CHEAPBOOK 2

More Inexpensive Exhibit Ideas

Compiled and Edited by Paul Orselli

INTRODUCTION to The EXHIBIT CHEAPBOOKS

There are hundreds of interesting and inexpensive exhibit ideas gathered in museums all around the world. In an effort to spread these ideas, I originally suggested having at least one regular session at each ASTC conference with the theme of sharing “cheap” exhibit ideas and creating some written record of how to replicate these simple and successful exhibit components with the museum field.

The Exhibit Cheapbooks were always intended to stress the “worldwide” nature of museums.
To that end, you will find varied exhibit ideas from many countries inside.

Every Cheapbook has been a 100% volunteer effort. Sincere thanks to all of the contributors!

Please enjoy and adapt the ideas found in The Exhibit Cheapbooks. Think of the entries not as shop drawings, but rather creative inspiration and jumping-off points for your own exhibit creations.

Have fun!

Paul Orselli

Paul Orselli, Cheapbooks Instigator and Editor
POW! (Paul Orselli Workshop, Inc.)
1684 Victoria Street
Baldwin, NY 11510
< paul@orselli.net >

Disclaimer

The exhibits and other descriptions of equipment contained in The Exhibit Cheapbooks have been compiled using sources believed reliable, and they represent the best opinion on the subject as of their publication dates. However, no warranty, guarantee, or representation is made by the contributors, the editor, nor ASTC, nor any other entity as to the correctness or sufficiency of any information herein. Neither the contributors, the editor, ASTC, nor any other entity assumes any responsibility or liability for the use of information herein, nor can it be assumed that all necessary warnings and precautionary measures are contained in this publication.

Credit

CHEAPBOOK TWO --- EXHIBITS TABLE OF CONTENTS

Air Table

Description

An air table provides a constant "conditioned" vertical column of air to use for a variety of aerodynamic experimentation. An endless array of "flyers" can be constructed of paper, paper cups, coffee filters or other light material and flight tested in the air stream. One obvious goal is to construct an aircraft that will stay aloft in the air stream for as long as possible.

An inexpensive version of an air table be assembled using everyday products and materials.

Materials

- 1 multi-speed box fan
- 4 bricks
- 1 plastic 5 gallon bucket
- 1 cardboard box
- 1 16" x 16" piece of egg crate light diffuser
- duct tape

Procedure

Place the fan facing up on the four bricks. Cut the bottom out of the five gallon bucket and place it on the fan upside down. Cut pieces of the cardboard box to cover the exposed corners of the fan not covered by the bucket and tape them on. Finally, place the egg crate diffuser on the bucket and you're ready for takeoff!

The diffuser is really the important part of the device. The air that a fan blade produces is very turbulent and the diffuser significantly reduces that turbulence, which allows the aircraft to stay in the air column for a longer period of time. The cardboard blocks unwanted air from outside the bucket.

This design can be made considerably more sophisticated and durable by using different components and building everything into a cabinet. Substitute a shaded pole fan motor, a speed controller, a cluster of 2" diameter PVC pipes (instead of the egg crate), a cabinet of your design, and you have an air table that will last for years. Some design suggestions:

- Use a 16" fan blade.
- Use a 16" diameter exit hole in the cabinet.
- Provide enough air intake for the fan.
- Cut the PVC tubes 12" long.
- Use PVC glue to glue the cluster of 12" tubes together. This cluster of tubes becomes the air diffuser.
- Expanded metal works well to set the tubes on.

Your cabinet design can be as simple or as complex as you desire, as plain or as fanciful as your imagination will allow, but the same basic principles all apply. Air is moved through a chamber and conditioned to lessen the inherent turbulence. In this case, the PVC tubes condition the air instead of the egg crate.

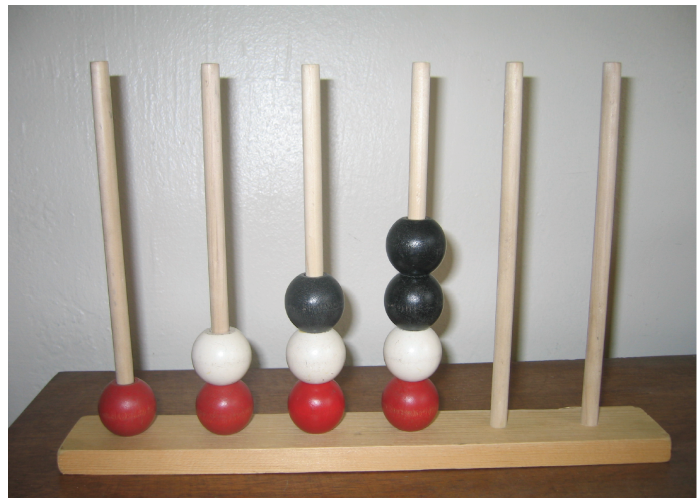
Air table designed by Dennis Gabbard, David McCauley and Robert Lindsey

Originally submitted to Cheapbook Two by Dennis Gabbard

Bead Loom

Description

This is a colorful, tactile activity that introduces the concepts of patterns and pattern making. This component is especially appealing to younger visitors and child/adult pairs.



Materials

- Wooden dowels (at least 1/4 inch diameter.)
- Large wooden beads.
  (Available from craft supply catalogs.)
- Storage container for beads.
- Birch plywood or hardwood for dowel base.

Construction

First decide how many rows and columns of beads you want to set up on your Bead Loom. This will determine the number and length of the dowels you use. The dowels in the Bead Loom pictured are about 12 inches high.

Attach your dowels to a wooden base by drilling holes into the base, and gluing the dowels into place.

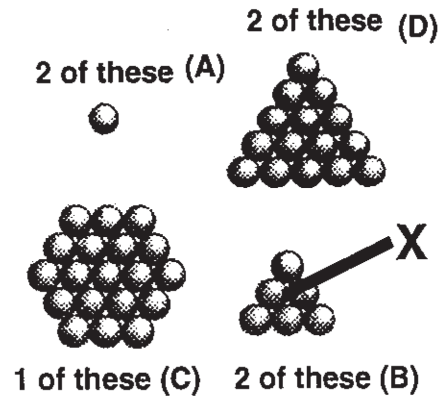
Lastly, attach your storage containers to the wooden base holding the dowels. Multi-compartment storage containers are often available at stores with home furnishing sections such as IKEA or Target. Your storage container should have a different compartment for each color of bead that you use.

Originally submitted to Cheapbook Two by Paul Orselli

Closest Packed Spheres Puzzle

Description

The seven pieces below can be fit neatly (without forcing) into a cubical box.



Materials

- 63 ping-pong balls (see Editor's note below.)
- Duco Cement to cement balls together.
- Clear acrylic
- Plastruct brand Plastic Weld solvent cement'
- Testor's brand spray paint
- Wood for base
- Small screws or escutcheon pins.

Construction

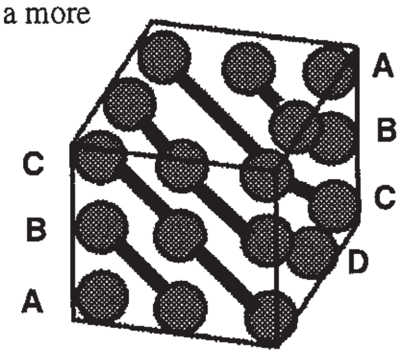
Create a box that is open at the top, with clear plastic sides and a wooden base. (See illustration below.) The inside is a cube with edges theoretically 3.828x the diameter of the balls used. Make it a tiny bit bigger!

The sides should be fastened to the base with small screws or escutcheon pins. The vertical edges should be cemented with Plastic Weld.

To avoid losing the single balls, cement them to the 6-ball triangle as indicated in the diagram above by the **X**.

Editor's Note

Several years ago Dan served as an advisor for the travelling exhibition, ***Geometry in Our World***, that used a more robust version of this device involving a larger acrylic box and tennis balls strung and tied together by an experienced sailor using a stout cord.



Simplified view of solution
(Some balls removed for clarity.)

Colliding Washers

Description

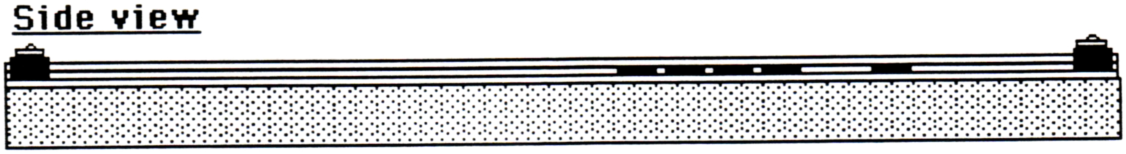
A string of large steel flat washers is confined to slide freely along an acrylic track. The model shown here has five washers in the track. The intended activity involves sliding one or more washers into the others. (Of course, creative visitors try many different and unpredictable variations!) Theoretically, if one washer is slid into the other four, then one washer is ejected from the back end of the group, and the first washer is stopped at the front end of the group. Similarly, sliding two washers into the remaining three cause the last two to separate from the group.

This exhibit demonstrates conservation of momentum (mass **x** velocity) in an inelastic collision. In a perfectly elastic collision, no kinetic energy is lost to other forms.

Construction

The bumpers at either end of the track are made from the top and bottom halves of a one-hole rubber stopper, held to the track by a round-head screw into the baseboard with a good sized flat washer under the screwhead.

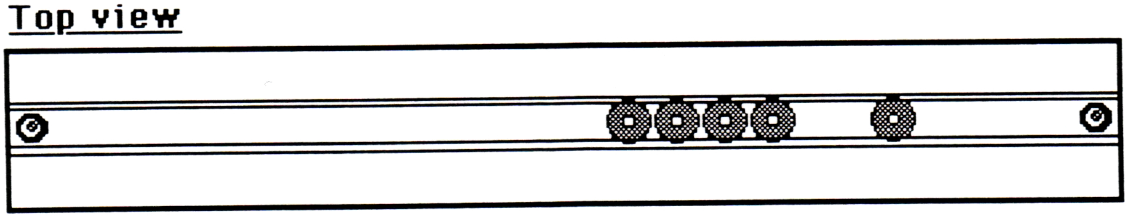
Side view



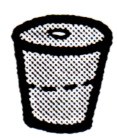
overall length, about 20 inches (1/2 meter) more or less

colliding objects are steel flat washers for 1/2 inch or 9/16 inch (12 or 14 mm) bolts (inserted into track with the rounded edge down)

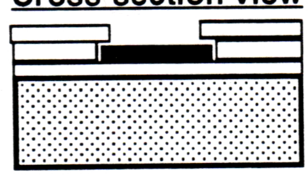
Top view



One-hole rubber stopper (#5, #6, or #7 is good.) Cut in half, and fasten one half to each end of base board with substantial round-head screw. Use good-sized washer on top.



Cross-section view



acrylic strips for base and guides, carefully positioned so that washers slide freely but closely guided.

base board: 3/4 inch thickness is suitable.

Originally submitted to Cheapbook Two by Albert J. Read

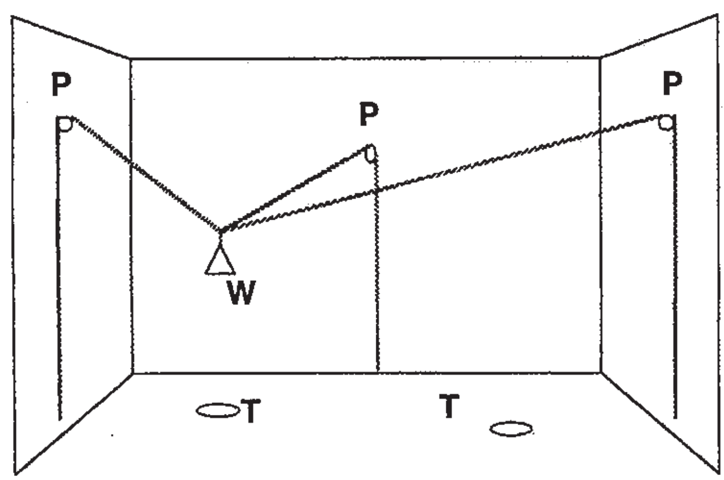
Device That Needs A Name (Three Pulleys)

Description

The original of this device was built in a tiny museum in Israel, and the inventor's name is unknown. It had only two pulleys that were ten or twelve feet apart and approximately eight feet above the floor. There was some kind of a weight and a bucket or trash basket in the middle.

Here, the design consists of three pulleys. The challenge is to get the weight into the bucket using only the ropes. With this basic arrangement the "target" must be on a line directly under the rope between the two pulleys, otherwise the challenge can't be met. The wonderful thing about this is that it requires two participants to cooperate and communicate to meet the challenge. For safety, the weight ought to be soft, e.g. tennis balls in a net or bag.

This basic idea can be adapted to fit your site. A large scale version could just as well be built with the pulleys mounted on two walls that meet at a right angle. A third rope and pulley can be added to make the challenge more complex. A table-top version is also possible, though it will need to be at least five or six feet wide. For added fun, the targets can be switches that activate sounds and/or lights.



P= Pulley W= Weight T= Target

Originally submitted to Cheapbook Two by Dan Goldwater

Electricity to Magnets to Electricity

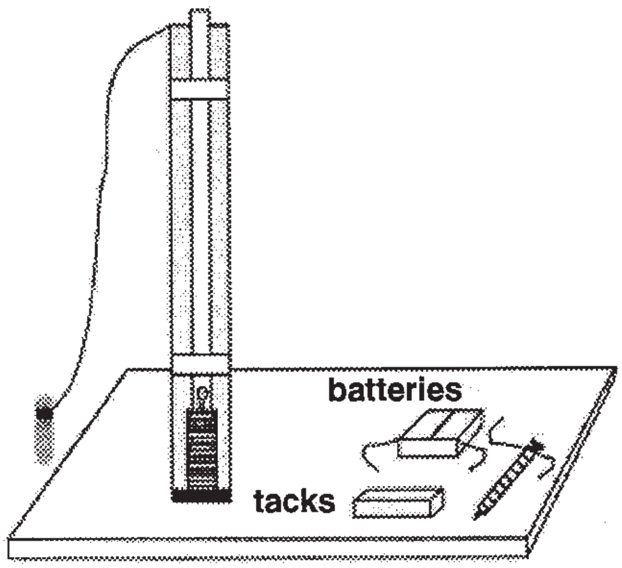
Description
This exhibit demonstrates that a moving magnetic field induces a current (Faraday's Law.) It also demonstrates the inter-relatedness of electricity and magnetism.

Materials
- base board (we used a sink cut-out donated by a local counter-top contractor)
- wooden board, about 6 inches wide, 3 feet long
- battery holder
- rechargeable batteries
- a nail, several thumb tacks
- insulated wire
- cow magnet
- enamel covered copper wire .006" diam.
- clear acrylic pipe, about 3/4 inch ID (big enough for the magnet to pass through)
- small rubber pad
- nylon cord
- one LED with wire leads attached

Construction
Attach the battery holder to the board, and insert the batteries. Wrap the insulated wire around the nail (about 200 turns). Strip a SMALL amount of the ends of the wire on the nail (we made it so the wire of the electromagnet had to be held, not twisted together—it prolongs the life of your batteries.) This is the part that shows that electricity can be used to make a magnet.

Wrap about 1000 coils of enamelled wire around the bottom 6 inches of the clear tube. Use a lathe to get nice even turns. Connect the LED to the ends of the copper wire. Secure the clear tube to the board, attaching both perpendicular to the base board, rubber pad at the bottom. (This is to cushion the magnet when it drops).

Attach one end of the nylon cord to the cow magnet, and the other end to the upright board. When the visitor drops the magnet through the tube, the moving magnetic field will generate a current in the copper coil, which will light up the LED. This part of the exhibit shows that a magnet can be used to make electricity.



Notes

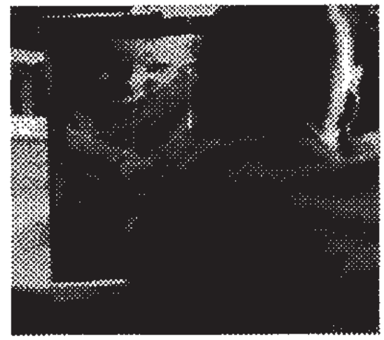
The batteries need to be checked regularly to be sure they contain enough charge to make an electromagnet. People of all ages are amazed that a magnet can make electricity.

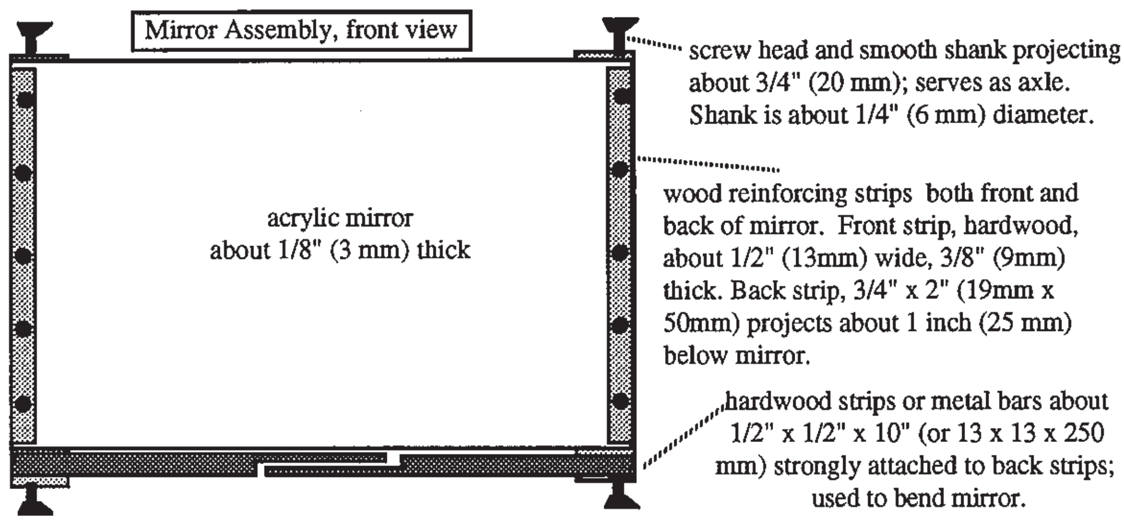
(This component was developed by LaDawn Haws and Felix Wolfe.)

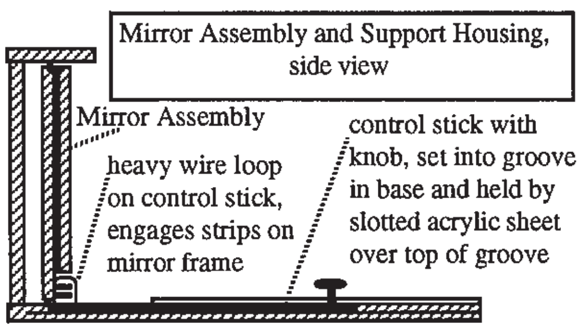
Originally submitted to Cheapbook Two by LaDawn Haws

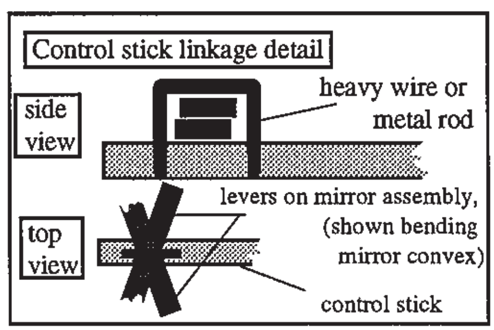
Face Changer

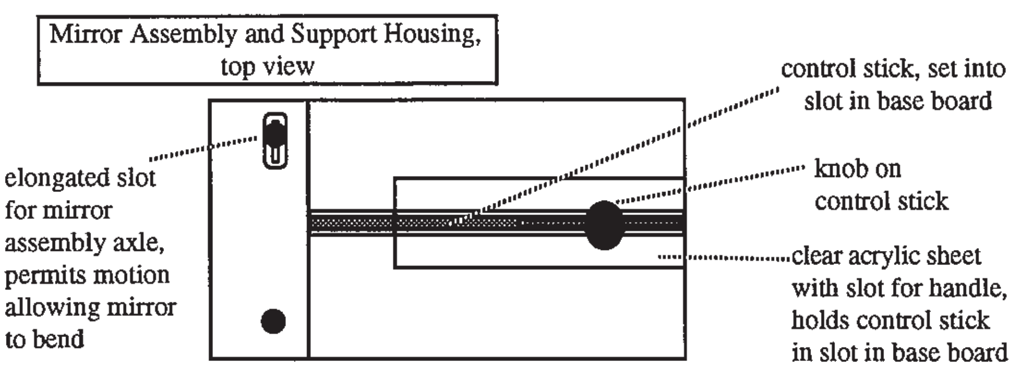
This exhibit allows you to change a mirror from convex to concave. As you look at your reflection, you can manipulate the mirror to alter the shape of your face.







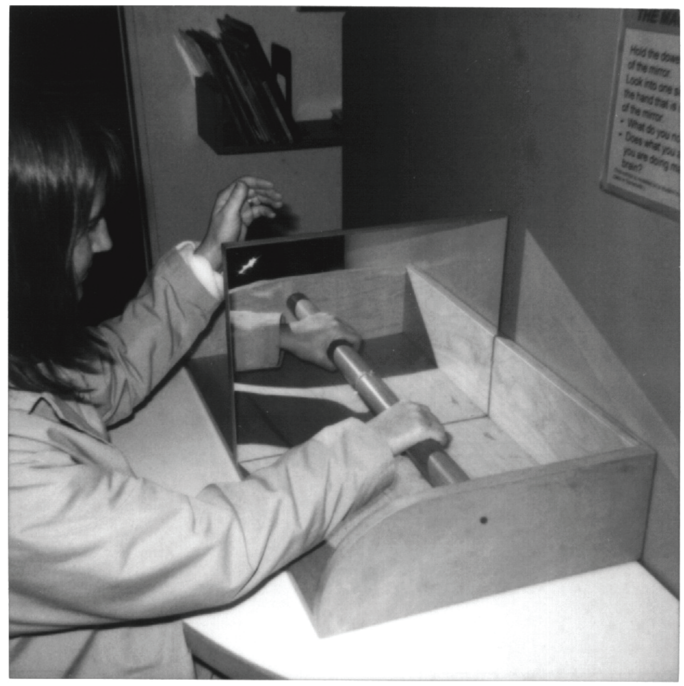




Originally submitted to Cheapbook Two by Albert J. Read

Hand “Mirrored”

Description
This optical illusion consists of a large dowel which passes through the center of a double sided mirror. Hold the dowel with one hand on each side of the mirror. Look into one side of the mirror then remove your hand from the other side. Look in the mirror. It will appear as if you are still holding the rod with both hands. By moving your hands in different ways you can expand this illusion.



Materials
- two 1/8" thick pieces of 14"x14" acrylic mirror
- 1" diameter by 24" long wood dowel
- cable ties
- glue (we use "Household Goop")

Construction
Glue the two sheets of acrylic mirror together and let dry.

Mark the center of the mirror and cut a one inch diameter hole. Slide the dowel through the hole half way. Fasten a cable tie around the dowel on each side of the mirror as close to the mirror as you can. This is the exhibit in its simplest form.

This component can easily be made into a more durable exhibit by making a wooden frame to hold the mirror in a fixed position.

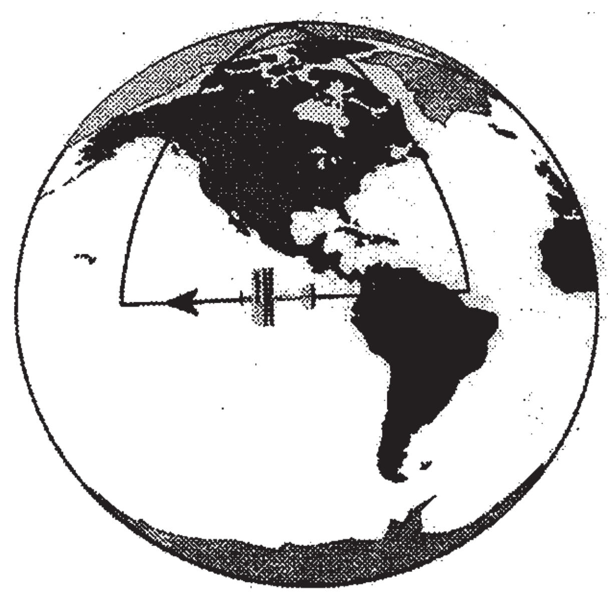
Originally submitted to Cheapbook Two by Geoff Nelson

Here's Looking at Euclid

Description
It's a funny old life this exhibits building lark, and one's sources of inspiration are not always under one's full control. Exhibit ideas can come from a new component, "I know just what I could do with this!" or a sponsor's product,"Wizzo Widgets are the most exciting product of the Twenty-first Century" or a neglected corner of the National Curriculum for Science, "We really should show Bloggs Effect to the Key Stage 1's ."

This one came from none of these sources and I've never actually made a complete version of it for Techniquest. Still I offer it to the world together with the account of its origin, in the hope that someone somewhere will be inspired to take it further.

Techniquest uses titles for all its exhibits, these are in part genuinely instructive and in part a demonstration that scientists are not old fuddy-duddys. This, in Techniquest, takes the form of appalling puns. For example, **Cagey Creatures** for our stick insects, in part because: they are "cagey" they hide from you, they are in cages, and the exhibit was devised by Ken Gleason (KG). Imagine my sadness when I had a great pun, but no exhibit idea to go with it. Inspiration came when I attended an Exhibit Developers Workshop at the Exploratorium in 1991. They were planning their navigation show and this exhibit idea arose from a short thought experiment.



Imagine you are in an incredibly fast plane flying along the equator due west. Using equallyincredible air brakes you subject yourself to massive G-forces by turning through 90 degrees to fly due North until you reach the North Pole where you turn again through 90 degrees to head due south. Here there is a problem, in that every direction is due south, but bear with me, the turn is through 90 degrees, whatever the resulting direction may be. Your wonder plane flies due south to the equator turns through 90 degrees and heads due west again until it joins up with its original flight path. The resulting path is a three-sided figure with three 90 degree turns giving a 270 degree triangle.

This is only possible because you are on the surface of a sphere, the Earth.
Even more amazingly real navigation does work this way!
Euclid defined geometry on a plane so this is non-euclidean, hence the title.

At the same workshop, Stuart Kollhagen of Questacon in Australia considerably improved the idea by cutting a square bottomed U-shape out of paper. When it is laid on the sphere the ends match up to make a triangle, so this is the un-bent 270 degree triangle.

A Non-Euclidean Triangle.

The exhibit was then made from a plastic globe filled with parcel foam. The triangle was made from thin urethane sheet and given a stand with a flat square around which the "triangle" fitted.

Critique: This is a one shot, one point exhibit which may only lead to confusion if presented to children at the wrong time in their mathematical education. It's fine for an exhibition on Navigation or Map Projections presented to an interested audience. For this reason, I've never made it for Techniquest, but perhaps you can add the extra twist or insight which makes it worth building. For me, I am still put in mind of the ancient exhibit fabricator's lament,
" There's an exhibit in there somewhere".

Finally, my colleagues in the Techniquest design office would like the world to know that the foregoing is all Harry White's own work and that they told him not to do it anyway.

Originally submitted to Cheapbook Two by Harry White

Howling Cats

Description

If your ambition in life is to play the National Anthem on elastic bands, as opposed to brass bands, then this is the exhibit you have been waiting for.

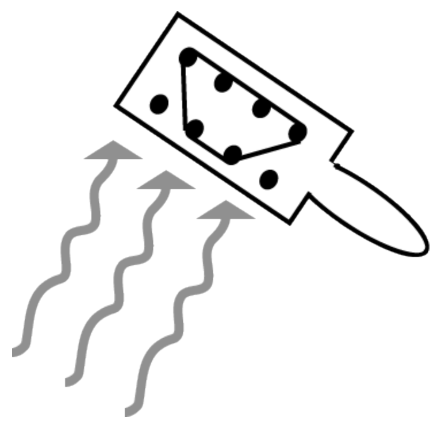
If you stretch an elastic band over the nozzle of a blower, then you can get the band to vibrate and emit a howling noise. Stretch the band and the pitch rises. Use several bands and you get sweet music, well ... in a manner of speaking if you are an afficionado of the Scottish bagpipes.

How the exhibit came about

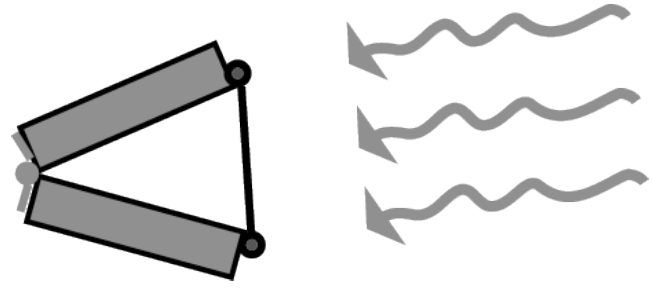
I am a compulsive paper clip destroyer, train ticket ripper and worse, roller of airplane tickets into tight tubes before checking in. Perhaps I should start smoking. Anyway, the idea came when I was fiddling around with an elastic band in the airstream of a Bernoulli blower. We were showing some visitors around at the time, and suddenly the howling started. Aha! There's an exhibit in this thought I. Aha! We are dealing with a bunch of nutters thought our prospective client.

Construction

Take a block of wood and drill several holes and insert dowels approximately 6 inches in length. Place the assembly in the horizontal airstream of a fairly powerful blower and stretch various elastic bands between the pegs to create a cats cradle and voila! Howling Cats!



You can make a playable version by stretching the bands across a hinged **V**-shape. Manipulate the arms of the **V** to vary the tension and move the **V** to introduce different bands to the airstream. You might call this version an "eeeowlian harp."



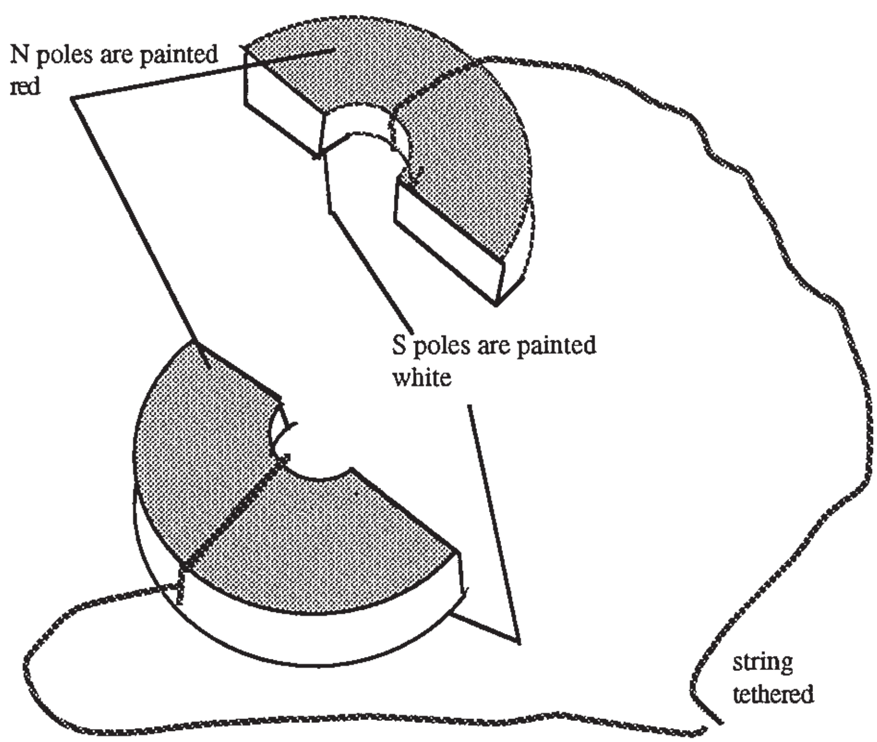
Originally submitted to Cheapbook Two by Steve Pizzey

Humpty-Dumpty Magnets

Description
Try to put the two halves of a broken ceramic ring-shaped magnet back together. It cannot be done, and is a good illustration of "like poles repel." Our visitors, young and old, enjoy this activity, which often brings an "Aha!" after a few moments of puzzled frustration.

Construction
To identify the polarity of the pieces, we painted the N poles red and the S poles white. The magnets are a little over 1" (25 mm) diameter and about 1/4" (6 mm) thick. You can find them at Radio Shack, unpainted.

We tie and glue string to the magnet halves and tether them to an acrylic plastic sheet about 1/8" x 6" x 8" (3 x 150 x 200 millimeters.) This keeps the magnets from wandering off. The acrylic sheet also supports a brief explanatory label.



Originally submitted to Cheapbook Two by Albert J. Read

Kaleidoscope Corner

Description
This is a multifaceted exhibit (no pun intended) which uses mirrors, light, and other objects to create taleidoscopes and kaleidoscopes. These "Create-a-Scopes" can be put together, taken apart, and put back together again with ease. Other components include a horizontal light box, a set of creative object cases, a window or vertical light-box, and tabletop kaleidoscope mirrors.

Background
A kaleidoscope is a tube with mirrors mounted inside, and brightly colored, moveable objects at one end. Looking through the clear end, the colored objects will be transformed into changing patterns as their image is reflected off the mirrors.
By removing the colored pieces, so that both ends are open, transforms your kaleidoscope into a taleidoscope.

Most people have seen kaleidoscopes with three equal-sized mirrors, the traditional set up. But is it possible to have a kaleidoscope with three different sized mirrors? What about two mirrors? What about fourmirrors? What would happen if you used four mirrors, all of different sizes?
This exhibit lets visitors pose and answer questions like these and more.

Materials

- 1/8 inch acrylic mirrors, in bulk or cut to size (minimum of 7" X 30")
  Try your local glass and mirror company, or AIN Plastics
  You can also use "Cuttable Mirrors," available through most science supply companies.

- 1/8" solid dark-colored, non-reflective, matte-finished Plexiglas sheet, in bulk or cut to size. Ask your local glass and mirror company, or AIN Plastics.

- Sticky back 1/2" Velcro dots,hook/teeth-side.
  You can find these at your local fabric store, or office supply store.

• Non-Sticky back 1/2" Velcro strips or roll, loop/fuzzy side.
Try your local fabric store.
• Colored stickers
• Sandpaper
• Clear, heavy-duty bookbinding tape [library supply companies.]
• Six 4" X 5" acrylic mirrors or "Cuttable Mirrors"
• Small portable light boxes [Science supply companies.]
• Clear compact disc cases

Construction

1. Cut five each of the mirror pieces in the following four sizes:
   7" X 1/2"   7" X 1"   7" X 1-1/2"   7" X 2"

2. Cut two each of the solid colored Plexiglas pieces to the following sizes:
   7" X 1/2"   7" X 1"   7" X 1-1/2"   7" X 2"

3. Sand and round off the edges of each piece.

4. Clean, then color code each piece with the stickers.
   (Choose one color for the 1/2" pieces, a different color for the 1" pieces, etc.)

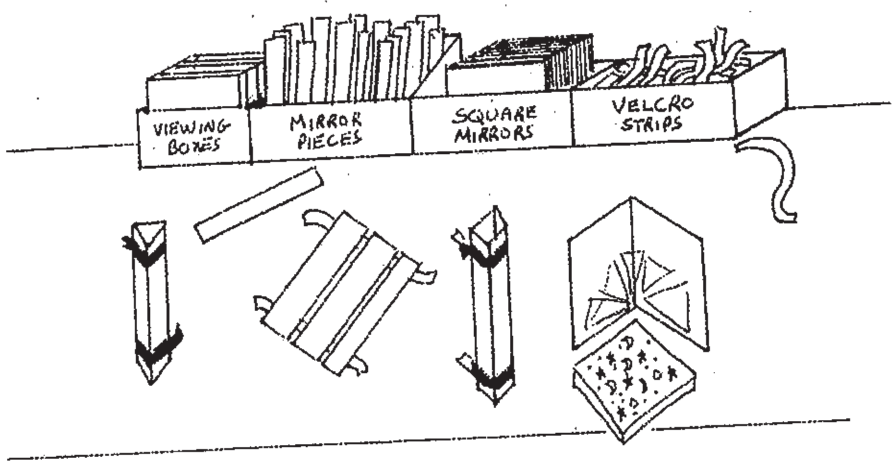
5. Put sticky back Velcro dots 1/2" from the top and bottom on the back (non-reflective side) of each mirror piece, and on the back of each solid colored Plexiglas piece.

6. Cut the non-sticky back Velcro strips into 4" and 8" strips.

7. Using the clear, heavy-duty, book-binding tape, secure the 4" X 5" mirrors together on the front and back to create a pair of "hinged" mirrors.

8. Fill the CD cases, or other containers, with a variety of small colorful objects such as feathers, sequins, leaves, dried flowers, small marbles, etc.

Exhibit Set Up
The exhibit can be set up with just the mirrors and Velcro, but providing the colored object boxes, light boxes, and table-top kaleidoscopes gives the visitor more options.



You may want to provide examples as shown above. Encourage visitors to explore different numbers and combinations of mirrors and plexi pieces as they create their scopes. Try shining light on, or behind, objects. Do objects appear different when you change the light source?

Special Thanks to Maria Conley of the Discovery Museums in Acton, Massachusetts for helping in the development of this component.

Originally submitted to Cheapbook Two by Steve Lechner

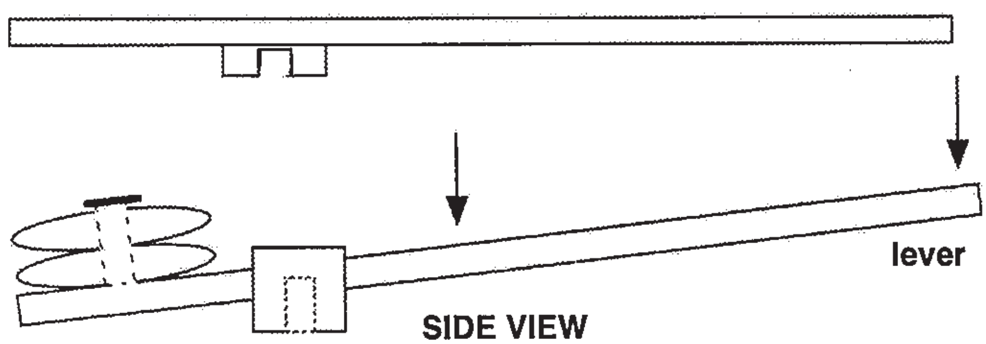
Lifting With Levers I

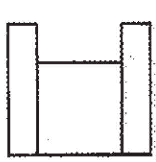
Description
This exhibit demonstrates how varying the length of a lever changes the amount of force needed to lift a weight.

Materials
- one 6-foot 2 x 4 piece of lumber
- two dumbbell weights (we used 20 lb plates, labelled)
- wood for the fulcrum
- dowel and washer (to hold the weights)
- rubber pad/doormat (to protect the floor under the weights)

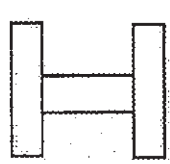
Small space version
Attach two pieces of wood (scrap wood works fine) to the bottom of the 2 x 4 approximately 1/4 distance from one end (see drawing.) This will provide a slot to rest on the fulcrum. Install the dowel on the same end of the 2 x 4. Now, add the weights. Put a large washer on top to keep the weights in place. The fulcrum is an H-shaped piece (see drawing below.)

Push down at the places indicated by the arrows. It is easy to lift the weights if the lever arm is long, but it is much more difficult if the force is applied near the fulcrum.



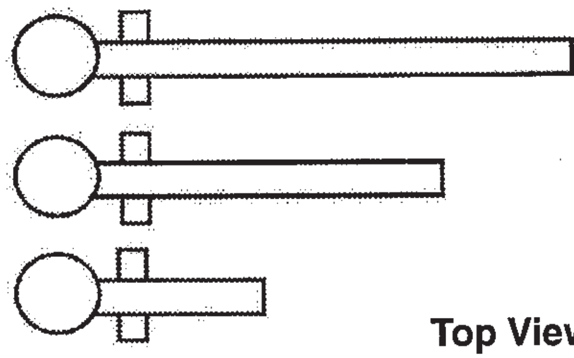


Fulcrum, side view



Fulcrum, top view

Cluster Version
Make a cluster of levers of different lengths (See drawing below.)
With this design, you only apply force at the end of each lever.



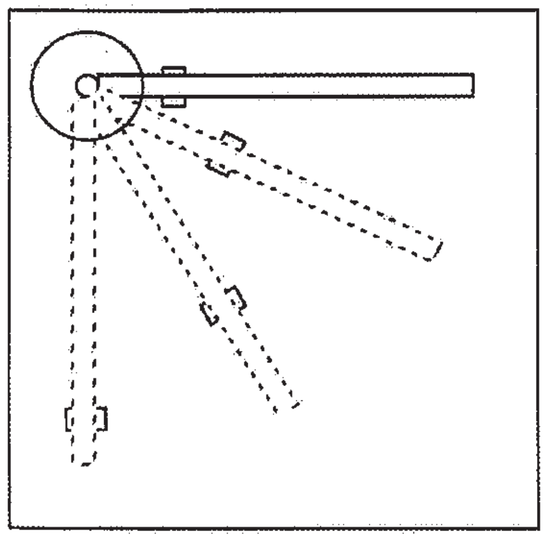
Top View of Cluster

(Component developed by LaDawn Haws and Felix Wolfe.)

Originally submitted to Cheapbook Two by LaDawn Haws

Lifting With Levers II

Description
To demonstrate the effect of moving the position of the fulcrum in a lever system.



Materials
- base board (approximately 20" x 20")
- one 2-1/2 pound dumbbell weight
- one 6-inch long carriage bolt
- wood disk, drilled in the center to hold the weight and to allow the lever to pivot to various fulcrum positions.
- PVC pipe (approximately 3/4-inch diameter)

Construction
Attach the bolt to one corner of the baseboard. This will be the pivot, allowing the visitor to try each of the fulcrums. Cut a disk out of plywood, and attach the PVC pipe, to the bottom of the disk. Set the weight on this platform.

Screw 2-inch lengths of pipe into the base board at various radii from the center of the disk. We used radii of 4 , 6 , 9 , 11 , and 14 inches, which require respective forces of 0.83 pounds, 1.5 pounds, 3.2 pounds, 5.5 pounds, and 17.5 pounds to lift the weight.

Notes
You could provide the visitor with a ruler, and ask them to calculate the forces, armed with the relationship that W1 D1 = W2 D2.

In order to make the historic connection to Archimedes and his claim to being able to lift the earth, we put an earth half-dome decoration over the weight.

(Component developed by LaDawn Haws and Darryl Smith.)

Originally submitted to Cheapbook Two by LaDawn Haws

Magnetic Canvas

Description

Magnetic Canvas is a tool for exploring magnetism through pattern-making, 3-D modeling, and artistic play. Visitors have a great time making designs, building structures, and experimenting with magnets. The galvanized steel canvas becomes a backdrop for any theme. For example, I've used bike parts for a neighborhood ***Bike Rodeo*** and found objects for an ***Art Scraps*** family day. I've laminated a map to the canvas and created appropriate magnetic objects and images for teaching lessons in geography, transportation and local history. You might make a landscape or have kids make their own game boards. Have fun!

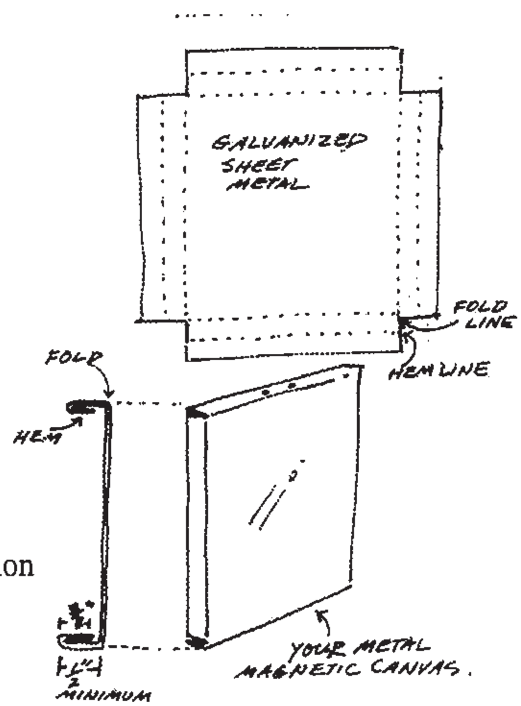
Materials & supplies

- galvanized sheet metal
- lots of magnets
- found objects (metallic and non-metallic)
- adhesives (spray and applied)
- scissors
- easel (to expose front and back sides of canvas)
- trays or bins (for holding sorted objects)
- clear urethane spray (optional)
- background image (optional)

Construction

<u>Metal Canvas</u>

Determine the size of galvanized sheet you desire, allowing for hem and fold. Cut corners, and hem and fold to make a rigid surface. Drill holes top and bottom as needed to secure to easel. (See illustration.)



If you don't have a metal shear and break, find someone who does. I have canvases made at a refrigeration outfit that does custom ventilation and ductwork. I also use pre-made canvases, like old broiler pans, furnace covers, steel drum and paint can lids, and refrigerator doors I've stripped the insulation out of.

If you're using a background image and protective laminate, it's best to have them rolled on professionally. Keep the overall thickness of image and laminate to 1/32 inch or so. Test to make sure your magnets will work through the final sandwich. If you're on your own, use spray adhesive and a plastic spreader to smooth the image flat. Then lay down a clear adhesive-backed sheet to protect the image, rolling it over the edges to slow the peeling-it-off syndrome.

Magnets and Found Objects

- **Non-metallic, flat materials** Use spray adhesive to bind paper, fabric, plastic and foil materials to a vinyl magnet sheet. Cut out your own shapes.
- **Non-metallic, 3-D objects** Use Goop or Epoxy to bind objects, like stones, clothes pins, buttons, and squashed aluminum cans, to magnets. You may need more than one magnet or stronger ones for larger objects.
- **Metallic objects** Try variations using magnets of various strengths with metal objects, like die cut scraps, nuts, bolts, and washers, bottle caps, paint can lids, street sweeper bristles (a favorite of mine), and rusty things—use your own judgement on safety issues. Have loose magnets available to play with alone and to sandwich between canvas and objects. You can place strong magnets on the back side of the canvas, so objects seem to stick magically to the front. Or bind magnets to the objects with Goop or Epoxy.
- **Magnets** Experiment with magnets of all kinds, large and small, strong and weak, whole and pieces. Find them in catalogues, electronic shops, loud speaker stores, and motor repair shops. You can get vinyl magnet scraps from your local sign company or buy it from their source.

All objects can be sprayed with clear urethane or another finish to renew and protect surfaces. Rusty things can take on a nice sheen.

Note
I find that Household Goop adhesive/sealant works well to adhere magnets to flat or uneven surfaces. Duro Master Mend Epoxy works well too, but isn't flexible. Both fill gaps and are clear and waterproof. But thefumes are mean. Work under an exhaust fan or outdoors.

Warning
Magnets can mess up credit cards and electronic devices. Keep this in mind when you are paying for a load of speaker magnets with your credit card or carrying them home in your car next to your laptop.

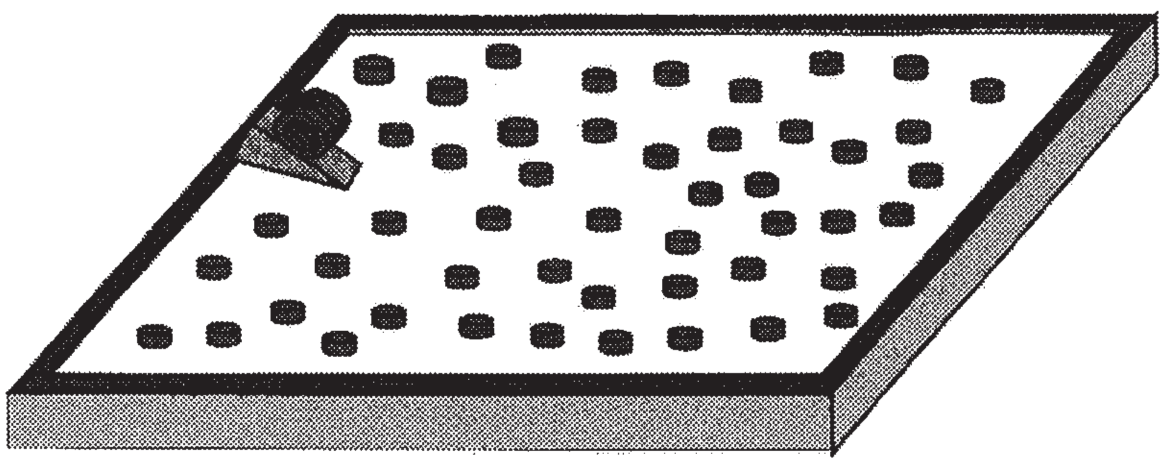
Post a sign near your **Magnetic Canvas** to warn visitors of such hazards!

Originally submitted to Cheapbook Two by Chris Burda

The Magnetrack

Description
The Magnetrack is designed to let children experiment with the sometimes unpredictable behavior of magnets.

The "roller" a set of four ring magnets taped together with black electrical tape, is rolled down the ramp to try to reach the other end of the track. Obstacles to the roller are small button magnets, randomly placed under a piece of Plexiglas.
As the roller moves over the button magnets, the attraction and repulsion of each magnet causes the roller's path to change and shift unpredictably. The whole track is reversible, so that the polarity of each button magnet can be changed relative to the roller.



Materials
- black electrical tape
- 1/4 inch and 1/8 inch clear acrylic sheet (Plexiglas)
- small "button" magnets
- small ring magnets
- birch plywood (for framework)
- clear packing tape
- Velcro

Construction
The Magnetrack is constructed of three pieces of Plexiglas, with a wooden frame mounted around the outside of the pieces to hold them together. A good size is 12 inches X 16 inches, but it can vary depending upon your space, or the sizes of your scrap Plexiglas.

Of the three pieces, two are 1/8 inch thick, and one piece is 1/4-inch thick. The 1/4-inch piece should be peppered with 1/2-inch diameter holes drilled in a random pattern. Enough holes should be drilled so that only a one- or two-inch space will exist between the button magnets when placed in these holes.

Lay the 1/4-inch piece of Plexiglas on top of one of the 1/8-inch pieces so that a supply of button magnets can be placed in the holes. Mix the magnets, so that a random arrangement of "north" and "south" poles are facing up.

Lay the second 1/8-inch piece on top of the magnet sandwich, and use the clear tape to seal the edges together in the corners.

Using the birch plywood, cut a strip about 60 inches long. Run it through a router to create a trough along the center of one length, 1/2-inch wide by 1/4-inch deep.

If your plexi pieces are are 12 inches by 18 inches, then cut the birch strip into two pieces 19 inches long and two pieces 11.5 inches long.

Drill and screw the four frame pieces together, with the plexi-magnet sandwich in between.

Cut a small ramp 2 inches wide X 1 inch tall X 2 inches long and Velcro it along one side of the track.

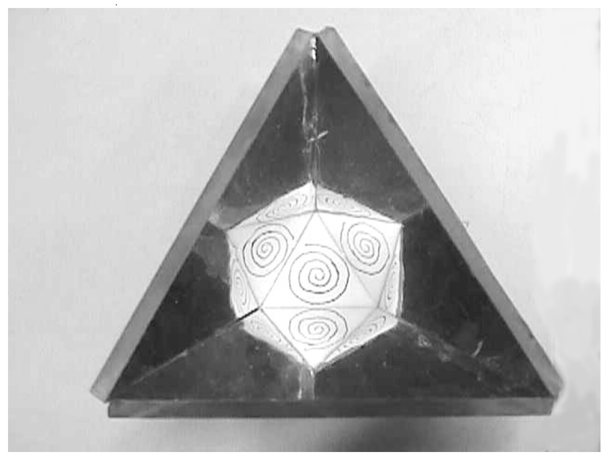
Roll the magnet down the ramp, and watch it go!

Originally submitted to Cheapbook Two by Steve Lechner

Mirror Wells

Description

A mirror well is like a kaleidoscope, it projects images of three-dimensional forms such as the platonic solids (regular tetrahedrons, octahedrons, cubes, dodecahedrons, and icosahedrons). Each mirror well looks like an open-bottomed bowl made from mirrored triangles that have been truncated into trapezoids. When a mirror well is placed onto a pattern, the pattern tessellates across each face of the form.



Mirror wells can be used to illustrate concepts about the symmetry of these platonic solids and provide opportunities for artistic design. Some museums have built giant versions of the icosahedron mirror well, mounted sideways, so visitors can put their heads through the bottom and tessellate their faces onto this form for other visitors to see.

Materials

- plastic backing (1/8-inch Styrene, Komatex, or Plexiglas.)
  [Mat board can be used instead of plastic but the mirror well will be less sturdy.]
- adhesive - glue sticks, or two sided-tape work well
- paper cutter
- saw for cutting plastic (such as a band-saw)
- grinder or sander
- masking tape
- hot glue
- reflective material - front surface reflective material such as high quality mylar gives the best image.

Construction

1. Choose one of the polyhedra from the examples below.

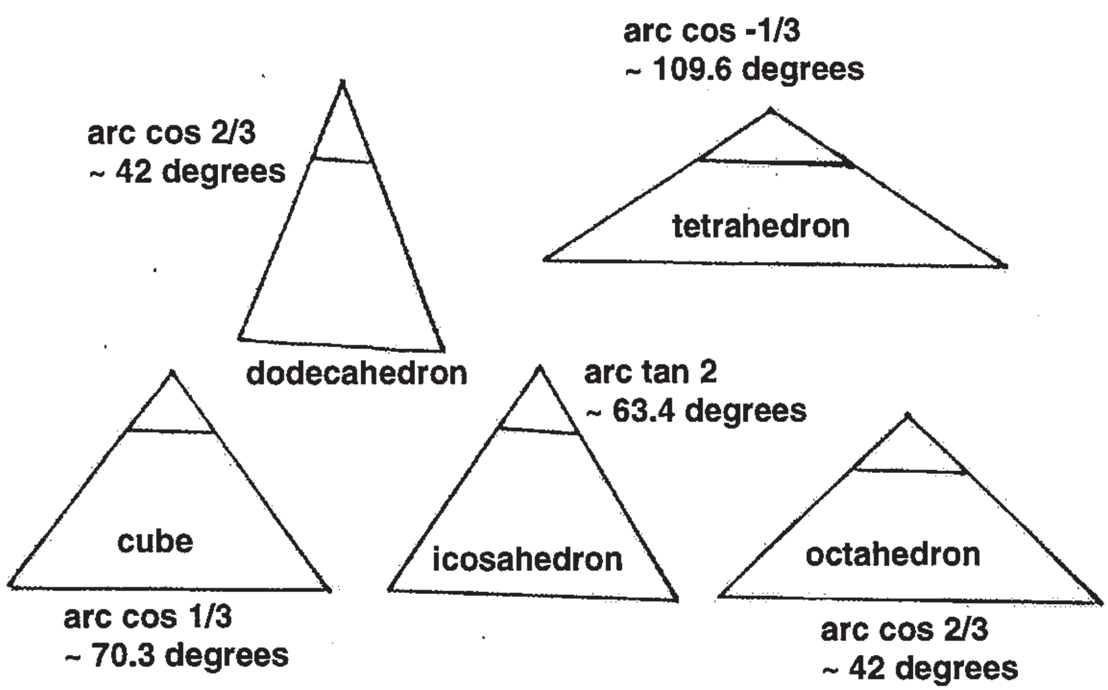
2. Make an enlarged copy of a triangle. Cut off the tip along the line, and trace the resulting trapezoid onto the plastic sheets and the reflective material.

3. Using a band-saw cut out three plastic trapezoids (triangles with the tip cut off). Cut four to make the cube, five to make the dodecahedron.

4. Using a grinder or sander, bevel the back of the bottom edge (the short side of the trapezoid) of the plastic pieces. This allows the mirrors to sit flush on a tabletop.

5. Using a paper cutter, cut the trapezoid shapes from the reflective material and mount onto the plastic shapes with the a glue stick or two-sided tape.

6. Put the trapezoids together in the shape of a bowl. The easiest way to do this is to put two pieces face-to-face and tape them with two pieces of masking tape along the edge. Do the same to the third trapezoid (or fourth or fifth, if appropriate.) Tape the first and last edges to form a bowl shape. Place the "bowl" on the table with the large opening down and adjust each piece of tape so the edges line up evenly. Check to see that you have a clean image and then hot glue the edges together.



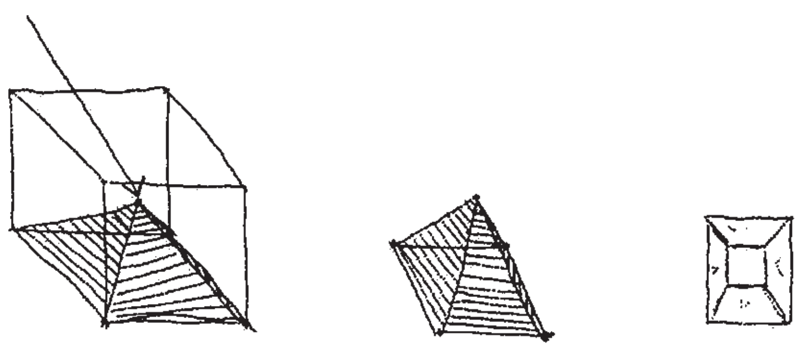
Notes

Display mirror wells on a table with a selection of various materials for making patterns. We used a Magna Doodle (so we wouldn't have to re-stock materials) with mixed success. They have a limited life span and some visitors were more interested in the Magna Doodle than the mirror wells.

More about Mirror Wells and Platonic Solids

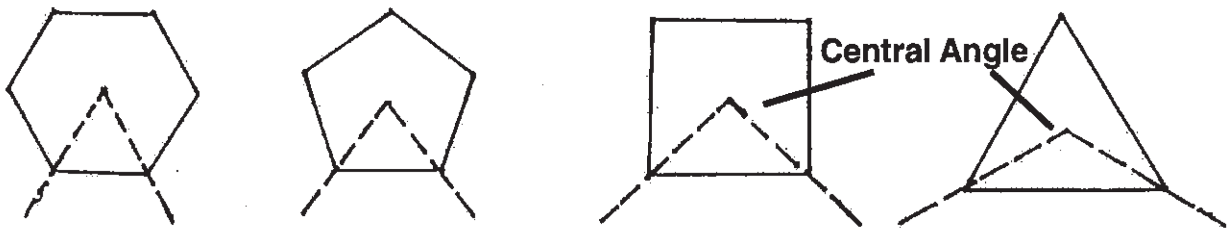
Platonic solids are the most regular of regular forms --- all angles, lengths of sides, and shapes of faces being equal. There are only 5 platonic solids (one of Euclid's proofs) and these five shapes show up again and again in the natural world, from molecules to minerals, to the shapes of certain microorganisms.

While the angles used to make the mirror wells may seem arbitrary, each is exactly a rational trigonometric function. Each is a small piece of the original solid that the mirror well generates. For instance, the mirror well which generates the image of a cube comes from drawing lines from the center point of the cube, to the vertices of one face. This pyramid-like shape can be turned into a mirror well by cutting off the top and mirroring the inside.



While it may seem surprising that a mirrored fragment of a shape can regenerate an image of the entire shape, this also works for two-dimensional images. For instance, a regular polygon such as a square, can be regenerated by looking into mirrors placed from the center point to the vertices of one side.
(See figures on following page.)

Place the hinged mirror on the dotted lines to regenerate a virtual image of the polygon.



For more information about platonic solids, their properties, and their appearance in the natural world, see: **Space Structures: Their Harmony and Counterpoint** (Design Science Collection) by Arthur L. Loeb, 1991, Birkhauser; ISBN: 0817635882.

Thanks to Paul Vollom from the Reuben Fleet Science Center, San Diego, CA for sharing information about the mirror wells from their Symmetry exhibition.

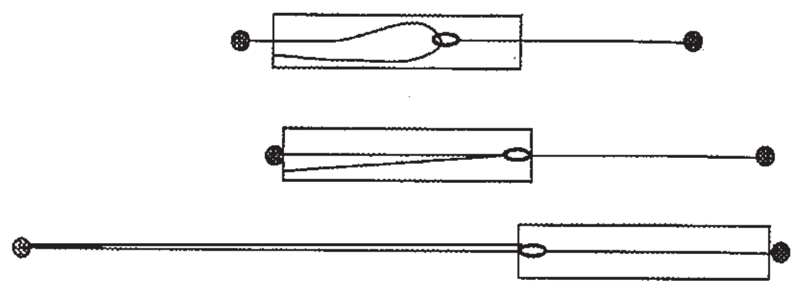
Originally submitted to Cheapbook Two by Fred Stein

Mystery Tube

Description
This is just a fun paradox—why is the string longer when it comes out one end than when it comes out the other end?

Materials:
- two inch diameter opaque plastic pipe 18 inches in length
- 2 wooden beads
- string
- stainless steel ring
- end caps for the pipe—we used wooden discs, drilled in the center (for the string to pass through)

Construction
Attach one end of a piece of string twice the length of the pipe to the inside of the left end cap. Thread the other end of the string through the ring, then through the hole of the end cap, and secure it to bead. (See illustrations below.)



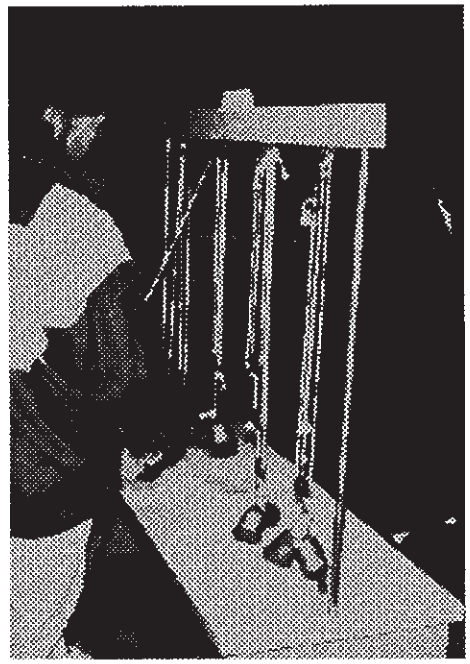
Attach another piece of string, one that measures the length of the pipe, to the ring. Thread the other end through the right end cap, and secure it to the other bead. Attach both end caps to the pipe.

When the visitor pulls the left bead, the string will be twice the length of the pipe. Pulling the other bead will show a string only half as long.
The challenge is to discover why this happens.

(This component was developed by LaDawn Haws and Stan Davis.)

Originally submitted to Cheapbook Two by LaDawn Haws

Pulley Systems: Which one is the joke?

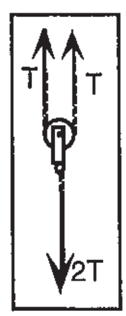


Description
Four different pulley systems are offered to the visitor. Each one has the same weight sandbag hanging from it, but the force needed to pull the knotted end of the rope and the distance the hand moves to make the sandbag rise, varies greatly from one setup to the other.

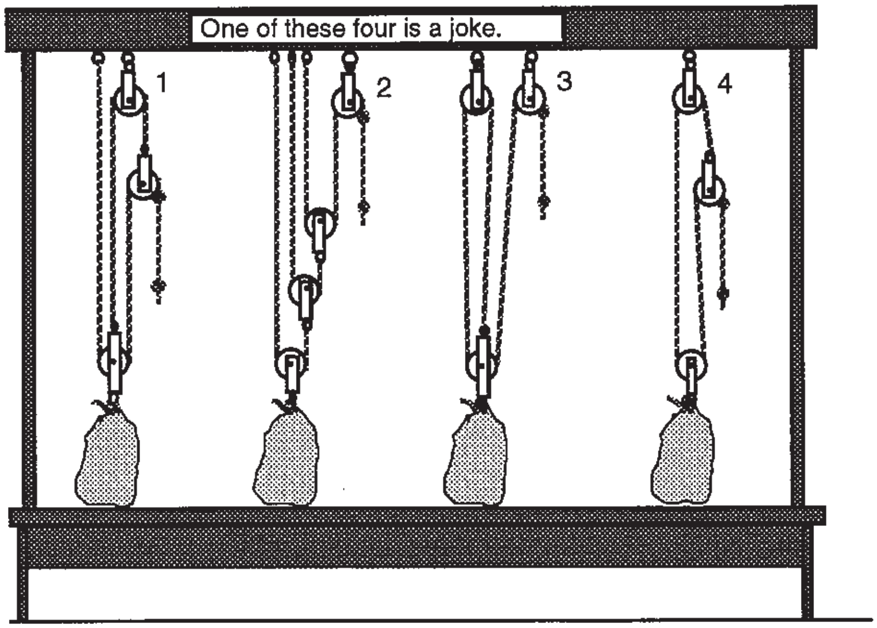
As the visitor tries each of the four options, system 4 is quickly perceived to be the joke. The rope pulls very easily, but the sandbag doesn't rise. This came from a 1903 physics textbook in which the system is called the fool's tackle.

System 3 is a conventional block and tackle, and since it is a workable system with a single rope, the ideal force-multiplying factor is 3. (The number of ropes connected to the movable pulley from which the load hangs.) Rationale: pulling on the rope establishes a tension (T) throughout the entire length of the rope. The total force is 3xT.

System 2 has more than one rope, so simply counting the supporting ropes to get the ideal force-multiplying factor is incorrect. This system can be called a power-of-two system. Its ideal force-multiplying factor is 8, (2 raised to the exponent 3.) Adding a fourth lower pulley would raise the factor to 16. See small sketch showing how rope tension is doubled at each lower pulley.



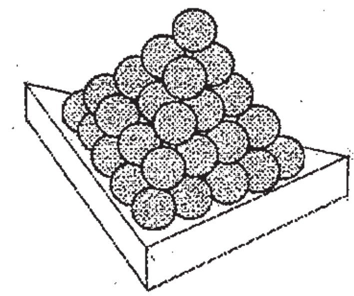
System 1, also from a 1903 physics text, is called Spanish Burton and is still recognized by some sailors. Its ideal force-multiplying factor is 4. Note the two separate ropes, one has twice as great a tension as the other.



The diagram above represents the complete exhibit.

Originally submitted to Cheapbook Two by Albert J. Read

Pyramid Puzzle



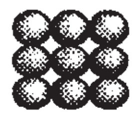
Description
The object of this component is to assemble these five sets of pingpong balls (shown below) into a triangular pyramid, or tetrahedron.

Materials
- 35 pingpong balls
- Duco Cement
- Testor's brand spray paint
- 1/2 inch wood for base

Pingpong Balls

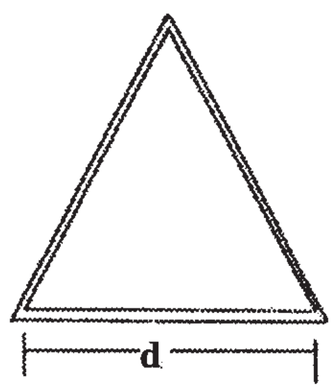
2 of these.

2 of these.



1 of these.

Construction
Create a base with an inside dimension (d) equal to six times the diameter of the balls you are using. For pingpong balls d= 8 5/8 inches.
(See diagram below.) Paint or laminate the base.



Originally submitted to Cheapbook Two by Dan Goldwater

Rubbing Plates

Background
This idea came to me after various attempts at creating rubbing plates for our small museum. From carving designs into Plexiglas with a Dremel tool, to gluing textures and objects to wooden tables. Both ideas worked out and were cheap, but seemed a bit crude. I tried pricing professionally manufactured rubbing surfaces but found them to be WAY beyond our meager budget.

My grandfather was a printer of the olden days and ways. I remember spending many hours in his printshop making rubbings from the many wood and lead type blocks that he had - from letters to logos and everything in between. I took one of these pieces from my keepsake chest to a nearby rubber stamp manufacturer to see if type such as this could still be created. It could, but it would be costly. When I described to the owner that I wanted to assemble various pieces to create a rubbing surface he presented a much easier (and affordable) solution.

I would need to supply him with the camera-ready artwork. No problem. I went to my trusty computer and printed out a 8 1/2 inch x 11 inch collage of copyright free artwork and returned to the shop. This particular shop creates their own stamps instead of shipping them out, so that made life easy for me. A negative was made of my artwork, which was then exposed to a light-sensitive plate. One run through the sink and the result was a hard polymer rubbing surface on a metal plate. The cost was $30, which the owner of the shop ended up donating.

This is actually the first step in creating a regular rubber stamp. Normally, a molding compound would have been poured over the plate, then rubber into that. If you have a source nearby, simply ask for them to provide you with the "MLD plate" only (you still may need to explain what you are going to do with it). Bold line art works best, especially if you will be using crayons for the rubbings.

Exhibit Setup
We attached the plates to a table and let the kids go for it. After one year and over 30,000 visitors none of the polymer has been scratched off and every image is as good as the first (depending on the person doing the rubbing.) It also makes for a professional presentation. It is amazing how much detail can be picked up. We use regular bond scrap paper for “canvas”. I’m not sure if there are larger plates available, but the 8.5 inch x 11 inch is standard.

Here's a sample rubbing of a seahorse!

Originally submitted to Cheapbook Two by Terisa Glover

Sound Mixing Bowls

Description
Have you ever wet your finger and rubbed it around the rim of a wine glass? A mixing bowl mounted on a base will make surprising sounds when you rub a rubber rod around the rim.

Materials
- Three #10 bolts and locknuts. length depends on what you choose to use for a base.
- Six rubber washers, 1/8 inch thick and 1 inch diameter
- Three metal washers
- Wood base to mount the bowls on
- Heavy duty stainless steel mixing bowls. You can use as many as you like. We used 10-inch diameter, 9-inch diameter, and 8-inch diameter bowls to compare the different sounds.

Construction
1. Drill a hole in the center of each bowl large enough to insert your bolt.

2. Decide on the size of base you want. It can be any size, as long as visitors can reach all the bowls. Once you have the base cut, lay out the bowls and mark their locations.

3. Drill holes in the base, one hole for each bowl..

4. Place two rubber washers, one on top of the other, centered on each hole in the base.

5. Place the bowl on the rubber washers. Next, place a metal washer on a bolt and push the bolt through the bowl, rubber washers, and base.

6. Secure each bolt with a locknut. Make sure the nut is on tight or the bowls will spin when they are rubbed with the rod.

7. To make a rubbing rod, we suggest using cast polyurethane round rods available through McMaster-Carr Supply Company. Simply cut the rod and file the edges. Wooden dowels will work, but it is likely that they will be used as strikers, making the bowls sound like gongs.

NOTE
The bowls produce a lot of vibrations which could be annoying to your co-workers whose offices are near by. We suggest a piece of 1/4-inch acoustic foam or rubber mounted between the exhibit and the floor to reduce noise.

Originally submitted to Cheapbook Two by Geoff Nelson

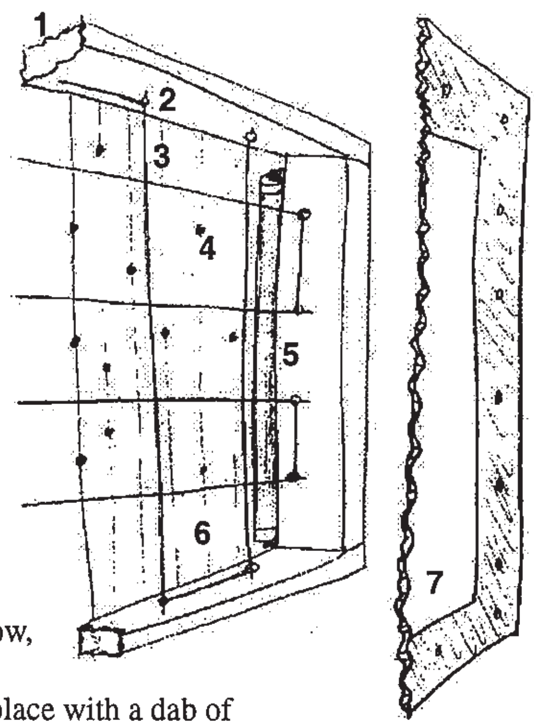
Space Glow

This device was built for a space ship exhibit at The Jersey Explorer Children's Museum. We did not have money in the budget for fiber optics.

Star Chart

The star chart uses black lights, florescent paint, and orange weed wacker line to create a pretty neat 3D glowing star chart.

Materials and Construction



1. Make a 2" x 4" frame and attach it to your wall.

2. Insert small screw eyes into the frame. The screw eyes are used to ***tightly*** string the weed wacker line.

3. Use two long pieces of florescent orange weed wacker line; one for the horizontal, and one for the vertical. This makes it easier to pull the line tight. I hid the end of the line behind the frame, tied a loop and stretched the loop over a nail.

4. You will need a supply of small round beads. Paint them white, to help the florescent paint glow, then paint them with florescent poster paint. String the beads onto thin black thread, held in place with a dab of glue (use tape to hold them in place while the glue dries.) Staple the thread onto the back edge of the 2x4's.

5. Mount two 48-inch long black lights on the back side of the 2x4's, facing the center of the chart.

6. Paint the background wall black, then speckle some florescent paint on the wall. This adds depth.

7. Cut a piece of 1/4" Plexiglas the same size as your chart. Spray paint the back perimeter black. Attach this piece to the front of the frame with screws (about every 12".)

Galaxy

This idea came from the starchart. To create your own Galaxy, you will need black lights, florescent paint, and various sizes of nails. Paint the nail heads to help create the illusion of depth.

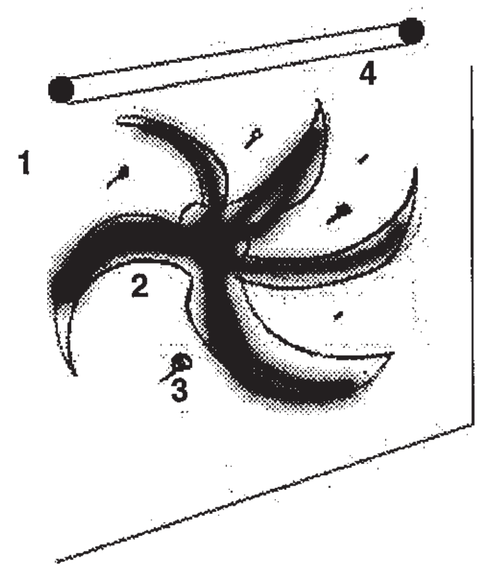
Materials and Construction

1. Paint a wall black, then speckle it with white paint. Paint a white area where the galaxy will be (the white paint behind the florescent paint will help it glow more brightly).

2. Now paint in a colorful galaxy with florescent paint. Spray paint is great for space gasses. Speckle some of the background with florescent paint.

3. Drive nails part way into the wall. Use different size nails to give the illusion of depth. Paint the heads of the nails to form the "stars" in your galaxy.

4. Mount a 48 inch black light facing the painting.

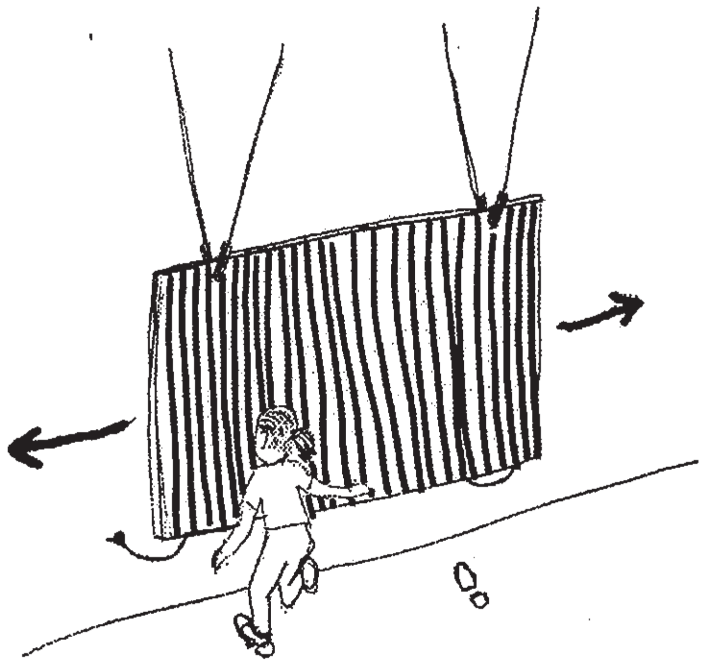


Originally submitted to Cheapbook Two by Gregg Malora

Swinging Stripes

Description
In this exhibit the visitor stares at a striped panel swinging side to side and tries to stay standing while balanced on one foot. It's harder than it sounds!

Before long visitors begin to lose their balance, sway, and put out their other foot to keep from falling. This exhibit is fun for two people to do together.
The experience makes a big impression on those who do it and those who watch.
Not the least of this exhibit's charm is that it is very funny to watch people teeter under the influence of this swinging pattern.



Explanation
Under normal conditions it's possible to balance on one foot by using the sensory feedback from your inner ear, muscle tension in your legs (proprioception), and the feedback from a stable visual scene. Your brain manages all these perceptual signals and directs your body to stay standing.

In this exhibit, your eyes view a powerfully unstable scene. Your brain gets confused with this information about whether your body or the world around you is moving.
Your brain tells your body to "correct" for this "motion" by making you move slightly with the swinging stripes. This just puts you off balance and gives your already confused brain even more to deal with. Though you can recover from the first few teeters, it becomes more and more difficult as you continue to look at the swaying stripes.

Materials

- One full sheet (4' x 8') of 1/4" masonite or smooth plywood
- 1" x 4" lumber in 8' and 4' lengths for providing a bracing frame on the back of the panel (4 pieces total.)
- eye bolts (to anchor panel to ceiling or wall brackets and tether to floor.)
- white tape OR striped fabric OR black and white paint (see stripe methods below)
- strong metal cable for hanging and tethering the panel.
- screw-down cable clamps
- stick on vinyl or spray paint stencil "footprints"
- sturdy vinyl tubing (to make a casing for the cable.)

Stripe Method 1

Stripes can be found "ready made" in most fabric stores. Look for a strong contrast --- light against dark--- and stripes that are 1/4" to 1/2" wide. You will probably find stripes running the length of the bolt so you will need to sew a few seams to get a piece that covers the dimensions of your board.

Stripe Method 2

Use masking tape and black and white paint to create a vertically striped pattern on your board.

Stripe Method 3

Paint the board black and use white vinyl tape to make the vertically striped pattern.

Construction

Screw and glue your 1" x 4" frame all around the back edge of your sheet of plywood to help hold the frame rigid and flat and provide a sturdy area for the hanging and tethering points.

Drill a hole in your panel at each of the two top corners that is big enough for your cable to go through. It would be great to use a couple lengths of vinyl tubing to line the hole to help keep the cable from wearing a groove in the wood.

Fasten eye bolts to the two back bottom corners of the panel, for tethering your panel.

Create stripes by tacking down fabric, sticking down tape or painting the panel. (See above.)

Hang panel from a V-shaped cable arrangement for stability and to aid the side to side motion. If you have enough ceiling height, longer cables mean less up and down travel when swinging.

Note
Make absolutely sure you are hanging this exhibit from a sturdy part of the wall or ceiling and that you are attaching things together in a way that can withstand movement and vibration.

Make sure that final height allows both 4 foot kids and 6 foot adults to get a full view of stripes. Tether panels loosely so that panel will swing freely for about 8 to 10 inches either side but won't swing out or into ceiling.

Try swinging panel from side to side and adjust length of cables or tethers as necessary. Check to make sure all connections are secure. You will want to do this periodically.

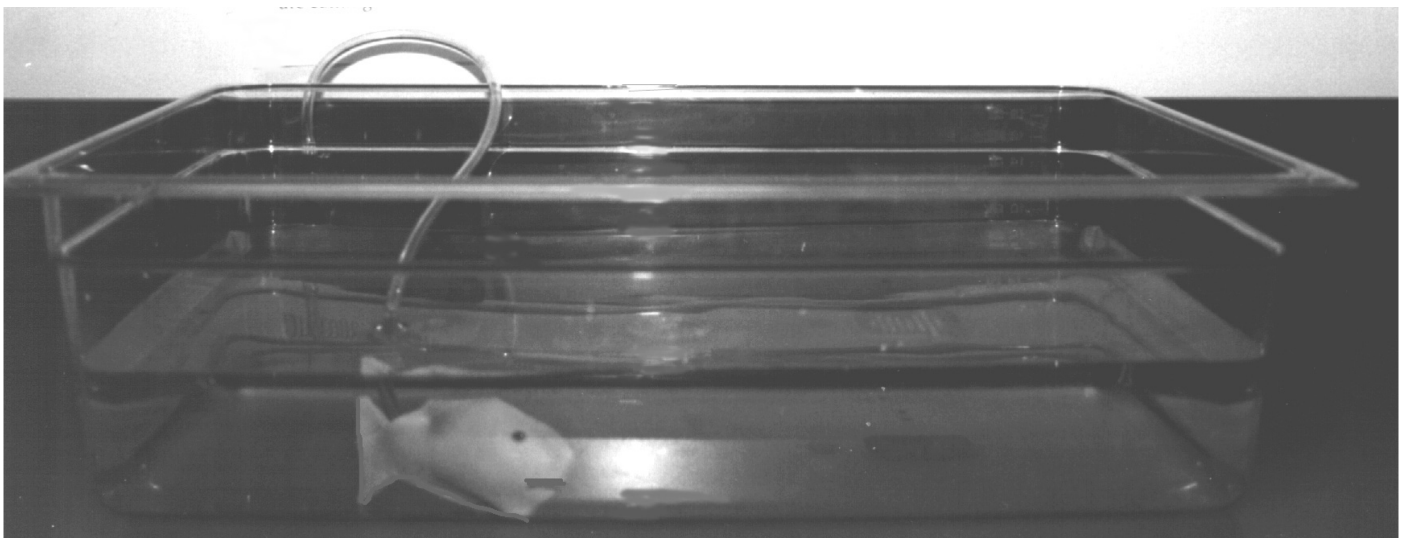
Put two single foot footprints on the floor at correct viewing distance, about 18 inches. Put up your label, and then stand back and watch your visitors fall over.

Originally submitted to Cheapbook Two by Claire Pillsbury

The Fish Sense

Description
Fish, including bony fish and sharks, have a fifth sense organ, called the lateral line. This sense allows them to detect vibration in water, and is used for hunting and avoiding predators. A hunting shark, for example, can detect prey up to several hundred feet away using its lateral line. In addition to feeling the vibrations, the shark can tell the direction the vibrations are coming from.

How well can you detect vibrations in the water? Can you tell which direction the vibrations are coming from?



Materials
- clear plastic water tank (see below)
- vibrating motor
- closed cell foam (Fun Foam)
- silicon caulk
- velcro strips
- plastic aquarium tubing

Setup
The exhibit consists of a tray of water (about 6 inches deep) with a small vibrating fish in it. One visitor should close their eyes, while a second visitor moves the fish to a point in the tank. The first visitor then puts their hand in the water, and tries to guess where the fish is — just from feeling the vibrations. How well can you sense vibrations as compared to a shark? How far away from the fish can you still feel the vibrations? Can you tell direction? Does it help to use two hands?

Construction
Any tank may be used but a clear plastic tank about 7 inches deep is best for visibility. We use a clear plastic food service tray 12 by 20 inches.

Fill the tray with 6 inches of tap water.

Now you may be asking where do you get a waterproof vibrating fish? After some sober reflection we found a small, waterproof, battery operated, 1.5 volt vibrating motor from Good Vibrations www.goodvibes.com. Your purchasing department will be happy to order this for you!

This oscillating motor has the convenient feature of a battery pack attached to a cord. We reinforced the cord with aquarium tubing and silicon. We also used silicon to re-waterproof the motor housing.

Using thin closed-cell foam (Fun-Foam) cut two fish shaped foam pieces and sandwiched the motor between them. Add a large washer for weight to keep the fish assembly from floating. Enclose the battery pack in a waterproof box and attached it with Velcro to the side of the tray.

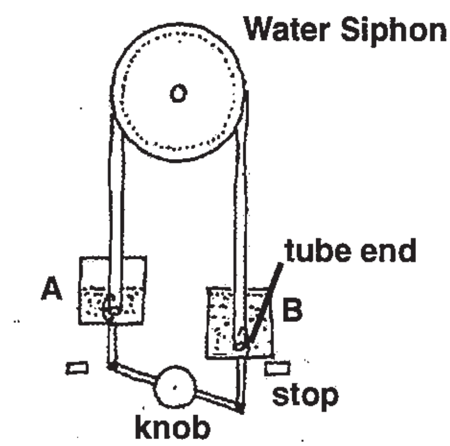
This exhibit has been quite successful in our Shark Explorer Class. Incidentally, a frequent question from teachers is, "How do you get the fish to vibrate?"
But then, this is Boston.

Originally submitted to Cheapbook Two by Alexander Goldowsky

Two Siphons

Description

The following are two exhibit ideas of siphons. The "Water Siphon" demonstrates an actual siphon. The "Chain Siphon" explains by analogy why and how the liquid siphon functions.



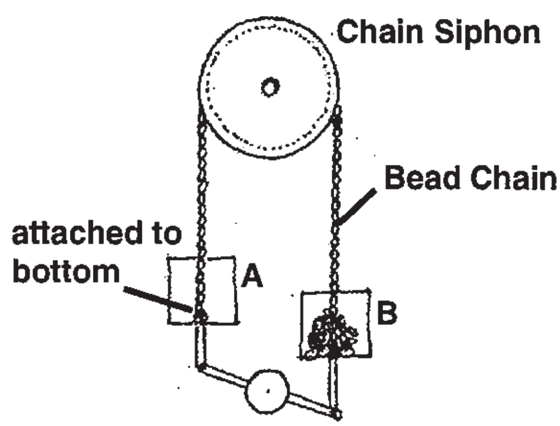
Materials

- Pulleys on bearings (7 inches in diameter)
- Flexible plastic tubing (1/4 inch diameter)
- Clear acrylic cylindrical containers
- Bead chain

Construction

For each siphon you will need to construct a simple lever-pivot assembly that is activated by a knob (which could be outside a case.)

The water siphon has a pulley on a bearing. The plastic tubing is placed over this pulley, while each end of the tubing is attached to the bottom of each plastic container.



The water siphon also employs "stops" to limit the action of the lever-pivot assembly. Color the water to create a stronger visual presentation. Keep in mind, that the water level must not fall below the tube ends.

The chain siphon employs a longer piece of bead chain than the length of the water tube. All the chain from container **A** can "flow" into container **B**, or vice-versa when the lever-pivot assembly is activated by turning the knob.

Originally submitted to Cheapbook Two by Shab Levy

Washer Dryer

Description

Using simple flat washers and threaded rods, you can make an exhibit that can be changed to fit any space. Once visitors get started, they won't want to stop playing with the hypnotically wobbling washers!

Materials

- Washers (1 3/8 inch diameter with a 9/16 inch hole is a good size.)

- Threaded rod to match your selected washers.
  (For example, with washers that have a 9/16 inch hole,
  you will want to use 1/2 inch threaded rod.)

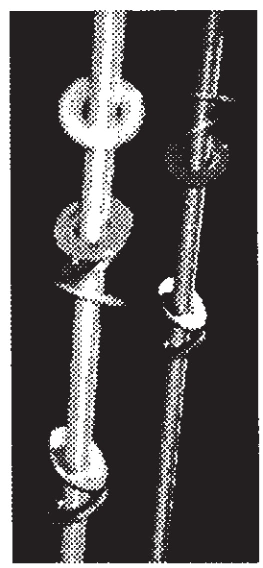
- Nuts (to attach threaded rods to a wall or exhibit backdrop.)

Construction

Place several washers on each rod.

Attach nuts on both the top and bottom of each rod to hold it in place.

Bring the washers up to the top of each rod and let go!



Closeup of Washer Dryer

Notes

It works best to have several rods running parallel to each other, so that visitors can have "washer races." Washers can be purchased that are made out of different types of metal, such as copper and brass.

Originally submitted to Cheapbook Two by Paul Orselli