning on the vacuum. If the craft will lift the chair alone, have a team member sit on the chair and push the vehicle around the room.

Once your air-cushioned vehicle has had its trial voyage, you should run a series of tests and enter your findings on the data sheet.

Evaluation

Evaluate your work process by answering these questions:

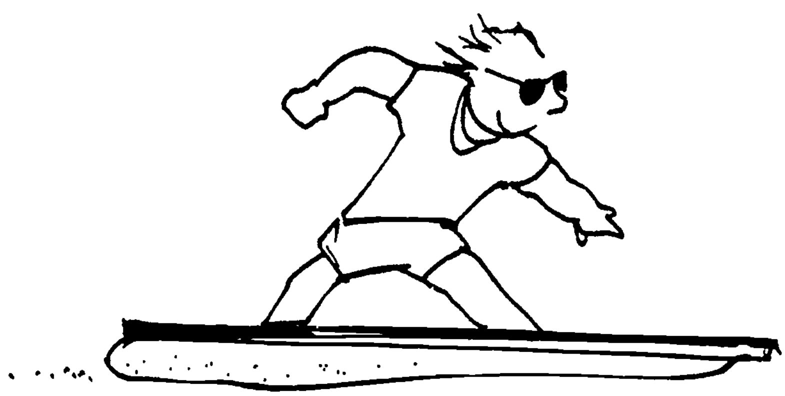
- Did you read the instructions carefully?
- Did you discuss each task before you began it?

Ask another team to evaluate your vehicle in terms of construction and usability.

Related Activities for an Integrated Curriculum

Study the geometry of a circle. How many degrees are in a circle? What is the circumference of a circle? What is its radius? What is its diameter? What is π?

Design and paint the top of your vehicle. Sculpt a large animal or tree on top of your vehicle.



Air-Cushioned Vehicle Data Sheet

Name of Vehicle

____

Team Members

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Formulae

The minimum amount of pressure needed to lift a weight off the floor is equal to the weight of the load (the plywood circle plus the chair plus the student) divided by the area of the inflated plastic coming in contact with the floor while under pressure.

The area of a circle is πr^2, where r is the radius..

Formula for Pressure	
Weight of Load	
Surface Area of Vehicle	
Minimum Pressure Required	

Magnetic Levitation Transport (MAGLEV)

Grade Level: 1–12. The Problem

You are to design and build a magnetic levitation vehicle that can traverse an 8-foot track in the shortest period of time. You have several options for powering your vehicle, including external wind power, electrified track or some kind of mechanical or electrical system on the vehicle itself.

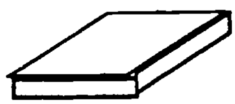
This activity directs students to design and test a vehicle that demonstrates the principles of magnetic levitation.

Magnet Research

You'll need to find out all you can about magnets and how they work. What are magnetic poles? Why does a suspended magnetic bar lie in a general north-south direction? What is the biggest magnet you know?

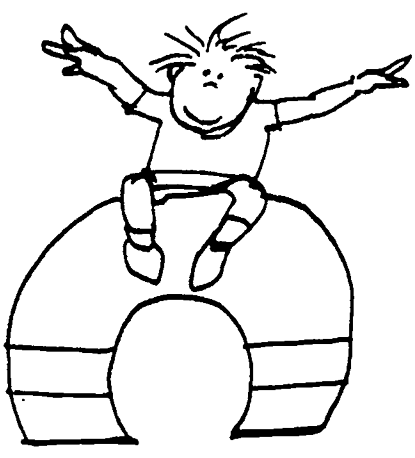
Use the flat ceramic magnets your teacher gives you to conduct some preliminary tests. How can you tell the north end of a magnet from the south end? When you place the north end of one magnet next to the north end of another, what happens? What happens when you place the north end of one magnet next to the south end of the other?

Grade Level: K-12



Your teacher has a special track for magnetic levitation. Examine the track. Measure its width. Notice the two rows of magnets on the track. Test their polarity by moving a free magnet close to them. Is the polarity the same for all the track magnets? Is it the same for a single row of magnets? Is each row of a same or different polarity?

See the Resource section for suppliers of the special track and magnets.



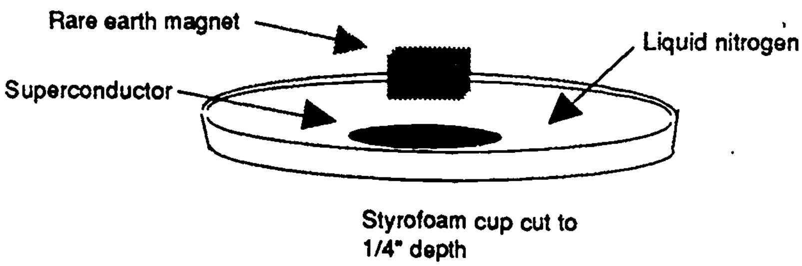
Research Superconductivity

Before you design and construct your MAGLEV transport, you may want to see how a rare earth magnet can be levitated over a superconducting material that has been cooled in liquid nitrogen. You'll need the following materials:

superconductor kit	liquid nitrogen in a Dewars flask	non-magnetic tweezers
rare earth magnet (Cobalt Samarium)	shallow styrofoam cup	safety glasses or chemical goggles

WARNING: Everyone watching this experiment must be wearing safety glasses or chemical goggles.

1. Pour the liquid nitrogen into the shallow styrofoam cup.
2. Use the non-magnetic tweezers to pick up the magnet and place it over the liquid nitrogen.



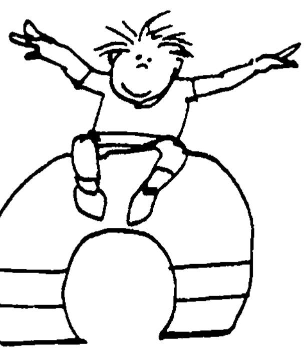
You can enhance the demonstration by placing an overhead projector on its side to project the floating magnet image onto a screen or wall.

Brainstorm Your Own MAGLEV Vehicle

Your MAGLEV vehicle can be powered by an external source or by a self-contained source. One external source might be an electric fan located a foot from the beginning of the track and standing on the same level as the track. If you want to use wind power, discuss what kind of sail or other windcatcher you could design to propel your vehicle.

If you want your vehicle to be self-contained, consider power systems created out of balloons, rubber bands, springs, or batteries.

If you want to research electrical power, find out how to electrify the track using a variable power supply of no more than 15 volts, 1 ampere.



Gather the Materials

You can build your MAGLEV device from any of the following materials:

possible vehicle materials	possible power source materials
cardboard	cloth for sails
paper	rubber bands
foam board	springs
plastics	small DC motors
balsa	balloons
aluminum sheets	propeller
eight 1"x3/4" ceramic magnets	wire

Design the System

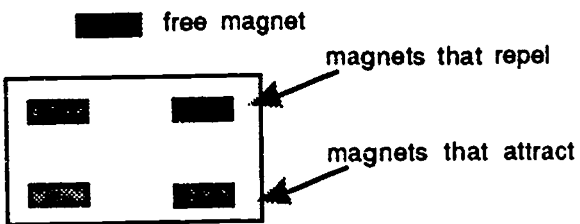
Once you have chosen your power supply, make a drawing of the entire system. Include in your design the materials used and directional arrows for the power source.

NOTE: Systems must operate free of human control. No sling shots, CO_2 cartridges, compressed air, rocket engines or model airplane engines are allowed.

Construct Your MAGLEV Vehicle Body

Read the directions through completely before you begin.

1. Cut out your vehicle body from your selected material. The width must be exactly 2 1/2" so that it will fit the track. The length of the vehicle can be anywhere from 3 1/2" to 6".
2. Following the diagram below, test mount two rows of magnets to the bottom of your vehicle. Use loops of masking tape (sticky side out) to mount each magnet, making sure that none of the magnets hang over the side of the vehicle.



3. Use a free magnet to test the polarity of each magnet mounted to the vehicle. If the polarity is not correct on any magnet, flip it over and test it again.
4. Test run your vehicle down the track by pushing it with your hand. If any of the magnets overhang the vehicle body, they will snag. Remount them and test the vehicle again. If the vehicle sticks to the track, rotate it 180° so that both sides repel instead of attract.
5. When you are certain that each magnet position and polarity is correct, you are ready to permanently mount the magnets. Be sure you are ready. Once you have hot glued the magnets to your vehicle, you will not be able to remove them. If you are not sure, repeat Steps 3 and 4. If you are sure, mark with a pencil the location of each magnet on your vehicle.
6. Use the hot glue gun to mount each magnet.

Construct Your MAGLEV Vehicle Power Source

With your vehicle body complete, you can focus on constructing the power supply. Follow your design closely and test the construction at each stage. If the design needs to be modified, make the changes on the drawing first, taking the entire design into consideration.

When your vehicle and power supply are complete, test run it on the track several times. Use a stopwatch to time it. If you have ideas to make it go faster, go back to your original design and make the changes there first. Then modify your vehicle and test run it again.

Evaluation

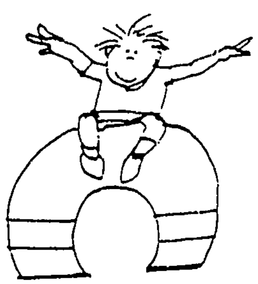
When you have made a number of test runs and are satisfied with your vehicle's performance, evaluate it yourself. Is your vehicle attractive? Is it well constructed? Does it run well? How fast is it in comparison to your classmates' vehicles?

Related Activities for an Integrated Curriculum

Write a technical report on how you designed and constructed your MAGLEV vehicle.

Research the British, German and new Disney MAGLEV and give an oral report comparing them.

Use the Science Tool Kit and a computer to time the vehicles.



MAGLEV Transportation Data Sheet

Name of Vehicle

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Team Members

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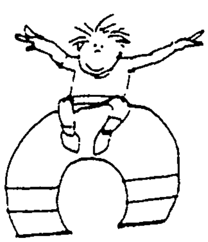
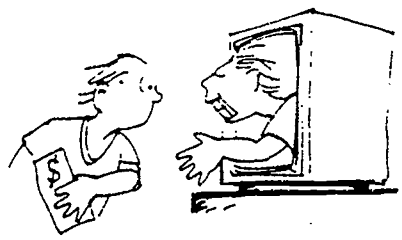
Formulae

Use the formula *Distance equals the time multiplied by the rate* (d = rt) or *Rate equals the distance divided by time* (r = d/t) to calculate the speed of your vehicle for each test run.

Make a chart or graph to illustrate the speeds for the different test runs.

	Test 1	Test 2	Test 3
Distance			
Time			
Rate or Speed			





Commercials

The Problem

This activity directs students to evaluate television commercials.

Your company has asked you to design a television advertising campaign for its product. Before you begin your design, you want to see what the competition is doing.

Research

Discuss with your teammates what products the following types of commercials might be best for.

- a story-line commercial tells a story with a beginning, middle and end
- a testimonial presents a famous person who uses the product
- a demonstration shows how the product works.
- an analogy attempts to make a viewer associate a product with a feeling or situation.

GradeLevel: 3–12

Conduct Your Test View

During the evenings of a single week, watch 15 commericals and record your findings on the Commercial Data Sheet on the following page. In the comments column, write your reasons for whether or not you would buy this product.

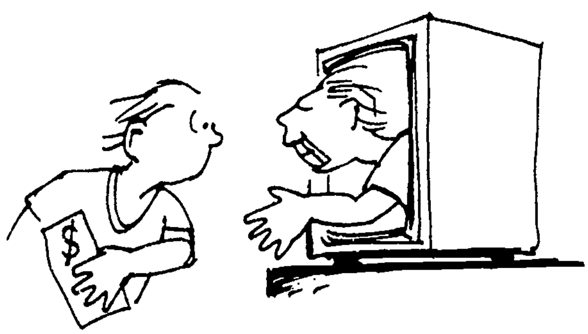
Related Activities for an Integrated Curriculum

Listen to several different radio stations and compare radio commercials to television commericals.

Research how products were advertised before the advent of radio and television.

Create a storyboard for a commercial for a product you like.

Borrow video equipment and produce a television commercial for a make-believe product.



Commercial Data Sheet

	Date	Time/ Duration	Station	Product/Message	Type	Comments
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Equipment

TechnoTool Tips

Teaching technology is more rewarding for students and staff when you have the right tools to do the job. In each of the learning activities, a short list of essential materials is given. However, the variety of the solutions to the problems may depend on what further materials are at hand.

The following standard consumable supplies should be available:

- plastic drinks bottles
- plastic detergent bottles
- polyethyline bags/sheets
- polyethyline tubing
- art straws
- plastic milk straws
- softboard pieces
- cardboard boxes
- stiff card
- beads
- paper clips
- plastic tubs
- soft iron wire
- material scraps
- sticky tape
- colored pens
- aluminum foil
- magnets
- plastic-covered electric wire
- thread
- string
- elastic bands
- plastic disposable syringes
- hardware scraps
- hobby shop scraps
- toy electric motors
- balloons
- brass paper fasteners
- pipe cleaners
- plasticine
- darning needles
- marbles
- tin lids
- polystyrene trays
- different glues
- electric & clockwork-powered toy vehicles
- 0.5-volt batteries
- popsicle sticks
- cup hooks
- drawing pins

In addition to standard classroom supplies, the basic TechnoTool Kit described below will get you off to a good start. You may want to host a "tool drive" and discover how many families are happy to donate a used tool to their child's class. Eisenhower II funds are also available for purchase of this type of equipment.

When you shop, here are some tips to help you make good selections.

Storage. A sturdy storage container makes all the difference between tools stored properly and tools no one can find. The Rubbermaid Action Packer listed below has proved to be extremely durable, surviving even the test of junior high school.

Drills. Electric drills vary. If you have a choice, a rechargeable drill eliminates the hazard of dragging electrical cords and makes sharing a single drill easier. Rechargeable drills come in voltages of 4.6, 7.2, 9 and 12 volts; the higher the charging voltage, the better the drill.

Saws. Coping saw blades are notoriously fragile. A fine-toothed blade is the proper blade for these activities; the 14" hardened blade is the best choice for straight cuts.

Knives. Exacto knives do not cut it. A retractable sheet rock knife has a longer blade and allows the kind of pressure required for many of the activities.

Glue guns. Low temperature glue guns are recommended for younger students. Although the glue sticks are expensive, having a safe tool for children with limited coordination is worth it. For older students, the trigger feed hot glue gun conserves glue better than the non-trigger type. Cordless guns eliminate power cord hazards.

Basic TechnoTool Kit

The materials listed below make up a basic kit for a class of 20 students. The total cost of each kit is approximately $500.00, depending on donations of used tools and sales. Most of these items are commonly found at reduced prices ir ‑maller hardware stores and lumberyards. Some hardware stores may even donate equipment.

Material	Source	Cost
1 Rubbermaid Action Packer 24 Gallon Tote Locker	K-Mart	$22.00
1 3/8" variable speed drill or Makita rechargeable or comparable	hardware store	$30.00 80.00
1 twist drill set 1/16" to 1/4"	hardware store	$12.00
1 flat spade bit set, 1/4" to 1"	hardware store	$11.00
5 Sandvik 14" hand saws, model 300-155T	Tool Warehouse, Barre-Montpelier Road	$12.00 each $60.00 total
5 pr slip joint pliers	hardware store	$4.00 each $20.00 total
5 pr diagonal pliers	hardware store	$5.00 each $25.00 total
5 pr long-nose pliers	hardware store	$5.00 each $25.00 total
5 quick grip bar clamp, 6"	hardware store	$12.00 each $60.00 total
5 flat blade screwdrivers	hardware store	$2.25 each, $12.50 total
5 No. 2 Phillips screwdrivers	hardware store	$2.25 each $12.50 total
5 12" combination squares	hardware store	$6.00 each 30.00 total
5 10' tape measures	hardware store	6.00 each $30.00 total
5 pr safety glasses	hardware store	$3.00 each $15.00 total
10 retractable sheet rock knives	hardware store	$3.00 each $15.00 total
1 small first aid kit	drug store	$10.00
2 low temperature mini-glue guns *	So-Fro Fabrics	$7.00 each $14.00 total
5 hot glue guns, standard size, 1/2" trigger feed**	K-Mart or Rich's	$11.00 each $55.00 total
10 7 oz. claw hammers*	hardware store	$6.00 each $60.00 total
10 16 oz. claw hammers*	hardware store	$6.00 each $60.00 total

*for elementary students
**for middle and secondary students

Special Equipment

Robotic Arms Equipment

Product	Source	Cost
5-axis robotic arm model 2000 & battery powered 2/2 joy sticks	Kelvin Electronics	$58.00 each
Battery recharger 8Ni-CAD	Kelvin Electronics	$18.00
Battery for robotic arm	Kelvin Electronics	$8.00 each
Computerized 5-axis arm	Kelvin Electronics	$199.00 each
C. C. Robot	Pneumatic Technology	

Laser Surveyor Equipment

Product	Source	Cost
1 mw modulated laser	Merridith Instruments	$328.00
Sound receiver for laser	Merridith Instruments	$88.00
0.5 mw–1.0 mw laser (non-modulated)	Pasco Scientific; Arbor Scientific, Scientific Laser Connection	$260.00–529.00
Plastic mirrors, 8.9 cm x 5.9 cm	Sargent-Welch Scientific	$8.29/6-pack
Metal mirror supports	Science Kit & Boreal Lab	$13.39/6-pack

Magnetic Levitation Equipment

Product	Source	Cost
MagLev Track with magnets	Kelvin Electronics	$89.00
Flat ceramic magnets	Kelvin Electronics	$36.00/200 magnets

Equipment for Miscellaneous Activities

Product	Source	Cost
Thin 2′ x 3′ aluminum sheets (use for modeling, can be cut with scissors)	local newspaper	$0.25 each
Clear plastic containers	local salad bar	recycle
large (30–50 cc) and small (5-10 cc) syringes	Local veterinary or farm supply	$0.59–$1.19 each
assorted beads, wood, containers, etc.	Re-store	$0.05–$0.99 each
Blue board with foam	construction dumpsters	recycle
Kevlar material scraps	sailboat supply	free (bring plastic bag)
large-gauge iron wire	coat hangers	free
Acrylic plastic scraps	Sign Company	free
Broken fluorescent light covers	School custodian	free
safety glasses (stylish)	MFASCO	$2.35/pair
electronic & solar kits (inexpensive)	Graymark	$4.25–$19.95
Books, furniture, computers, etc.	NAEIR	$150 district tmembership; products for shipping costs only

Information

Periodicals

Publication	Level	Type/Cost	Address
Air and Space	9-12	subscription, $18/year	National Air & Science Museum P.O. Box 51244 Boulder, CO 80321-1244
Connect	K-8	hands-on math/ science/ $24.50/year	Teachers Laboratory P.O. Box 6480 Brattleboro, VT 05302
Consumer Report	general	subscription	Box 53017 Boulder, CO 80321-3017
Design	9-12	system design	Mercury Airfreight International 10B Englehard Avenue Avenel, NJ 07001
Design	10-12	international $40/yr	Computer ACtion Ltd. Central House 27 Park Croydon CRO 1YD, UK
Discover	7–12	subscription	P.O. Box 420087 Palm Coast, FL 32142-9944
Exploration Science Snackbook	K–12	$19.95	The Exploration Store 3601 Lyon Street San Francisco, CA 94123 1-800-359-9899
Final Frontier	6–12		P.O. Box 534 Mt. Morris, IL 61054-7852
NASA Tech Briefs	9–12	free NASA series	NASA CASI P.O. Box 8757 Baltimore, MD 21240-9985
Odyssey	1–8	science that's out of this world	Cobblestone Publications 30 Grove St. Peterborough, NH 03458-1454
Omni	7–12		P.O. Box 3056 Harlan, IA 51593-2087
Popular Science	7–12	subscription, $13.94/12 issues	P.O. Box 5096 Harlan, IA 51593-2596
Probe			American Scientist P.O. Box 54095 Boulder, CO 80322-4095
Research & Development	9-12	free publication	P.O. Box 5833 Denver, CO 80217-9937
Scientific American	9–12	subscription	P.O. Box 3186 Harlan, IA 51593-2377

Periodicals (continued)

Publication	Level	Type	Address
Sci-Net	teacher	bulletin of events, science information, free	Vermont Dept of Education 120 State Street Montpelier, VT 05602
Science Scope	6-8	8 isues/yr	National Science Teachers Associate 1724 Connecticut Ave. NW Washington, DC 20009
Technological Horizons in Education Journal	teacher	free subscripton	T.H.E. Journal Circulation Department 150 El Camino Real, Ste 112 Tustin, CA 92680-3670
Technology Today	teacher		International Technology Education Association Reston, VA
The Big Paper	K-6	6 issues/yr ~~quarterly~~, ~~$12/year~~ 24/year	The Design Council Subscription Dep Central House, 27 Park St Croydon CRO1YD, UK
The Futurist		subscription	World Future Society 7910 Woodmont Ave. Bethesdy, MD 20814
The Planetary Report	9–12	$25 membership to the Planetary Society	The Planetary Society 65 North Catalina Avenue Pasadena, CA 91106
The Technology Teacher	K-12	membership in ITEA	Intenational Technology Education Association 1914 Association Drive Reston, VA 22091
Ties Magazine	teacher	$10 donation	3219 Arch St. Philadelphia, PA 19104
Tops Ideas	teacher	hands-on learning donation	Tops Learning Systems 10970 S. Mulind Rd. Canby, OR 97013
USA Today	K-12	technology information, $110/year	P.O. Box 79040 Baltimore, MD 21279-0040
Video Systems	9–12	free subscription	Reader Service P.O. BOX 12946 Shawnee Mission, KS 66282
Zillions: Consumer Reports for Kids	middle school	subscription, $12/year	P.O. Box 54832 Boulder, CO 80322-4832

Books

Title	Cost	Source
Amazing Models series by Peter Holland (Water Power, Balloon Power, Rubber Band Power)	$7.95 each	Tab Books, Inc. Blue Ridge Summit, PA 17294-0850
An Introduction to Craft, Design and Technology by Stuart Dunn		Small World Technology P.O. Box 607 Hillsboro, OR 97123
Arco Book of Electronics series by Helena Sturridge: (Robots: Reel to Real, Lasers: *Lightwave of the Future,The Electricity Story*	$11.95 each regular, $4.98 each special	Arco Publishing Company New York, NY
Communications Systems by Charles Johnson	$24.95	The Goodheart-Wilcox Company South Holland, IL
Craft Design and Technology by Stuart Dunn		Small World Technology P.O. Box 607 Hillsboro, OR 07123
Creative Technology: A Classroom Resource by J. Aitken and G. Mills	$118.00 (and worth it)	Small World Technology P.O. Box 607 Hillsboro, OR 07123
Earth Science by Robert Bonnet & Daniel Keen (science projects)	$9.95	Tab Books Blue Ridge Summit, PA 17294-0850
Electronic Projects Made Easy by Stuart Dunn		Small World Technology P.O. Box 607 Hillsboro, OR 07123
Exploratorium Science Snack Book by Exploratorium Teachers Institute	$19.95	Exploratorium Mail Order 3601 Lyon Street San Francisco, CA 94123
Exploring Technology (second edition) by E. Allen Bame & Paul Cummings		Davis Publications, Inc. Worcester, MA
Exploring Transportation by Johnson, Farrah-Hunter	$24.95	The Goodheart-Wilcox Company South Holland, IL
Food for Thought: Edible Earth Science	$11.95+$2.50 S&H	Idea Factory, Inc 10710 Dixon Drive Riverview, FL 33569
Flying Circus of Physics with Answers by Jearl Walker	$14.95	John Wiley & Son New York, NY
Gravity Power	$7.95	Tab Books Blue Ridge Summit, PA 17294-0850
Great Unsolved Mysteries of Science by John Grant	$6.98 special Atlanic Book Warehouse	Chartwell Books, Inc. 110 Enterprise Avenue Secaucus, NJ 07094
Hand on Nature edited by Jenepher Lingelback	$16.95	The Sewall Co. Box 529 Lincoln, MA 01773

Books (continued)

Title	Cost	Source
Handbook for Space Colonists by Harry Stine	$11.95 $3.98 from Atlantic Book Warehouse	An Owl Book Holt, Rinehart and Winston New York, NY
Handbook for Space Pioneers by Stephen Wolfe and Roy L. Lysack	$12.00 $2.98 special	Westbridge Books A Division of Davis & Charles
The Hologram Book by Steven A. Felier and Joseph E. Kasper		Prentice-Hall, Inc.
Hydroponics for the Home Gardener by Steward Kenyon	$12.95	Key Porter Books 70 The Esplanade Toronto, Ontario, Canada M5E R2
Illusion of Lifelike Robots by Gene William Poor		Small World Technology P.O. Box 607 Hillsboro, OR 97123
Laser Activities for the Classroom by Harold Wood, Joe Verboys and George Evans		Davis Publications, Inc. Worcester, MA 01608
Laser Cookbook: 88 Practical Projects by Gordon McComb	$7.98 special	Tab Books, Inc. Blue Ridge Summit, PA 17294-0850
Science Now: Understanding the World of Tomorrow	$21.95 regular $6.98 special	Arco Publishing, Inc. New York. NY
Solar System Log by Andrew Wilson	$15.00 regular $4.49 special	Jane's Publishing, Inc. 115 Fifth Avenue New York, NY 10003
Superconductivity: The New Alchemy by John Langone	$19.95 regular $4.49 special	Contemporary Books Chicago, IL
Technology Activities Idea Book 1		International Technology Education Association 1914 Association Drive Reston, VA
Usborne Illustrated Series Invention & Discover (Robotics, Lasers, Ecology, Physics and other titles)	$7.95 or $6.95 each	Usborne Publishing Ltd. 20 Farrick Street London WC 2E 9BJ UK
What the World Needs Now by Steven Johnson	$7.95	Ten Speed Press Berkeley, CA
Young Scientist Series (Jets, Electricity, Stars & Planets, Space Flight, Undersea, Human Body)	$7.95 each	EDC Publishing Co. 10302 E. 55th Place Tulsa, OK 74146

Software

Software	Level	Type	Source
Car Builder (Apple II)	8-12	simulation design, construction, testing of automobiles	Modern School Supply
Science Tool Kit (Apple II, IBM)	4–9	3 modules: Speed and Motion, Earthquake Lab and Body Lab	Broderbund
Robot Builder I & II (Apple II)	7–12	robot design problems (challenging)	Kitchen Software
Sim Earth (Macintosh, IBM)	9–12	simulation of 4 time scales: Geologic, Evolution, Civilization, Technologic	Broderbund
Earthquest; Ecology (Macintosh)	6-12	hypercard stacks of interactive games & simulations	Earthquest Inc.
Physics (Macintosh)	9–12	mechanics, velocity, orbital motion	Broderbund
Interactive Nova (Macintosh & videodisc)	5–12	WGBH science series on animals, life science, global ecology	Scholastic
Science Explorers (Apple, IBM)	1–6	interactive discovery science including weather, simple machines	Scholastic
Appleworks Science Database (Apple II)	7–12	weather & climate lab	Scholastic
Playing w/ Science: Temperature (Apple II)	K-7	experiments in temperature	Wings for Learning/Sunburst
Sun Lab (Apple II)	4–8	simulations of astronomy	Wings for Learning/Sunburst
Build a Circuit (Apple II)	4–8	simulation of electric circuitry	Wings for Learning/Sunburst
Data Insights (Apple II)	7–12	science activities using data from life, earth, physical, biological sciences	Wings for Learning/Sunburst
Experiments in Physical Science (Apple II)	4–8	measure light, temperature, sound data for analysis	Wings for Learning/Sunburst
Space Databases (Apple II)	4–12	database files on manned space missions & space probes	Wings for Learning/Sunburst
The Explorer Series (Macintosh)	8–12	simulations in biological & physical sciences: AC/DC circuits, diffraction, gravity, population ecology	Wings for Learning/Sunburst

Multimedia

Title	Type	Source
Astro Smiles, Space Suit, L&A, Mars, Toys in Space	video: camera in space, imaging	NASA Resource Center; available from Vermont College Computer Resource Center
Beyond 2000	television	PBS, cable TV
Discovery Channel: Inventions I, II & III	video	Smithsonian Institute
Ergonomics	slide set	BP Educational Service
Solar: Four Square Feet of Sunshine	18 minute video on cooker box construction	Solar Box Cookers International
Sun Racer	video: solar power auto race across Australia	General Motors; out of print, copy available from Tom Keck
Tucker: The Man and His Machine	video of grass root auto company	video rental store

Resource Addresses

Sources for Special Equipment

All Electronics Corp.
P.O. Box 567
Van Nuys, CA 91408

American Science & Surplus
601 Linden Place
Evanston, IL 60202

Arbor Scientific
P.O. Box 2750
Ann Arbor, MI 48106
1-800-367-6695

Chaney Electronics, Inc.
P.O. Box 4116
Scottsdale, AZ 85261

Cymar Scientific
131 N. Broad St.
P.O. Box 530
Carlinville, IL 62626

Devics Plastic, Inc.
P.O. Box 651043
133 West haven Ave.
Salt Lake City, UT 84165
1-800-533-5843

Edlie Electronics
2700 Hempstead Tpke
Levittown, LI, NY 11756-
1-800-645-4722

Edmund Scientific
101 East Gloucester Pike
Barrington, NJ 08007-
1380

Global Computer Supplies, Dept 3A
11 Harbor Park Drive
Pt Washington, NY11050
1-800-227-1296

Herbach and Rademan
18 Canal Street
P.O. Box 122
Bristol, PA 19007-0122
1-800-848-8001

IASCO Plastics
5724 West 36th St.
Minneapolis, MN 55416
1-800-328-4827x2662

Kelvin Electrronics
10 Hub Drive
Melville, NY 11747
1-800-645-9212

Learning Spectrum
1390 Westridge Drive
Portola Valley, CA 94028
1-800-USE-SOS-2

Learning Things, Inc.
68A Broadway
P.O. Box 436
Arlington, MA 02714

Merridith Instruments
P.O. Box 1724
Glendale, AZ 85301

MFASCO
P.O. Box 386
Roseville, MI 48066-0386
1-800-221-9222

NAEIR
P.O. Box 8076
Galesburg, IL 61401

Northern Hydraulics Inc.
P.O. Box 1724
Glendale, AZ 85301

Omnitron Electronics
280 N. Midland Avenue
Bldg. 2-2A
Saddle Brook, NJ 07662

Pasco Scientific
P.O. Box 619011
10101 Foothills Blvd.
Roseville, CA 95661-9011
1-800-772-8700

Pitsco
1004 East Adams
Pittsburg, KS 66762
1-800-835-7777

Sailworks
Pike St
Burlington, VT 05401

Sargent Welch Scientific
PO Box 1026
Skokie, IL 60076-1026

Science Kit & Boreal Lab
Tonawanda, NY 14150
1-800-828-7777

Scientific Laser Connection
P.O. Box 433
Glendale, AZ 85311

Small World Technology
P.O. Box 607
2092 East Main Street
Hillsboro, OR 97123
1-800-542-3555

Surplus Center
1015 WEST "O" STREET
P.O. Box 82209
Lincoln, NE 68501-2209
1-800-228-3407

Technology Creators
HC 1 Box 1625
Soldotna, AK 99669
1-800-728-3174

TESCO
5724 West 36 Street
Minneapolis, MN 55416-
2594
1-800-328-4827, ext. 2662

Trans Tech Creative Learning Systems, Inc.
9899 Hibert, Suite C
San Diego, CA 92131
1-800-458-2880

Software Developers and Distributors

Auto Desk
2320 Marinship Way
Sausalito, CA 94965

Broderbund Software-Direct
Dept 15
P.O. Box 6125
Novato, CA 94948-6125

Earthquest Inc.
125 University Ave.
Palo Alto, CA 94301

Edu Soft "A"
45 Route 4 West
Woodstock, VT 05091
802-457-4161

Educational Resources
1550 Executive Drive
Elgin, IL 60123
1-800-624-2926

Education Department
State of Vermont
120 State Street
Montpelier, VT 05620
Attn: Robert Dunn

Fas-Track Computer Products, Dept C1
7030C Huntley Road
1-800-927-3936

Kitchen Software
903 Knebworth Ct.
Westerville, OH 43081

MacWarehouse
P.O. Box 3012
Lakewood, NJ 08701
1-800-255-6227

Modern School Supply
P.O. Box 958
Hartford, CT 06143
1-800-243-2329

Pre-Engineering Software
1266 Kimbko Drive
Baton Rouge, LA 70808
1-504-769-3728

Scholastic Inc
2931 E. McCarly St., PO Box 7502
Jefferson City, MO 65102
1-800-541-5513

Wings for Learning/Sunburst
1600 Green Hills Rd.
PO Box 660002
Scotts Valley, CA 95067
1-800-321-7511

Veriner Software
2920 SW 89th Street
Portland, OR 97225

Multimedia Sources

BP Educational Service
Britiannic House
Moor Lane
London EC2Y 9BV, UK

Computer Resource Center
Vermont College
Montpelier, VT 05602

ICS Warehouse, Inc.
1802 East 18th Street
Tucson, AZ 85719-6509
1-800-528-1593

Lousiana Nature and Science Center
11000 Lake Forest Blvd.
New Orleans, LA 70127.
Telephone 504-246-5672.

National Audio Visual Supply
1 Madison Street
E. Rutherford, NJ 07073
1-800-528-1593

NASA Central Operation of Resources for Educators
Lorain County Joint Vocation School
15181 Route 58 South
Oberlin, OH 44074

PBS Video
1320 Braddock Place
Alexandria, VA 22314-1698

Smithsonian Institute
1000 Jefferson Drive SW
Washingtn, DC 20560

Solar Box Cookers International
1724 11th Street
Sacramento, CA 95814

International Technology Education Association
1914 Association Drive
Reston, VA 22091
703-860-2100