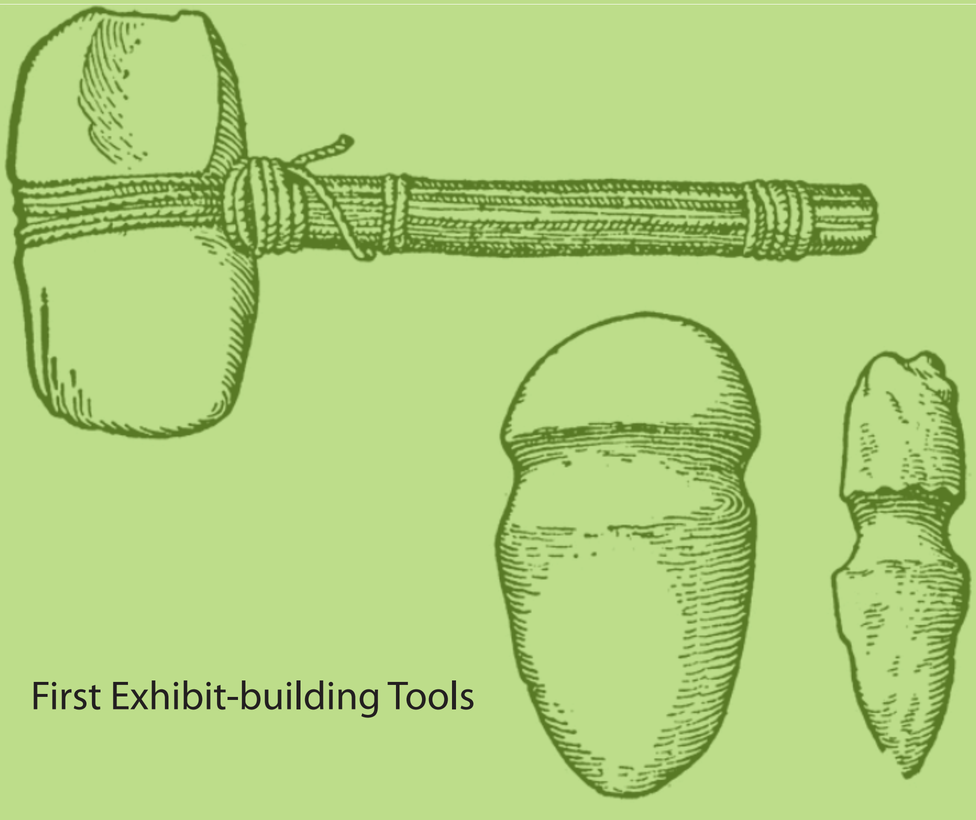
# CHEAPBOOK 3

## Even More Inexpensive Exhibit Ideas



First Exhibit-building Tools

**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!

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**Credit**

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# Archimedes' Screw

**Description**

Our Archimedes screw consists of a clear hose wound around a shaft - the lower end rests in a container of plastic balls; the upper end is equipped with a wheel that is attached to the wooden shaft. When the wheel is turned, the lower end of the hose scoops up the balls from the lower reservoir. The balls travel up the hose and drop into the upper reservoir, where they roll down a chute back into the lower reservoir.

We built this prototype in-house and used it for a couple of weeks on the exhibit floor until the final version came back from our fabricator.

The Archimedes' screw was originally designed to move water from a low point to a higher point. We couldn't use water indoors, so our Archimedes screw moves balls instead. We chose ball pit balls since they are not a choking hazard, don't bounce very well, are light and are inexpensive (especially in bulk).

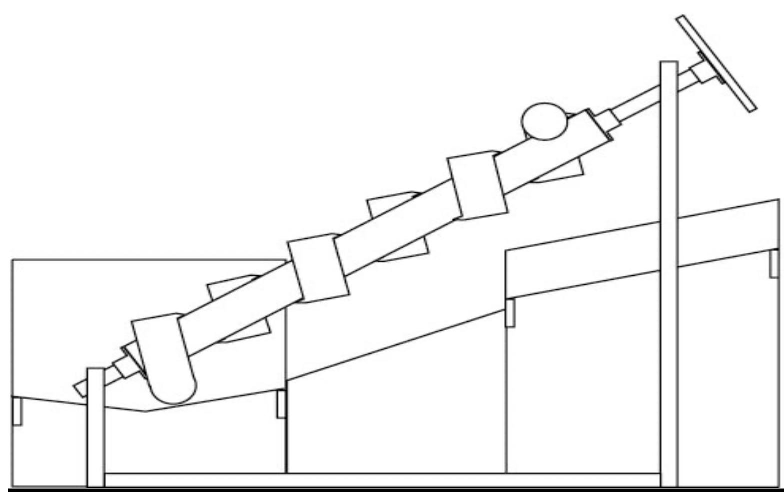
Due to the relative complexity of the actual construction, the following description of the prototype should be read as a point of departure and not an actual plan.

**Materials**

- Two 50 gallon plastic drums
- 4" diameter clear PVC hose (Blo-R-Vac Clear-View PVC Hose, McMaster Carr)
- 4" diameter wooden post (non-treated)
- 1 1/4" black pipe (O.D. 1 5/8"), 6"(+/-) length and 12"(+/-) length
- Round flange Kee Klamp fittings for 1 1/4" pipe (McMaster Carr)
- 3/4" plywood
- Wooden 2" x 4"s
- Thin (1/8" or 1/16") HDPE plastic

(We buy a lot of our plastic from a company called Yemm and Hart- they produce really nice HDPE sheets made from recycled materials. http://www.yemmhart.com/)

- 3" diameter ball pit balls (toy store or other supplier)
- Metal pipe strapping, or (better yet) nylon strapping (like that on backpacks)



## Construction

***Basic framing***

We used a simple 2x4 frame to cradle the screw shaft. We drilled holes (angled to correspond with the pitch of the screw shaft) at the ends of the 2x4s to capture the black pipe on the ends of the wooden post. The Kee Klamp flange fittings have large setscrews to hold the black pipe. When installing the screw shaft between the 2x4s we attached the black pipe to the lower end and fed this through the angled hole in the lower 2x4. We then fed the unattached piece of black pipe through the upper angled hole and attached it to the shaft using the fitting. The use of Kee Klamp here makes the screw shaft easily removable during and after the construction process.

***Lower reservoir***

The walls of the lower reservoir should be high enough to contain the balls (when the screw is turning, the balls jump around like popcorn) but low enough for young visitors to see inside. We used HDPE with holes cut out of it for the wall, but we could have used the actual drum wall. The drums can be cut in place using a jigsaw.

For the floor, we made a shallow cone shape out of HDPE sheeting so that the balls collected towards the center. Consideration needs to be made for clearance between the floor and the low point on the screw hose (only the low, open end of the hose should scrape against the cone shaped lower floor.)

***Upper reservoir***

For the upper reservoir floor, we cut an HDPE ellipse and set it in the drum so that it slopes down towards the ramp. We made the exit door in the upper reservoir a bit longer than the width of three balls side by side (to keep them from jamming.) We added a sliding door so that the balls could be collected in the upper reservoir before being sent down the ramp to the bottom.

***Screw shaft***

For the prototype, we used lengths of metal pipe strapping to secure the hose to the wooden post. However, on the finished version, we used nylon strapping, which is much better. The steeper the pitch of the screw shaft, the tighter the coil must be in order for the balls to travel up the tube. (We used a 10' hose wound around a 4' post.)

We riveted an HDPE collar to the inside of the low end of the hose to give the hose some rigidity to scoop up the balls. The wheel is a 10" disk made from 3/4" plywood with a Kee Klamp flange attaching it to the black pipe.

***Ball return ramp***

This was a simple plywood ramp that fit in between the upper and lower reservoirs. On the final version, we put a splitter at the bottom of the ramp to funnel the balls to either side of the screw shaft.

Originally submitted to Cheapbook Three by Joe Victory

# Balancing Act

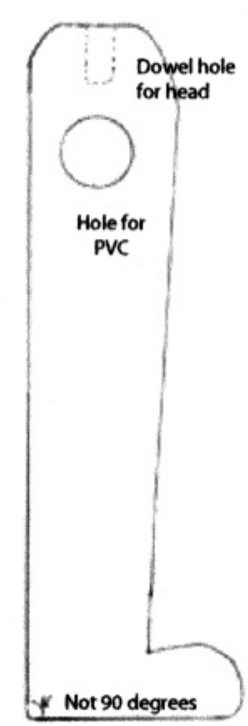
**Description**
How does weight distribution allow something to balance? Does the size of the base matter? This exhibit has three different dolls with different size bases that have PVC arms, and 2" steel rings as weights. This is part of one exhibit in a traveling exhibition, ***The Body Carnival***.

**Materials**

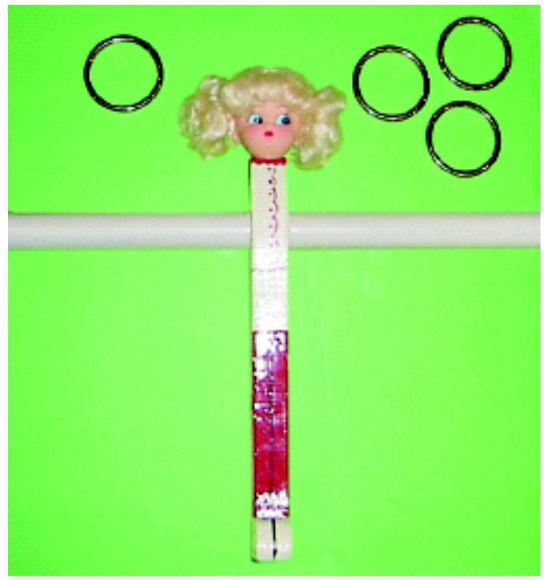
- Three widths of hardwood plywood (although any wood can be used, you will experience less breakage along the foot region with plywood).
  [Note: You can actually use a hardwood along with a hardwood plywood and get three different widths by gluing them together and planing the hardwood.] Recommended widths: ½", 1", 1 ½"
- ¾" PVC (schedule 40)
- Doll heads with an opening that will fit a dowel.
- Great Stuff insulating foam sealant
- Wooden Dowel (sized to barely fit inside the bottom of your doll heads)
- 2" steel rings (available at most hardware stores).
- Vinyl tape (not necessary but a nice touch)

**Construction**

1) Cut out the design using a jigsaw or band saw – make sure the bottom of the feet are perpendicular to the side of the wood (you may want to re-cut the bottoms on a table-saw to ensure a square cut). Note: you will want the back of the doll to have a very slight forward lean (otherwise it may tip backwards too easily).
2) Drill a hole in the top edge of the wood for a dowel.
3) Cut a dowel to a length that will fit in your hole from #2 and nearly to the top of the inside of your doll head.
4) Glue the dowel in the hole you drilled. Let it set.
5) Next, cut out a hole in the side of the doll for the arms. We used a slightly smaller drill bit, then filed the hole out a bit so that the PVC fits tightly.
6) Cut your PVC arms to length (21" or so is a good length if the wood height
   is about 11").
7) Sand off (or use acetone) any writing on the PVC arms, and file down the edges.
8) Using a rubber mallet, hammer the arm into the hole you cut for the arms. We found it easier to coat the PVC lightly with a lubricant such as silicone prior to hammering it into place. Glue if necessary (if the arms are a bit small for the holes you cut).



9) Add the head by spraying the inside of the doll-head with Great Stuff and pushing the head onto the doll. Clamp the head if possible – otherwise the head may want to rise up on the dowel as the Great Stuff continues to expand.
10) Paint the dolls as appropriate.
11) Using a vinyl tape, tape the arms off in 4 equal segments to help
12) Put the dolls out on a level table with the 2" steel rings.
13) Pose the following questions to your visitors via signage – Are wider dolls easier or harder to balance? How can you make one ring balance three rings?

**Note**:
It really helps to create a carpeted or padded table designed to minimize the rings bouncing around when the units tip over.

Originally submitted to Cheapbook Three by William Katzman

## Ball Floaters

**Description**

We developed Ball Floaters as part of our AirPlay traveling exhibition, one of the TEAMS exhibits we've done with NSF funding. We built four of them in a cross-shaped arrangement so that visitors could watch each other. You can build as many as you like.

I came up with this idea after remembering my dad balancing ping-pong balls on a vacuum cleaner exhaust hose.

**Materials**

- Wood or MDF
- Perforated metal
- 1- 1/2 inch PVC pipe
- PVC cement
- Pipe clamps (see below)
- Air blower (see below)
- 1/4 inch hardware cloth
- Clear Schedule 40 pipe
- Lightweight foam balls

**Construction**

Build a cabinet first. Our cabinets are 16" wide, 34" long, and 20" or 24" high, with a nice kickspace, formica tops, and a side that opens with a key lock. Add a vent hole with some kind of grating on it so that air can get into the cabinet. We have foam filters on ours to keep the dust out, but then you need to clean the filters occasionally. We also have a concrete block in the bottom of our cabinets to stabilize them.

Lay out, cut, and then assemble the white PVC pipe sections (standard 1 1/2" PVC plumbing pipe from the hardware store). You should glue them, because if you attach them together with screws, the screws will protrude on the inside and damage the foam balls as they shoot through. You'll mount the tube onto the cabinet using pipe clamps (we used self-locking nylon pipe hangers from McMaster-Carr, 30075T11). Size the length of the beginning of the tube so that it will protrude down into a hole in the cabinet top.

We made it so that the upward-facing-holes in the T-connectors were on 6"centers. Block the end of the tube with a plug that is removeable, as you will occasionally get a ball stuck there. We have a little solid plug in the end also to keep the foam balls from going into the end.

We eased the inside edges of the T-connectors with a Dremel tool, cutting away as much of the extra plastic as we could to make the ball's journey around the corner a little more gentle.

Drill a hole in the cabinet for the tube - nice and snug. Mount the tubing assembly onto the cabinet top. Mount the blower (Graingers 4C442 140 cfm) underneath the cabinet so that it blows air up into the tubing. Mount a piece of 1/4" hardware cloth in-between the blower and the underside of the cabinet top so that if someone forces the foam balls down into the output tube they won't end up in the blower all shredded to bits (we learned this the hard way).

You can either mount a simple wall-switch into the side of the cabinet so that you can turn the exhibit on and off, or you can get fancy and install a timing relay so that a visitor can push a pushbutton on the cabinet top and have the blower run for 15 or 20 minutes. Make sure that all of your wiring meets code.

Cut several lengths of clear sched. 40 pipe (McMaster-Carr 49035K87, 1 1/2" PVC, clear) 6" to 18" long, and clean up the ends where they are cut so that there are no sharp edges or burrs. Visitors will put these into the upward-facing holes.

You need 1 3/8" foam balls for this exhibit, and you have to look for them. We bought 3,000 surplus foam balls from a foam supplier (they were used for some kind of toy), but we're running low now. NERF balls may work, or you may get lucky in the cat toy department. Ping pong balls work but they're very hard on the face when they shoot out of the tubes upwards!

It's good to mount some kind of basket or bucket onto the cabinet so that there's a place for the balls to go (when the occasional visitor actually picks them up off the floor! )

Originally submitted to Cheapbook Three by Bob Raiselis

## Bead Stream

**Description**

This is a simple resonant frequency/ wave device prototype. Multiple strands of strung beads are draped over a 30 degree inclined plane. All the strands are attached to a bar at the top that is shaken back and forth by the viewer. If the strands are the same length, parallel waves migrate down the surface of the inclined plane. If they are different lengths, the wave patterns vary. The first prototype of this device was developed by Paul Orselli and Clifford Wagner.

**Materials**

Materials for the Bead Stream as shown in the picture:

- One 4'x8' sheet of smooth plywood
- Two C-clamps that act as guides for the rod
- 3/4" PVC pipe (any rod will do, but being lightweight is a plus, since it enables users to shake it back and forth faster)
- bead strands (http://www.mardigrasoutlet.com/details.asp?ProdID=154 )
- means to hold the bead strands to the pipe.

**Construction**
After gathering your ingredients, allow at least five minutes to create and test the prototype. Grab a chair, put one end of plywood on it, clamp the two clamps on the top end of the plywood as guides for the rod.

The rod needs to move freely under the clamps; screw the screw on the clamp inwards enough to create the space to allow this freedom. Tape bead strands to the rod, play with spacing and amount of strands. Shake, bake and modify until well done. Slide the chair in further to try steeper plywood angles.

**Notes:** The above directions are given because this is an example of a perfect prototype, fast, cheap, variable, and informative (The first shakes and we knew we had a hit). Since water in exhibits is always a maintenance nightmare, we had planned a beadstream in the traveling exhibition , "A Garden of Gizmos", with the original idea being that they would be a visitor controlled conveyor belt of beads running in a sculpted channel. After fiddling around in the shop, we unpacked the bead strands, started playing, and the prototype was born!

A "final" version for the exhibit floor can be fancier. Formica surface (even smoother). A step for young humans. A vertical lever attached to the rod with a bicycle handle grip on it, better at visually informing the user what they are expected to do. Or a crank with connecting rod to make the back and forth happen. That's not quite as open ended an activity as just shaking the rod, though. Luxury version might have interchangeable cams (nautilus, two-lobed, sharp lobed? etc.) It's always good when brainstorming ANY interactive to toy with ideas for the "luxury version". Sometimes you'll find the luxury version worth doing if it makes for a great visitor experience, and is actually possible.

The bead strands listed above are plastic beads glued to a string. The string can break, but when it does, you don't have loose beads running all over the floor. You can string your own using Kevlar or monofilament string and decrease the chance of breakage, but even with that, someday it might break and loose round beads on a hard surface are a fall hazard. A carpeted floor will decrease this hazard. Always remember, the first rule of interactives: Thou shall not hurt the visitor. In the final version the beads strands need to be fast and easy to change out.

Originally submitted to Cheapbook Three by Clifford Wagner

# Cartesian Floater

**Description**

This is a variation of the familiar Cartesian Diver. The "diver" starts sunk at the bottom of a long sealed vertical tube full of water. A syringe is connected through a length of flexible transparent tubing to the stopper at the top of the vertical tube. By pulling the piston of the syringe far enough, the "diver" is made to float to the top of the vertical tube. The reduction of pressure inside the tube causes the air inside the diver to expand; the increase in the amount of water displaced increases the buoyant force acting on the diver. When the buoyant force becomes greater than the diver's weight the excess upward force causes the diver to rise. The diver's rise or fall can be delicately controlled by slight movements of the syringe's piston. Since the diver is transparent the user can see and relate the diver's rise and fall to the changes in volume of the air inside the diver.

**Materials**

*(Dimensions for typical table-top exhibit, can be scaled up or down)*

- Acrylic tube, clear, 1-1/4 inch OD, 1 inch ID, length 30 inches
- Acrylic sheet, 1/4 inch thick, about 6 inches square (for base)
- Dropper, Polyethylene, 1 ml (From Amazon and elsewhere)
- Copper wire, 14 gauge or so, several inches (diver weight)
- Monofilament nylon line, thin (such as 6-lb. test), 3 inches
- Syringe, plastic, 50ml, Luer tip (From Amazon and elsewhere)
- Nylon string, braided, substantial (such as 40-lb. test), 6 inches
- Flexible clear plastic tubing, 5/16-inch OD, 3/16-inch ID, 40 inches
- Rubber stopper, size #5-1/2, one hole
- Short rigid tube to connect 3/16" ID tube to rubber stopper
  (Can be improvised from cheap round ballpoint pen barrel)

**Construction**

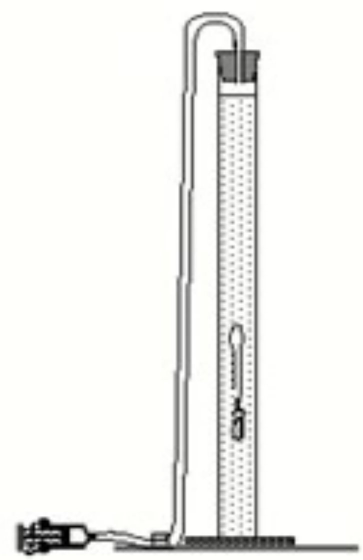
1. Cement one end of the acrylic tube to the center of the acrylic base.
2. Drill holes, snug-fit to the braided nylon string, through the barrel of the syringe at the handles and through the piston's handle about half-way up its length. Refer to sketch detail.
3. Thread the braided nylon string through the drilled holes, as in sketch. Tie large knots near ends of the string, located so the handle can go all the way in, but not all the way out.
4. Push-and-twist one end of the 3/16 inch ID flexible vinyl tube onto the Luer fitting on the syringe. It jams on surprisingly firmly.
5. Use short length of rigid tube to connect other end of vinyl tube to the rubber stopper.
6. Poke a small hole through one wall of the dropper's tip, and thread the monofilament line through it. Tie string's ends together to make loop for copper wire weight to hang from.
7. Put diver into tall jar of water. Hang enough copper wire from the string loop so the diver barely floats when full of air.

**<u>Construction</u>** (continued)

8. Fill acrylic tube with water to within 1 inch of the top.
9. Drop the air-filled diver into the tube.
10. Push handle of syringe all the way in and then insert rubber stopper into top of acrylic tube.
11. Pull handle of syringe all the way out. Excess air bubbles may come out of diver. This is OK. Diver should float to top of acrylic tube.
12. Push handle of syringe in. Diver should sink when handle is part way in, and then float when handle is pulled nearly all the way out.

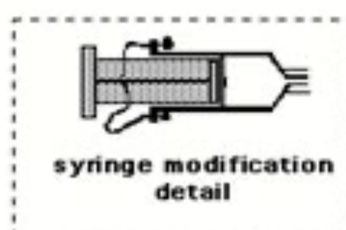
**Notes:** To prevent visitors from pulling the Cartesian Floater over, fasten the top of the acrylic tube to a strong vertical support and affix a point on the flexible tube near the syringe to the table.

Put a horizontal line halfway up the acrylic tube and challenge visitors to hold the diver motionless at that mark. It is nearly impossible, since the buoyant force changes with pressure, and the pressure varies with depth as well as with syringe setting. This may lead to appreciation of the swim bladder in fish.



A variation in the design involves cementing a small rigid tube horizontally into the bottom of the main tube and connecting the syringe to it. Plug top of tube with solid rubber stopper. The syringe and connecting tube as well as the main tube are completely filled with water. One can use a smaller syringe for the buoyancy control since in this sealed system the only air to be expanded is inside the diver.

Originally submitted to Cheapbook Three by Albert J. Read




## Cork Sinker

**Description**

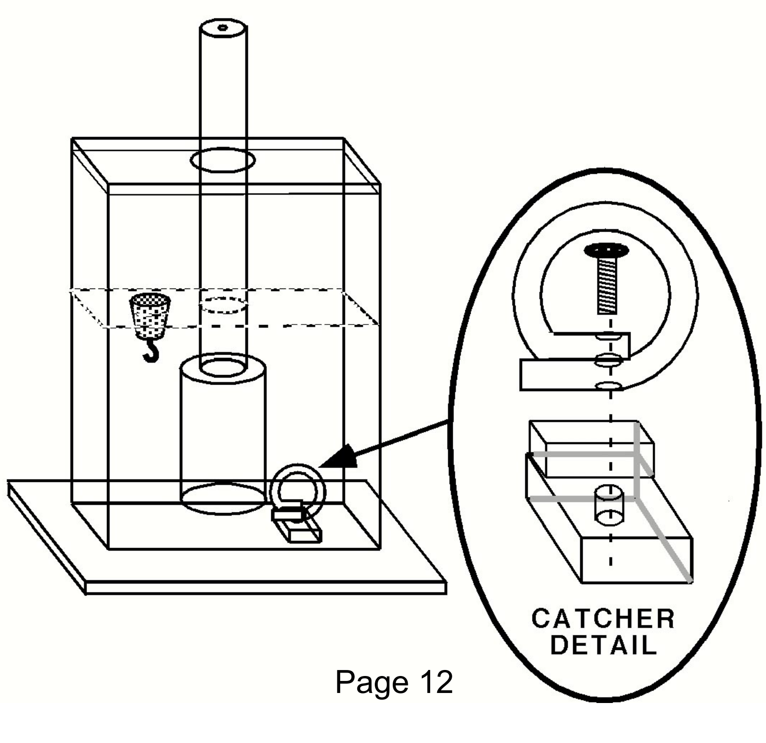
This is an adaptation of the venerable activity using an inverted glass containing a handkerchief which remains dry as the glass is pushed, open end down, to the bottom of an aquarium, thus showing that air is a substance that takes up space.

In a tank half-full of water, a small cork floats. A hook projects from the cork's bottom. Near the center of the tank's bottom there is a loop into which the hook can fit. An acrylic tube, open at the bottom and closed at the top except for a small hole, projects through the tank's lid. By manipulating the tube with some air trapped in it, the cork can be submerged to the bottom of the tank and hooked onto the loop. The crucial action needed by the visitor is to close the hole at the top of the tube air-tight with a thumb in order to trap air inside the tube.

**Materials**

*(Dimensions given are for typical tabletop exhibit, can be scaled up or down)*

- Acrylic sheet, 1/4 inch by 6 inches by 12 inches (2 pcs., tank front and back)
- Acrylic sheet, 1/4 inch by 4 inches by 12 inches (2 pcs., tank ends)
- Acrylic sheet, 1/4 inch by 6 inches by 8 inches (1 pc, tank bottom)
- Acrylic sheet, 1/4 inch by 4-1/2 inches by 6 inches (1 pc, tank top)
- Acrylic sheet, 1/4 inch by 1/2 inch by 5-1/2 inches (2 pcs, tank top flange)
- Acrylic sheet, 1/4 inch by 1/2 inch by 3-1/2 inch (2 pcs, tank top flange)
- Acrylic tube, 2 inch OD, 1/8 inch wall, 3 inches long (lower section of sinker-tube)
- Acrylic sheet, 1/4 inch thick, 2 inch diam., 3/4 inch centered hole (sinker-tube joiner)
- Acrylic tube, 1 inch OD, 1/8 inch wall, 12 inches long (upper section of sinker tube)
- Acrylic sheet, 1/4 inch thick, 1 inch diameter, 3/16 inch center hole (top, sinker-tube)
- Acrylic block, 1/4 inch thick by 1-1/4 inch by 1 inch (catcher base)
- Acrylic block, 1/4 inch thick by 1/2 inch by 1 inch (loop brace, catcher base)
- Vinyl tubing, 1/4 inch OD, 1/8 inch ID, 5 inch length (loop)
- Machine screw, brass, round head, 6-32, 5/8 inch length (loop fastener)
- Machine screws, brass, flat head, 6-32 by 1/2 inch, (2 ea., for fastening top to tank)
- Cork (or spherical fishing bobber), about 1 inch diameter



**Construction**

1. Cement the loop brace block to the catcher base block. (Refer to sketch)
2. Punch holes, snug fit for 6-32 screw, through vinyl tube,1/2 inch from each end.
3. Drill and tap hole for 6-32 screw in catcher base block.
4. Assemble catcher loop to base block with screw, as shown in sketch..
5. Assemble and cement the tank front, ends, and back to the base and to each other. Tank inside measurements should be 5-1/2 inches by 4 inches. Also cement the catcher loop assembly near the center of the bottom of the tank.
6. Assemble and cement flange pieces to lid. They may need to be trimmed slightly to fit snugly inside tank's walls. Then drill, tap, and countersink 6-32 holes horizontally through tank walls, aligned with slightly larger holes centered in lid's flanges so flat-head screws can secure lid to tank. Drill 1-1/4 inch hole through center of lid for the sinker tube. (Smaller hole can be enlarged with round file or taper reamer.)
7. Assemble the sinker tube components (refer to sketch). It may be necessary to true up the tubes' ends on a lathe to get proper fit for secure cementing.
8. Assemble floater. Make hook from 1/8 inch brazing rod or heavy solid copper wire (16 gauge or heavier) inserted through cork or affixed to bobber.

Originally submitted to Cheapbook Three by Albert J. Read

# Crayons in Deodorant Containers

## Description

Many museums have hands-on rubbing stations where children can reproduce patterns by placing a blank sheet of paper over a die and rubbing the paper with a crayon, somewhat like making brass rubbings or headstone rubbings. Art museums have a particular difficulty with this, since untethered crayons in the hands of small children can be a hazard to works of art in the galleries. When the Toledo Museum of Art opened a hands-on gallery with a rubbing station, it launched me on a search for the ideal rubbing crayon: One that could be secured to the hands-on station yet give a satisfactory experience for children. Deodorant containers turned out to be the perfect container.

This design was arrived at through a lot of trial and error. The method sounds complicated and seems awkward the first time. It's actually pretty simple, but it takes longer to write out than to demonstrate. After two or three containers, it becomes pretty straightforward. It is important to prepare the containers to take the melted crayon or they won't work properly. Once a container is prepared, it can be reused until it is worn out or broken (several months), so the time invested in preparation pays off in the long run.

## Construction

*Preparation of the Containers*

I use stick deodorant containers that are oval in section and have a threaded center post inside. A small platform rides up and down the center post and pushes the deodorant out the top. The best kind of container to use is the type made for gel-stick deodorant. The small platform inside the container has gasket sides that seal against the wall of the container and keep the melted crayon from leaking into the bottom. I never thought I would spend so much time staring at deodorant containers. People at the local supermarket must wonder if I have some kind of fetish.

Used containers work perfectly well, but after several staff said, "Yeeeuuuw- you're using USED containers?" I bought new ones and emptied them out. It goes against my Green principles, but you have to pick your battles. Taboo body parts are not something I'm ready to take on. Pry the top off the gel container by sticking a screwdriver into the slots and gently prying. Empty out any remaining gel deodorant, remove and keep the plastic platform that goes up and down the screw, and wash all parts thoroughly to remove all traces of the deodorant. I stick them in the dishwasher. The little platform inside the container is usually made from nylon plastic and won't grip the cast crayon well enough to prevent the crayon from sliding out. I drive several screws part-way into the top of the platform, leaving enough of the heads exposed for the melted crayon to flow around and lock onto.

**Construction** (continued)

To fasten the crayon holder to the gallery work surface, I rivet a double link of decorative chain to the underside of the container, leaving a loop exposed. The loop can then be attached to a chain or lanyard using a HEAVY DUTY fishing split ring (which are used to attach lures to the ends of fishing lines). This allows you to change containers fairly easily. I would stress that you should use heavy-duty split rings. I was astonished to discover that little kids were pulling hard enough on the containers to cause standard split rings to deform and open up, detaching the crayon from the chain into the hands of the frenzied child. What do they feed these kids?

Almost ready now! Just before pouring the melted crayon into the container, you will need to coat every surface that will touch the melted crayon (except the small platform that travels up and down the screw) with a candle mold release spray. This can be found in craft supply stores. The spray is highly flammable, so use it in a well-ventilated area away from an open flame. With the plastic platform removed from the inside of the container, spray mold release on the inside surfaces; shake out any excess. Insert the plastic platform and screw it down as far as it will go. The next step is important; the crayons won't work unless this step is performed. To keep the melted crayon from flowing around the center screw post and binding to it, it is necessary to place a plastic soda straw over the post while casting. The straw must be coated with candle mold spray and slid over the center post just before casting. You will need to hold it down against the bottom of the container while you pour the melted crayon into the container. After a moment the crayon in the bottom of the container will cool and harden enough to hold the straw in place and you can let go. You may have to search a bit to find soda straws of the right diameter.

*Melting the Crayon and Casting*

I recycle broken crayons from our art classes. Sort your crayons out by color groups; the artists among you will know how to combine crayons of different colors to avoid the sort of putrid hues I ended up with the first few times.

The staff of our Family Center melts crayons in a double boiler, but I prefer to use Pyrex measuring cups in a microwave oven. You will need a container with a slight spout in order to pour the melted wax into the container, and I'm not sure how well glass measuring cups would do in a boiling water bath. If you use a microwave to melt the crayon, be careful. Melted crayon is flammable, so if you microwave it too long it could flash up. Watch the Pyrex container inside the microwave to make sure the crayon doesn't start smoking. Don't use crayons with metallic particles in them in a microwave. I found that 6-8 broken-up crayons would melt in a microwave in about 3 minutes. Since microwaves are all different, start with a shorter time and work up to test the timing for yourself. You want to melt the crayon thoroughly, but have it still be slightly viscous. If the crayon is too hot, it could deform the deodorant container.

**Construction** (continued)

With the deodorant container prepared and coated with mold release as described above, and with a soda straw (also coated with mold release) slid over the center screw and pressed against the bottom of the container, carefully pour in the melted crayon. I wear oven mitts for this step and cover my work surface with paper towel or newspaper. After a moment you can let go of the soda straw. The crayon will cool and shrink from the outside, leaving hollows in the center. You will want to fill those hollows with more melted crayon when that happens.

After the crayon has thoroughly cooled and hardened, you can remove the soda straw. Sometimes the hardened crayon sticks slightly to the inside of the container, but if you deform the container by squeezing the sides gently, it should pop free. The upper surface of the hardened crayon is often irregular; I usually shave it down to a flat surface so that the first users have a better rubbing surface.

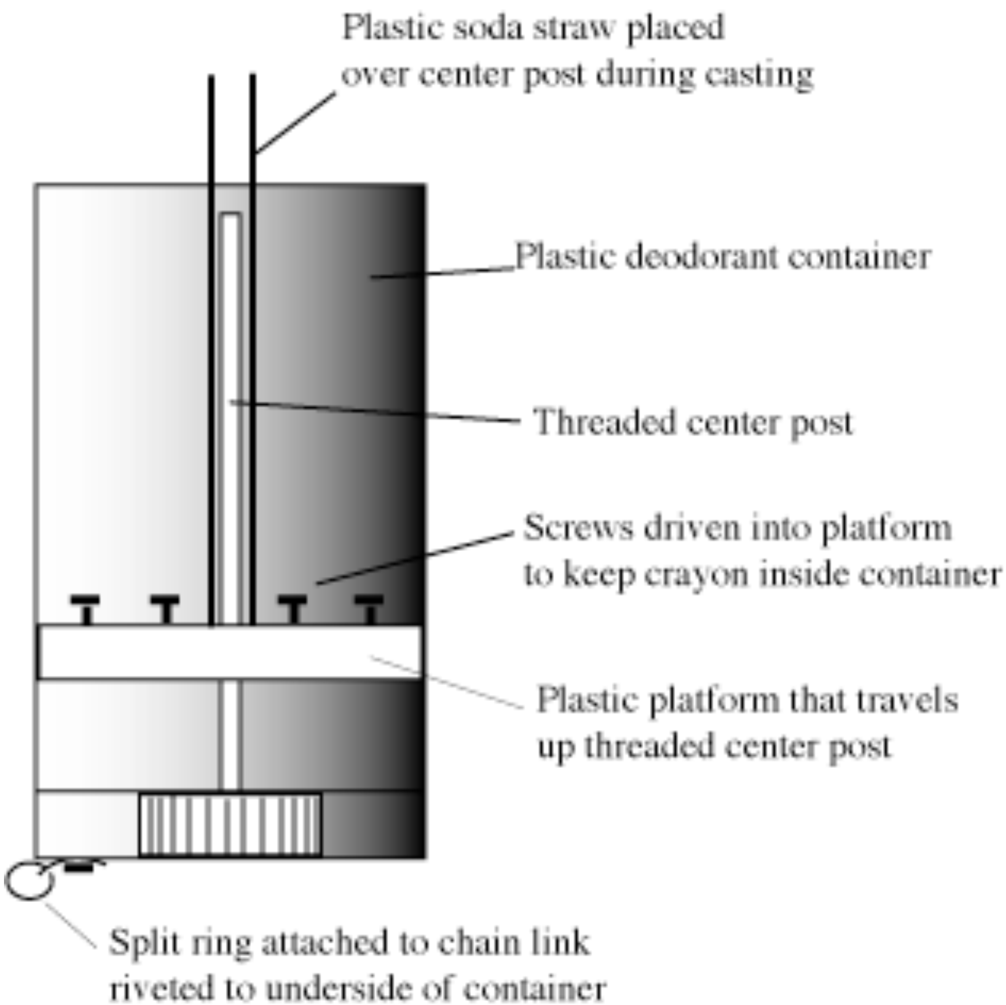
**Notes on Rubbing Dies to Use with Crayons**

We have experimented with a couple of different ways to produce dies for gallery rubbings and found, unfortunately, that the most labor-intensive way works the best.

We have on display a set of Egyptian hieroglyphs cut several years ago from linoleum block by Ruth Voyles, who at that time was director of our Family Center. The designs are carved in relief and are works of art in their own right. Linoleum block material comes in 1/4 inch (6 mm.) thickness. Although it can be purchased already bonded to a wood or particle board block, we used the thin stock in order to countersink it into 1/4 inch deep recesses in our desktop.

Since that time we have had rubbing dies made by a local rubber stamp company using a photo-sensitive vinyl material. That is a lot less labor-intensive, but unfortunately the stamp material is not as hard as the linoleum and doesn't produce as crisp a rubbing. It also cost about $100 to produce an 8 by 10 inch (20 by 25 cm.) block of Japanese characters. The linoleum is cheap and relatively easy to cut, although patterns as elaborate as Egyptian hieroglyphs require a high level of skill.

Crayon will inevitably be rubbed into the designs on the dies. We have tried several cleaners and found the best to be orange cleaner and degreaser. It also removes crayon from the rubbing desk without harming a painted surface. It is not caustic and has a pleasant citrus scent. After you clean the desk, you smell like you peeled a dozen oranges. It can be found in craft supply stores and stores specializing in art supplies.

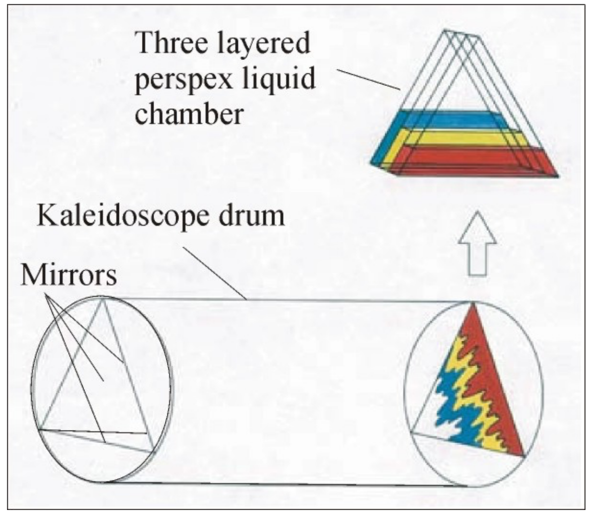



Originally submitted to Cheapbook Three by Timothy A. Motz

# DYNAMIC KALEIDOSCOPE

**Description**

The static mosaic of a standard kaleidoscope has been replaced by a three layer triangular transparent plastic box with coloured viscous liquid inside each of the three chambers. As the kaleidoscope drum rotates, the liquid layers trickle down lazily creating a dynamic mosaic of coloured patterns.




**Materials**

- Four numbers of 4 mm thick plexi triangular pieces of required size depending on the size of the kaleidoscope drum.
- Adhesive and a disposable injection syringe for joining the plexi pieces for making the liquid chambers 3 numbers each of 2 mm thickness.
- Ordinary transparent cooking oil of required quantity to fill in one third of each chamber's cavity.
- Small quantity of oil-based dyes of three colors (Red, Blue and Yellow) for colouring the transparent oil in each chamber.

**Construction**

Place the triangular plexi pieces one on top of the other with 1/2" wide 2 mm thick plexi spacers between consecutive layers and join them using adhesive administered by means of the injection syringe. Make two numbers of 1/8" tap holes for each cavity for filling the coloured liquid in each of the chambers. Fill in almost one third of the chamber's capacity.

Originally submitted to Cheapbook Three by Ingit K. Mukhopadhyay

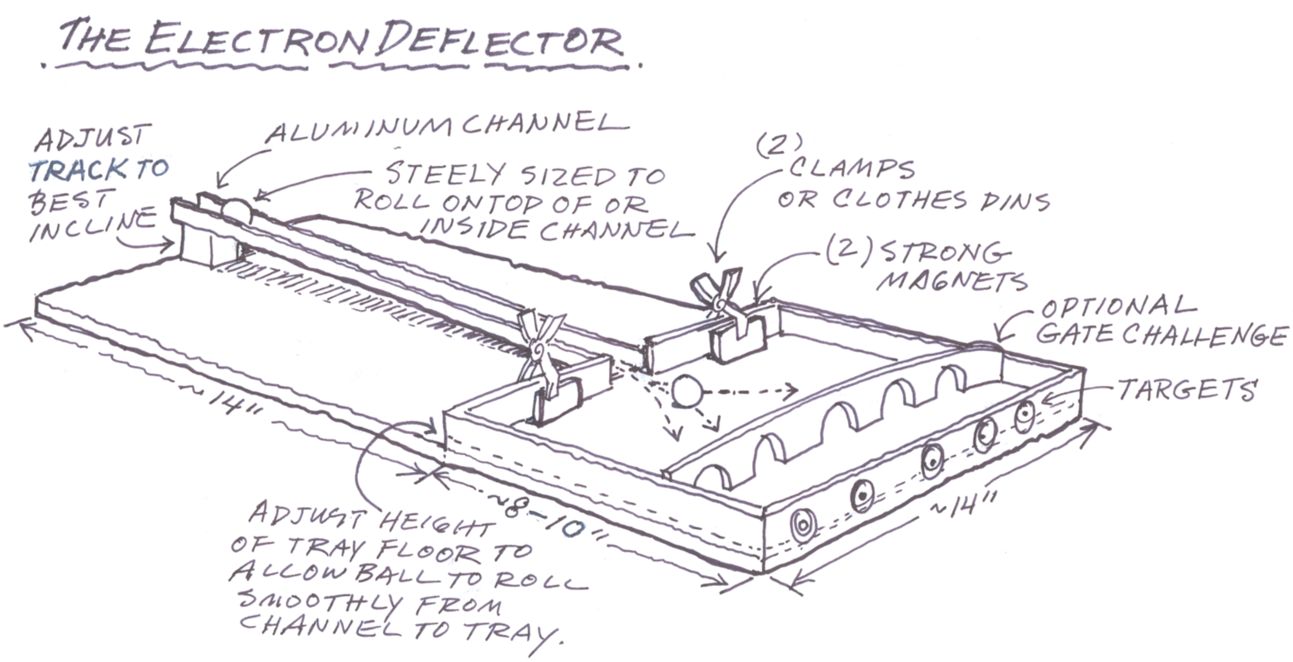
# The Electron Deflector

## Description

This device was cobbled together to demonstrate how an electron beam can be steered by a magnetic field much like a cathode ray tube. The device can also be used as a physical model to demonstrate "gravity assist." Astronomers use gravity assist to propel spacecraft farther out into space. A spacecraft is steered close by a planet and its speed is accelerated by the gravitational field of the planet. As the craft sweeps around the backside of the planet, it is flung with more acceleration into outer space.

## Materials

• Piece of 1/2 " plywood 14" by 14"
• Three strips of ½" plywood 1" by 14"
• Two strips of ½" plywood 1" by 10"
• Steel ball bearing(s)
• 1" aluminum channel 14" long
• Wood block 1" square
• Two strong magnets
• Two clamps



**Construction**

This exhibit can be adjusted to size, up or down, as needed. The main thing is to provide for some adjustment to the incline of the track that the steel ball bearing rolls down, as well as allowing for "fine-tuning" in the placement of the magnets that cause the actual deflection.

Originally submitted to Cheapbook Three by Kit Cube and Chris Burda

# Five Senses

**Description**

Discovering the world around us would be impossible were it not for our five senses, but the body's tools of discovery are usually taken for granted and often misunderstood. So we've put together five "sense boxes," an interactive exhibit to encourage children to explore the stuff that lets them see and hear and touch and taste and smell. This exhibit is made up of 5 boxes, each representing a different sense, and includes a set of 25 game cards.

**Materials**

*Sense Boxes*

- Twenty 9.5" square pieces of pine (or comparable material)
- Five 10" square pieces of pine (or comparable material)
- Five different colors of glossy latex spray paint (we used red, blue, green, yellow and black)
- Twenty-five separate items to place on or in boxes (5 for each sense)
    - For Sight Box: Prismatic foil, color wheel, non-breakable mirror, optical illusion and a 3D image (cut into circles approximately 4" radius or smaller)
    - For Sound Box: Guitar strings and eyehooks, rattle, wind chimes, bells and bike horn
    - For Taste Box: Pretzels (salty), lemon drops (sour), candy (sweet), dark chocolate (bitter), peppermints (minty) and5 canvas sacks
    - For Touch Box: Corduroy, satin, sandpaper, bumpy rubber and faux fur (cut into 8" squares)
    - For Smell Box: Lemon zest or lemon car freshener, pine needles or pine car freshener, floral potpourri, coffee beans, cinnamon sticks and 5 baby food jars with lids.
- Sixty 1.5" wood screws
- Staple gun and staples
- Wood glue
- Hot glue
- Fishing line
- Ten small eye hooks
- Eight 2.5" bolts with locking nuts
- One sheet of felt with an adhesive backing cut into ¾" x 2" pieces (8 per box)
- Molding
- A few pairs of 3D Glasses

*Cards*

- Enough paper and laminate to make a set of 25 cards (ours are playing card sized, but any size will work)

## Construction

*Boxes*

1. Build five separate boxes using four- 9.5" pieces of pine and one 10" piece. Arrange four 9.5" pieces of wood into a cube using a butt joint and hold it together with wood glue (a vice grip or sturdy clamp will be helpful). Use two wood screws per connection. Place the 10" piece of pine on top and fasten it down using wood glue and four wood screws.
2. Once building is complete, paint each box a different color.
3. Assemble each of the boxes according to the sense
   - **Sight box:** This box will use the non-breakable mirror, optical illusion, 3D image, prismatic disc and color wheel for the sight box. We cut each of these items into a circle to represent eyes. Attach each item to the outside of the box with hot glue (to reinforce, use staples and then pound flat with a hammer), the prismatic disc will need a hole drilled in the middle and can be connected with a bolt and locking nut. Be sure to leave a border around each item to see the color of the box. (If desired, you may want to attach the 3D glasses to this box to avoid being misplaced.)
   - **Touch box:** This box will use the corduroy, satin, sandpaper, bumpy rubber, and faux fur. Items should be cut to 8" squares. Attach the squares of each fabric to the outside of the box using hot glue (again, the squares can be reinforced with staples). Be sure to leave a border around each item to see the color of the box.
   - **Taste box:** This box will require that you use a jigsaw to cut a hole in the center of each side. We cut a diamond shape hole into ours to represent the mouth. Affix a canvas sack to the inside of each side in the box (four in all). We left the opening of the bags on the outside of the box and held them down with door molding. Finally, place a salty item on one side, bitter on another, sweet on another, sour on the fourth and minty on the last side. Guests can grab a treat out of each side and discover which taste buds are affected. (We use all pre-wrapped treats and we warn our guests of potential food allergies.)
   - **Smell box:** Attach the lids of the baby food jars to the inside of the box in the center of each panel with a finishing nail or super glue. Drill 10 to 15 small holes trough the box and the lid. We drilled these in the shape of a triangle to represent the nose. Put different scented items into each baby food jar and screw on to the lids.
   - **Sound box**: Use small screws and fishing line to attach the rattles and bells each to a different side of the box. The fishing line to give some mobility to these items. Attach the chimes so that they can be free moving. Ours had a wooden piece at the top, that suspended the chimes and we just screwed that piece onto the box. Mount the bike horn to another side, with bolts. You may find that using locking nuts will work best, so that the horn does not become loose. Screw in the eyehooks in two rows of 5 on one panel and then run the guitar strings from one column to another.

*Cards*

1. Number each side of the boxes (we used white and black paint pens to do so).
2. Create a card for each item on the boxes. On one side of the card you can set up a phrase such as "I am furry", or "I chime." On the backside of the card you can have an image of the item along with a key indicating which box and side the item is on (e.g., a red diamond with the number 3 inside tells the visitor that the taste box side 3 is the item they are looking for). If your audience speaks a language other than English you may want to create a second set of cards for the audience. We have created a set in both English and in Spanish.

**Notes:** We have created five 10” x 10” square boxes, but the concept can really be modified to any size boxes, small 3” x 3” boxes might be great for little hands to hold as well as to touch and feel.


Originally submitted to Cheapbook Three by Dawn Hawkins

# Goofy Goggles

**Description**
How does vision affect balance? Find out by altering your vision and trying a simple task such as walking on a straight line. Along with the inner ear, vision has a huge effect on your balance. We explored the whole concept of balance in a variety of exhibits in a traveling exhibition, ***The Body Carnival***, and this was one of the methods of exploring the role of vision in balance.

We used commercially available drunk driving glasses, and simply reinforced them. Then we provided the visitor with a path to attempt to walk.

**Materials**

- D.W. Eyes Goggles part #79197 (NOTE: this is the one special, expensive part of the exhibit.) Supplier: Health EDCO www.healthedco.com
- Reinforcing Material (Sintra, Aluminum, or Masonite) 2" x 2" square
- Screws
- Glue appropriate to the reinforcing material used
- Tape or other "path" material

**Construction:**
Almost no "real" construction is needed, but we found that it was necessary to alter the goggles slightly so that they could endure the museum environment. In our case we had some leftover pieces of ½" Sintra that had been used for a sign. You would want to adapt our instructions for your particular supporting material. For example, using rivets for aluminum, instead of sheet metal screws.

1) Cut out a triangle of supporting material that will go across the exterior bridge of the nose to reinforce the goggles. We used some leftover ½" Sintra style material that we had on hand. We used a jigsaw to cut out the initial triangular shape then sanded the edges to give a smoother look.
2) Drill three small holes (in a triangular pattern) through the inside of the black plastic goggles into the supporting Sintra.
3) Apply an appropriate glue on the back of the Sintra (Plastix, or even a silicone caulk will probably work).
4) Using pan-headed or washer-headed small (1/4"-1/2") sheet metal screws, screw from the inside of the goggles through the plastic, into the Sintra. This will give a mechanical means of bonding as well as give the glue time to cure between the two plastics.
5) Now unscrew the big black circular "nuts" that keep the exterior eye piece on.

6) Put a bit of silicone or loctite along the nuts threads and screw it back on. (Why did we do this? To make it harder for visitors to unscrew them later on!)
7) Adjust the elastic headband (that's connected to the goggles) to fit snugly on an average visitor's head. Sew each side of the elastic, so that it cannot be removed.
8) Lay out your walking path on the floor (note, if you are using tape on carpet, we strongly recommend a less aggressive tape such as Gaffer's Tape – Duct tape often leaves nasty glue marks on the carpet that are very difficult to remove). We recommend having two 90 degree turns.
9) Add signage that says something to the effect of: "Can you follow the yellow path while wearing these goggles? The goggles distort your vision, causing items to appear in different locations than they really are. How does this affect your balance?"

**Notes**:
The goggles will likely move around, so we found it good to have a place to hang the goggles or a bin to put them in, and we normally had 2-3 goggles out so that if one wandered off, another one was nearby.

In our signage, we also added a bit more explanation to try to connect all of the different areas our exhibit was concentrating on (the exhibit had a number of interactives, all relating to balance.)

The remaining science text was:

Your ability to remain upright depends on your:

1. *Eyes.*
2. *Inner Ear*—fluid filled tubes inside your head similar to carpenters' levels.
3. *Proprioceptors*—nerves allowing you to know where your body parts are without looking. That's why you can touch your nose with your eyes closed.
4. *Center of Gravity*—the way your weight is distributed.
5. *Base of Support*—the area supporting your weight.

Originally submitted to Cheapbook Three by William Katzman

# Harvey the Invisible Rabbit

**Description**
The old magician's trick, but with entirely see-through apparatus.
Pulling a glass rabbit from an apparently empty glass top hat.

**Materials**
Various, that's part of the fun.

- A 3 Liter Glass Beaker with no markings
- Thin acrylic sheet for "hat brim"
- Thicker acrylic Sheet for Rabbit
- A little piece of Styrene
- Various Baby Oils or Esso Primol 352 or Sugar Solution
- A lifting mechanism and a clear case.

**Construction**
I've always loved the Exploratorium's exhibits, and once, many years ago whilst wandering around in a seething mix of admiration and envy, I noticed the Glass Rods exhibit. It consisted of a bundle of glass rods that you could lower into a tank of clear liquid, when you did some, but not all, of the rods disappeared. It was fascinating once you knew and appreciated it. I played with it for ages, but it wasn't attracting that many visitors. I decided that it was an under-regarded treasure and that one day I'd do a blockbuster version.

Later I found that the exhibit was described in one of the legendary Cookbooks (Recipe No. 104) and if you don't have a set go now and get one. The exhibit used a mixture of Kerosene, which would worry our Fire Officer and Wesson Oil which is unknown in the UK. So, I would have to find a suitable pairing of solid and liquid with similar refractive indices.

A scan of a few reference books and some measurements yielded the following table.

**Solids**

| | |
|---|---|
| Flint Glass | 1.65 |
| Styrene | 1.59 |
| Crystal | 1.56 |
| Crown Glass | 1.52 |
| Perspex (Lucite?) | 1.495 |
| Pyrex Glass | 1.45 |
| Ice | 1.31 |

**Liquids**

| | |
|---|---|
| Propiophenone ($C_6H_5.CO.C_2H_5$), | 1.527 |
| Sugar Solutions | 1.3 to 1.5 |
| Baby Oil (Tesco) | 1.51 |
| Esso Primol 352 | 1.46 |
| Clear Lemonade | 1.38 |
| Silicone Oil | Various |
| Water | 1.33 |

Pyrex Glass and Esso Primol 352 is a good combination, but I couldn't cut Pyrex.

Crown Glass and Propiophenone worked well but although the Health Sheets on Propiphenone gave it the all-clear, it smelt nasty.

In desperation, I tried a few clear liquids from the pharmacy and Johnson's Baby Oil and acrylic worked first time and smelt pretty good too.

I took a glass beaker added a slightly bent acrylic ring to make a glass top hat. Then I cut out a 2D shape of a cartoon rabbit in acrylic, for effect I added an opaque box tie and stuck it on. Then lower the rabbit into the Baby Oil and only the bow tie remains. A Glass Rabbit that disappears in a Glass Top Hat.

For variation you could try a acrylic Cheshire Cat with a Styrene smile. The Rabbit's called Harvey as a James Stewart tribute, but you could update it and call him Donnie instead.

**Notes:**
I measured the refractive index by the critical angle method using a laser pointer and a D-shaped trough, this seemed like a good idea but actually the results were only valid for red light and the liquids needed a little tweaking for best effect in white light.

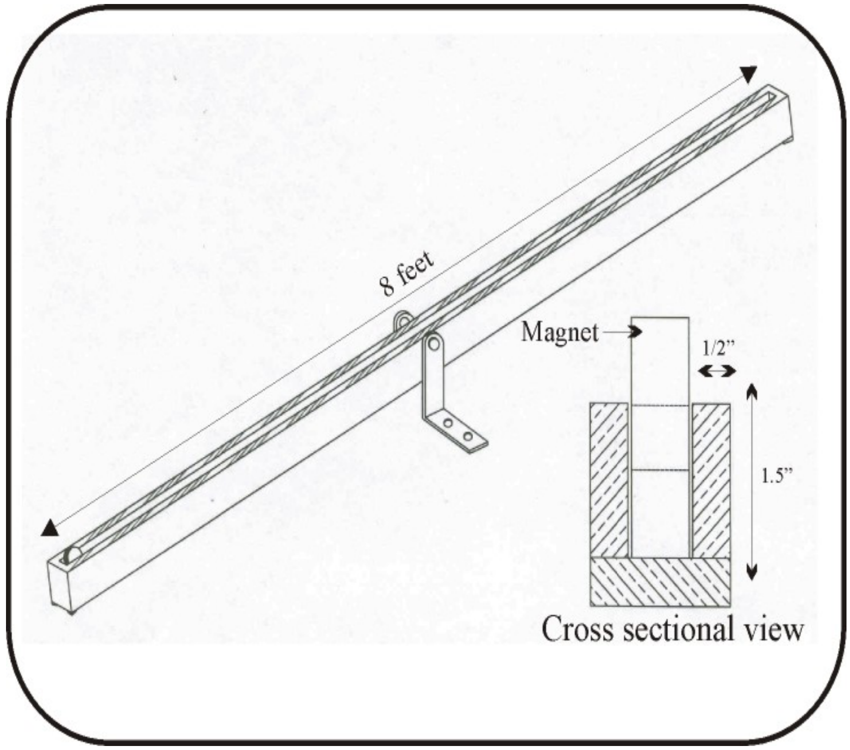
There were a few problems with bubbles getting stuck to the rough surface of my crude rabbit cut-out so I would recommend flame polishing to lose the nooks and crannies.

Originally submitted to Cheapbook Three by
Harry White

# LAZY CHANNEL

**Description**

A disc or ring magnet rolls lazily down an inclined channel made of aluminium. The phenomena of Eddy Currents and Lenz's Law are clearly demonstrated.




**Materials**

- 1/2" thick aluminium channel of dimension as mentioned in the sketch.
- Two rigid aluminium posts for pivoting the channel at its centre so that it can be tilted either way about the pivot.
- One 1.5" or 2" diameter by 1/2" thick permanent disc magnet.

**Construction**

- Block both ends of the aluminium channel by riveting 1/2" thick aluminium cut-pieces
- Pivot the channel at the middle by means of the support post.
- Place the magnet inside the channel and tilt to one side.

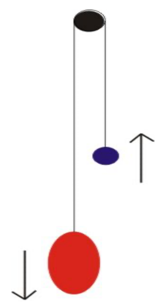
Originally submitted to Cheapbook Three by Ingit K. Mukhopadhyay

## LITTLE AGAINST THE BIG
## How to block the fall of a body using a smaller one

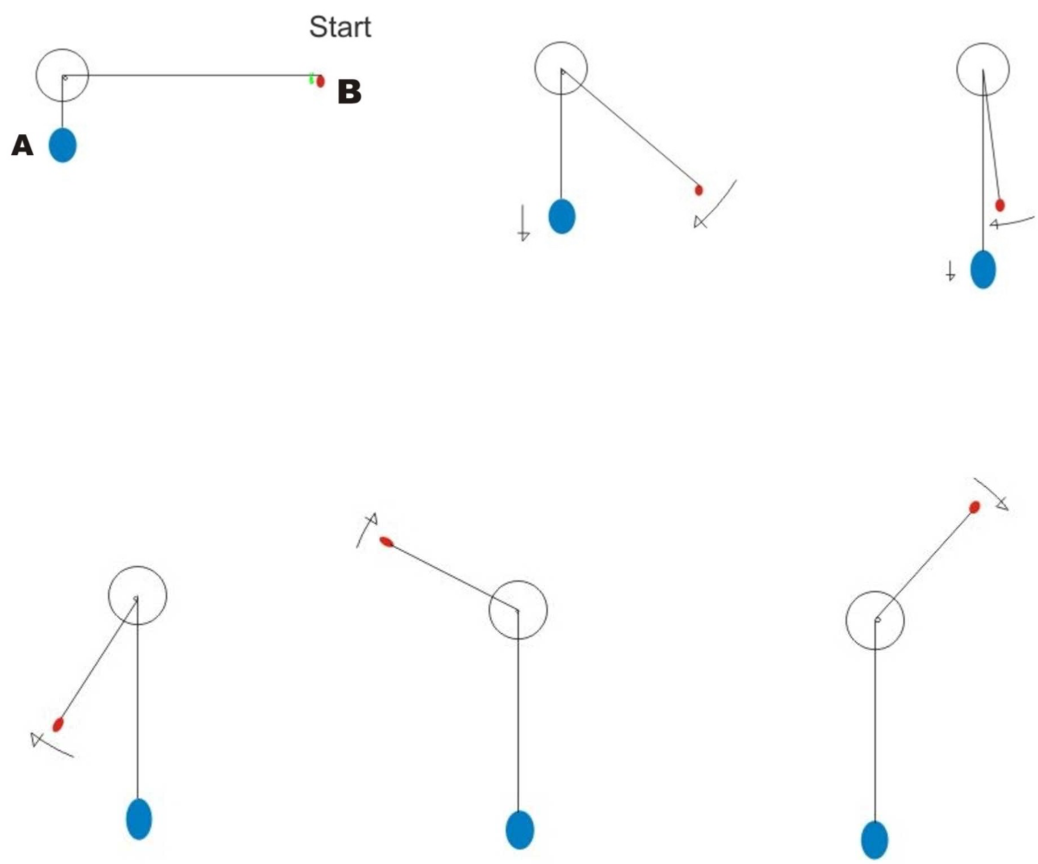
**Description**

If different bodies are attached to the rope of a pulley, the heavier one pulls the lighter one: «the big one beats the smaller one».

The same thing occurs if we take a short rope, attach to its ends two different weights A and B, and put it on a horizontal pivot P, which works as a pulley:



However, if one releases B from another position, i.e. a lateral position (see the sequence of drawings), then things don't go that way any more. A begins to fall, pulling B, but this, after having reached the same height on the other side, continues the race, winds itself around P and block A: «the little one beats the big one».



This idea was suggested to us when observed a colleague playing a game in 1996, during the 1st Science Centre World Congress in Vantaa (Finland).

**What is going on**

In the simplest case, when the initial situation is similar to which of fig 1, both velocities of A and B are aligned with the rope and so they remain afterwards: the body A falls vertically, B goes up in the same direction but counterclockwise. In fact, B is lighter than A (mg<Mg; where g is the *acceleration of gravity* and m and M respectively the masses of B and A).

In other cases, when the initial position of B is out of the vertical passing through the pivot P, while A falls vertically, B falls as well, but it is also forced to go up. In conclusion, it follows a composed motion which gives a curvilinear trajectory.
Let's consider it like a pendulum, at first. If the pendulum's length were constant, the trajectory would be a circular arch and, for the *law of the conservation of mechanical energy*, B would reach the same height from which it had started. But the fall of A progressively reduces the rope's length which holds up B and obliges it to move along a spiral, that is on a trajectory whose radius becomes shorter and shorter.
This fact forces B to gain a greater velocity and to go up a level higher than the one from which it had started, ending by turning around P. This way, the rope winds around the pivot and encounters friction with it. The friction blocks the fall of A.
Let's explain the phenomenon, paying attention to the *law of the conservation of mechanical energy* which is a general law:

| |
|---|
| T (kinetic energy)+U (potential energy)= constant.<br>$\Delta T = -\Delta U$ |

During the motion of the system, the heavier body goes down and the lighter one goes up by the same absolute quantity $\Delta h$.
As g does not change, the variation of the total potential energy $\Delta U$ will be $(m-M)g\,\Delta h$. Considering $\Delta h$ and g positive, note that $\Delta U$ is a negative quantity, being $M>m$.
Hence the global variation of the kinetic energy will be positive, being $\Delta T = -\Delta U$.
A and B, therefore, increase their kinetic energy. But, while A has no further possibility of changing again the energy increase into potential energy, B has this possibility because it is dangling.
When this occurs, B reaches a level higher than that from which it has started and so even allow it to rotate around the pivot.
As soon as the rope winds around the pivot, the friction which blocks the sliding of A comes into force.
Note that, during the motion, two forces are holding back the fall of A: the friction, of which we have just spoken, and the centrifugal force, produced by the rotation of B.

**Materials**

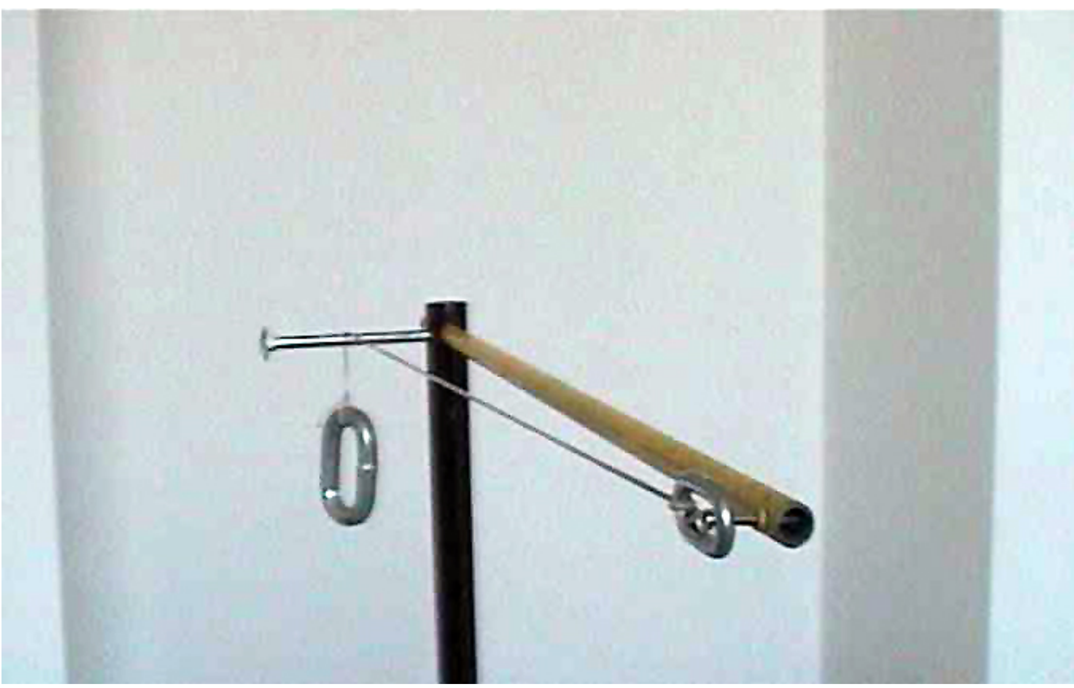
- The  weight of a plumb line;
- A smaller weight, for example, a bolt;
- A rope about a meter long;
- A vertical support (made of  wood or iron: see the drawing) on which are fixed:


1) a pivot (P)
2) a lateral arm, the end of  which holds a latch ( see the drawing) for blocking the smaller weigh;

- A base to hold the vertical support;
  For one more extempore realization of the experiment it is sufficient to have: a pen (as pivot), a string and any two different objects.

**Construction and Operation**

1) Tie the heavier weight (A) to an end of the rope and the lighter weight (B) to the other end.
2) Lay the rope on the pivot, leaving A suspended.
3) Bring B to the right and hang it to the latch, so that B is blocked.
4) Unfasten B and let it fall.



**Notes:**

In order to understand the relationship between the height to which the pendulum rises and the spiral movement in a more constructive way, it is possible to do a little auxiliary experiment. Use the left hand to hold the weight A steady and let go of B. B will go forwards and backwards always reaching about the same height. In fact it moves as a pendulum whose rope does not change its length.
Repeat the experiment.

This time, when B is reaching the level from which it has started, pull the rope at once. You can note that B *jumps* higher then P. To see the effect more clearly, and to note that the jumps always occur, execute the pull both in « phase », that is when B has gone back to its starting point, and in «opposition», that is when B lies in the symmetrical position, or better, in the middle of the pendulum's oscillation.

When you pull in «phase», B jumps above the pivot, freeing itself from the bond;
Conversely, when you pull in «opposition», it jumps again above the pivot, but it binds itself to the bond.

Originally submitted to Cheapbook Three by Pietro Cerreta and Canio Lelio Toglia

# Magnetic Word Wall

**Description**
Visitors can rearrange magnetic words, symbols, or images to make sentences, phrases, or captions.

This recipe is very flexible because you select and create the thematically appropriate words and images and type of interaction. For example, visitors could compose sentences with words related to exhibit topics, create captions for objects, or organize taxonomies.

**Materials and Method**

1) Start by looking online to identify and contact sign making businesses. You want to find those that can print the sturdy rubbery magnetic sheets designed to stick on the outside of cars or trucks. Pricing per square foot can vary and will also depend on how many colors you need, single color being the least expensive. Be sure to ask them what file formats they can work with for the "art" (Adobe Illustrator, InDesign, etc.). You may also want to ask them about standard width of the magnetic material, charge to cut the words out after printing, minimum quantity charges, and quantity discounts.

2) After identifying your sign maker/printer you are ready to create your word image layout in the appropriate application and file format. Be sure to make your words or images large enough for visitors to take in at a glance; 72 point size is not too big. Try printing everything out on paper and taping your words to the wall, then stand back to check for appropriate scale.

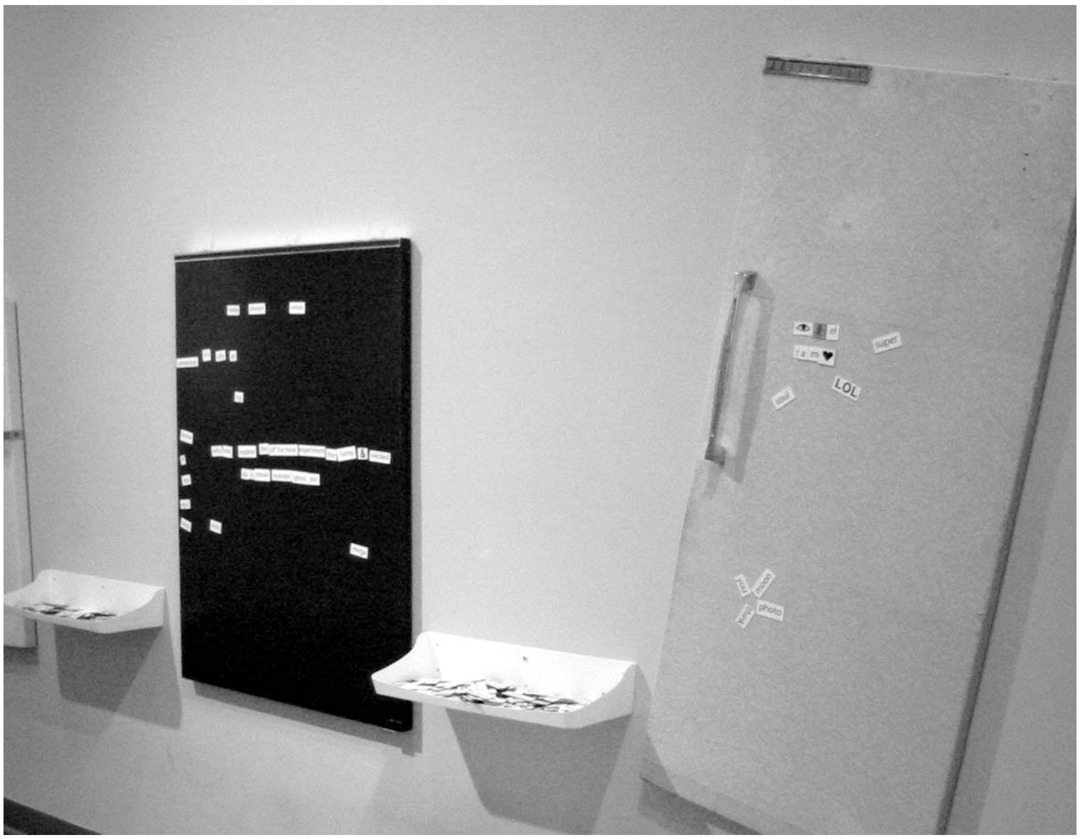
It is advisable to produce multiple instances of all words and images. This redundancy allows for a backup set of spares, and you can provide a more versatile set of magnets for the visitors. Pack the words in to fill the dimensions of your print job and make the maximum use of the square footage of your order. Make sure you consider word and line spacing and have an adequate margin for each magnet after you or the printer cut them out.

3) For your magnetic "canvas", there are at least three options:

a) Pre-owned Refrigerator Doors
Two big advantages of refrigerator doors are their familiarity to visitors as a magnet surface and the price. Used refrigerator doors are often available for free from stores that sell refrigerators. Call around and find the appliance stores that pick up the old refrigerators for disposal when they deliver a new refrigerator.

b) Painted Sheet Steel
Note that stainless steel is unsuitable because it won't attract magnets however ordinary "mild" steel will work. A careful and thorough paint job is recommended to keep the steel surface from rusting and to hold up under normal visitor use.

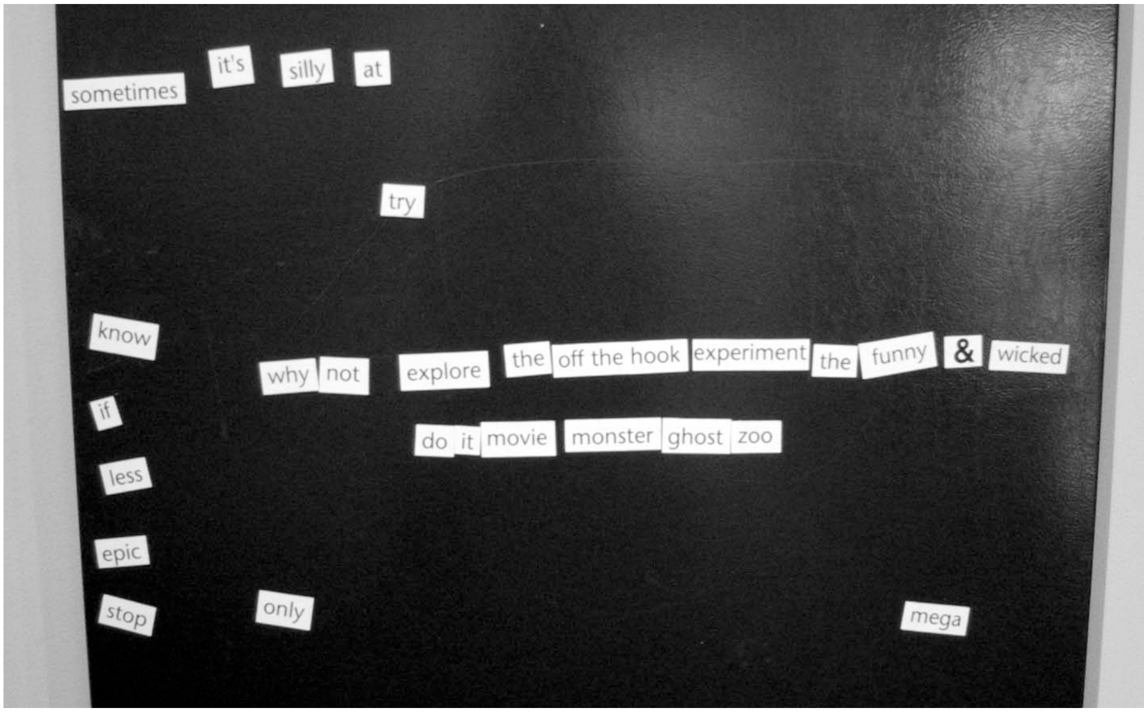
c) "Magnetico" Laminate made by Abet Laminati
This unique laminate surface has metal embedded just below the plastic laminate and provides a clean finished look. There are multiple vendors for this brand in the United States - use the URL below to locate the one nearest you. "Magnetico" can be used in fabrication just as you would any other laminate. Using laminate adhesive, glue to board and frame or incorporate in cabinetry. One drawback is the limited color choice of matte gray or glossy white. **https://us.abetlaminati.com/**




4) If you didn't choose to pay the sign maker to cut out your words you will need to do this yourself. Be prepared with a good matte knife, many fresh blades, and a large flat cutting surface. It helps to have a heavy metal ruler to guide the first cut of each line. The rubber material is fairly abrasive and will dull the blade edge, so change blades frequently. To cut neatly, take your time and change blades as needed. It is tempting to use scissors but only do this if you can afford to ruin a few pairs.

5) Mount your magnetic "canvas" surface(s) on the wall. Provide wall-attached trays or a lipped narrow shelf for the vocabulary and image "pool". The shallow window box shape of "mud pans" used to mix patching compound for dry wall are an inexpensive "tray" option and are available at most large hardware stores. Drill a couple holes in the long side and mount to the wall.

It's easy to change this exhibit when a new theme arises or inspiration strikes. Just create another graphic layout on your computer and order up another print run at the sign shop.




Originally submitted to Cheapbook Three by Claire Pillsbury

## Mirrors with a Twist

**Description**

If a plane mirror reverses left and right, why doesn't it reverse up and down? If two plane mirrors at right angles do *not* reverse left and right, why *do* they reverse up and down when the arrangement is turned sideways? This exhibit places these two mirror configurations side by side, allowing the visitor to experience and explore the phenomena.

**Materials**

- Plane mirror, approx. 16" wide x 20" high
- Two plane mirrors, approx. 11" wide x 20" high
- 1/2 inch plywood to back mirrors and form mounting bracket
- 1/2 inch steel rod, approx. 8"
- Two laboratory rod mounting flanges
- 1/8" nylon or other plastic sheet to use as spacer

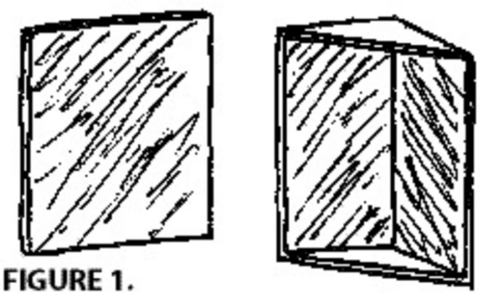


FIGURE 1.

Side by side arrangement of "reversing and "non-reversing" mirrors.

**Construction**

1) The right-angle mirrors are mounted on a frame built of 1/2" plywood. Ordinary rear-surfaced mirrors can be used, beveled to 45º along the joined edge, without causing an objectionably visible joint.

2) The pivot, which allows the arrangement to be turned sideways, uses a 1/2" steel rod and standard laboratory mounting flanges. One flange is attached to the mirror frame with a set screw holding the rod in place; the other is attached to a wall or suitable frame and serves as a bearing.

3) The dimensions of the mirrors given above are such that the opening of the right-angle mirror arrangement is about the same size as the single mirror. The mirrors should be placed so the apex of the right-angle mirrors is in the same plane as the single mirror in order to produce images an equal distance (and size) from the viewer. In addition, they should be angled slightly towards each other so that a viewer can see both images at the same time.

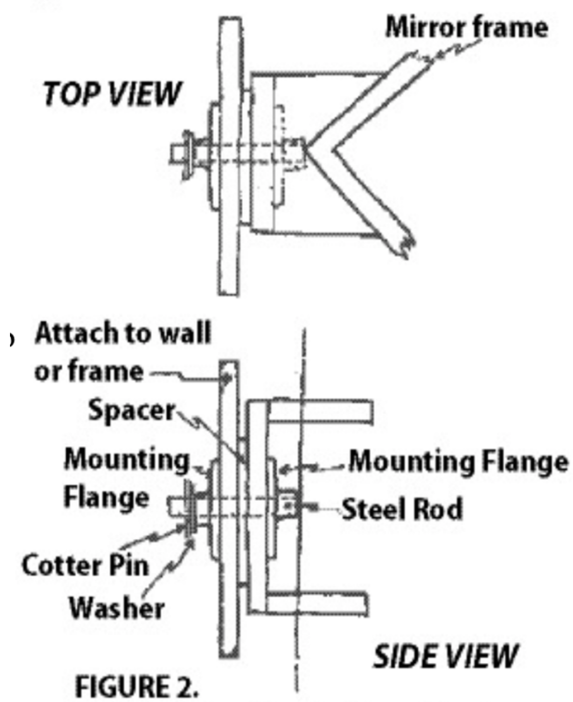



FIGURE 2.
Detail of pivot for right-angle mirrors.

**Notes:**

The question “If a mirror reverses left and right, why doesn’t it reverse up and down?” may sound silly at first, but answering it requires careful thought and definition of terms. The right-angle mirror arrangement, with its unfamiliar non-reversed image, provides a discrepant event to trigger further questioning and investigation. And turning the mirror sideways and seeing the image turn upside-down provides still another discrepant event.

**A staff member or labels can help stimulate thinking with some of the following questions:**

- Does a mirror really reverse left and right? What do the terms “left” and “right” mean?
- Are they the same as “left-handed” and “right-handed” uses to describe gloves, corkscrews, etc.
- Does a mirror also reverse east and west?
- How does a mirror change left hands into right hands—something you can’t do in the real world?
- How do the two mirrors work together to produce a non-reversed image? How does this same working together produce the upside-down image?

Originally submitted to Cheapbook Three by Ted Ansbacher

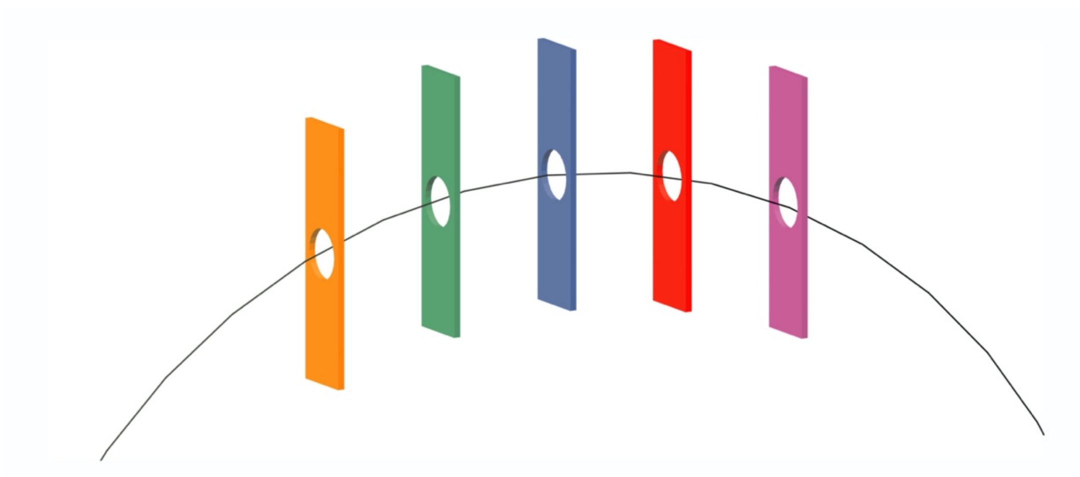
## Fun With Parabolic Throws (A Projectile Motion Exhibit)

### <u>Description and Methods</u>

This exhibit is popular in our centre. People adopt various postures, styles and tactics to get the projectile through all the “holes”. It will be nice if when they achieve this, they realize they have explored and attained a correct launch angle and initial velocity so that the projectile follows the path defined by the hole centers. It is FUN and there is CHALLENGE, great opportunities for some healthy COMPETITION within groups – families, peers etc.

The exhibit is based on mathematics and physics of projectile motion. To brush up on your knowledge here, just SEARCH for ‘Projectile Motion’ on the Internet.
There are some great sites and loads of information available.

One way to make sure your exhibit is a true parabola is to use one of these sites. We suggest a throw of e.g., 40 m/s and an angle of 60 degrees for launch. Print this parabola and then use this to project for size onto a wall. Now you can align your ‘holes’ to be at the required heights. You can draw your parabola in accordance with $y = -x^2$



For the first prototype, I used some small hula hoops and attached these by string, adjusted to the parabola shape and tied the strings to a rod. Staff had great fun in the office challenging each other with this prototype.

The next prototype was with holes in some thick cardboard to shapes similar to those illustrated above.

Finally, we now have this exhibit in our centre in the format here in this photograph. It is a very popular exhibit

Originally submitted to Cheapbook Three by Geoff Snowdon

## Persistance of Vision

**Description and Methods**

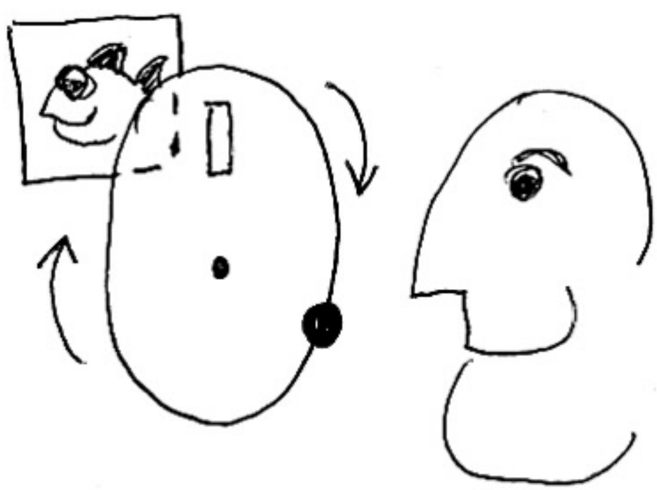
This exhibit consists of a 3" square transparency mounted to a wall. The transparency is illuminated from behind. A piece of translucent acrylic was between the light bulb and the transparency. We created the transparency by photo-copying a color photo onto clear plastic.

In front of the transparency was an opaque disc about 8" in diameter. The disc was mounted to a shaft and the shaft passed through a bearing block. There was a knob mounted to the disc so the user could spin the disc.

The disc has a radial slot cut into it, approximately 1/8" wide, so that when you spin the disc, the image of the transparency can be easily seen.

**Materials**

• Acrylic sheet
• Transparency material
• Polycarbonate or Sintra (for spinning disc)
• Shaft and bearing assembly
• Knob



Originally submitted to Cheapbook Three by Dave Bailey and Russ Durkee

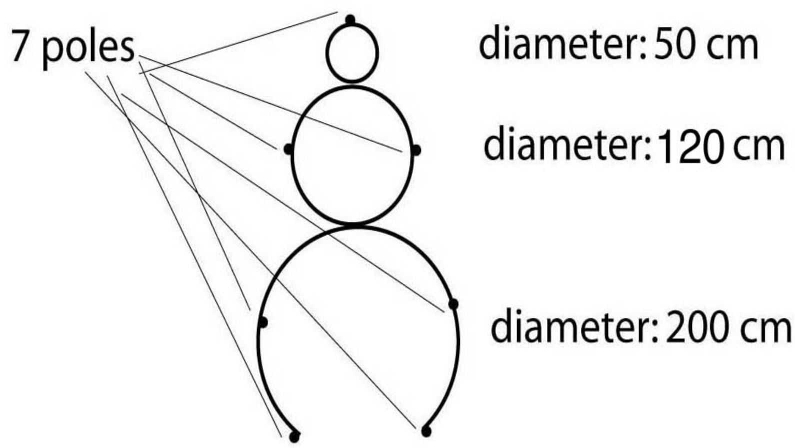
**PERSONAL SPACE: How close is close?**

**Description**
This is a wonderful way to experience the concept of *personal space:* that invisible 'bubble' that surrounds each one of us, which acts as a demarcation line and determines the interpersonal distances among us. Our personal space expands or shrinks depending on our moods, the social situation, the culture, and the kind of relationship we have with another person.

**Materials** (see photo and diagram below)

SIDE VIEW

TOP VIEW




• 3 round metal rails (to create a circular 'shower' space of 200 cm, 120 cm and 50 cm in diameter, respectively, as shown above:)
• 7 metal poles (2 meters long each) on which to fasten the three rails to floor
• Thin translucent material to enclose each space via curtains:
space of 200 cm diameter: 2 curtain halves, 210 cm wide and 160 cm long each
space of 120 cm diameter: 2 curtain halves, 180 cm wide x 160 cm long each
space of 50 cm diameter: 1 curtain of 140 cm wide x 160 cm long

**(SAMPLE LABEL TEXT) To do and notice**
1. Enter each of the three spaces with a partner, starting from the largest.
   How does it feel as each space gets smaller?
   In which space do you feel least at ease?
2. Does it make a difference whether the other person is of the same gender or the opposite gender? Try it!
3. Also ask another visitor who you don't know to enter the spaces with you. How does *that* feel?

*When is close too close?*
*Exhibit Text largest space (ø = 200 cm)*

**SOCIAL ZONE**

(3 - 1.2 meters)

Most interactions between people take place in the *social* zone.
This distance is just short of enabling a handshake or other physical contact. It is the socially accepted and 'safe' distance in our interactions with business associates, colleagues, employers, teachers, and during formal meetings and negotiations. If conversation shifts to more personal topics, participants might move closer together.

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*Exhibit Text medium space ( ø = 120 cm)*

**PERSONAL ZONE**

(1.2 - 0.5 meters)

The *personal* zone characterizes interactions between family and friends.
This zone makes physical contact possible. Within this distance, we can touch the other person if we so chose. Good colleagues are often permitted to enter this zone, as a sign of trust and friendship.
The personal zone is where we like to keep our family and friends: literally and figuratively "within arm's reach"!

--------------------------------------------------------------------------------

*Exhibit Text smallest space ( ø = 50 cm)*

**INTIMATE ZONE**

(0.5 - 0 meters)

The *intimate* zone is restricted to those most near and dear to us: our partners, immediate family, and very close friends. In this zone we love, comfort and protect. Physical contact is unavoidable.
It is in the intimate zone where we feel least at ease with others who try to 'enter' without our consent. Interaction with others within this intimate zone is experienced as extremely distressing and threatening if it is against one's consent.

Originally submitted to Cheapbook Three by Diana Issidorides

## PET-bottle rocket launcher

**Description**
A cheap and simple good working outdoor launcher for PET-bottle rockets.

**Materials**
- Acrylic (Perspex) tube 180x1500 mm.
- Approx 8 meter of steel rods 10 mm diameter
- steel sheet 1.5 mm
- two plastic hinges
- two tube clamps 200 mm
- knob for handle.
- PET-bottle rocket*

**Construction** (Please refer to photos below)

Use the steel rods and sheet steel to construct a support frame for the Perspex tube. In this way you create both a steady base as well as a means for changing the launch angle.

In the bottom of the Perspex tube there is a "floor" of Perspex covering the full tube to support the rocket before blastoff. Load your PET-bottle rocket into the tube.

There is an opening in the tube from the side with the height of approx 2/3 of the rocket (PET-bottle with fins). The opening goes not all the way down to the "floor" so the tube can be tilted either way without the rocket falling out.

**5 – 4 – 3 – 2 – 1 .....**

**Notes:**
* We use a kit called "Rokit" from a company in UK. (https://waterrokit.com/)
It contains all you need to convert a PET-bottle to a rocket: fins, hose with brass connections to the pump and rocket, rubber nozzle with adapter for the bottle. www.rokit.com

We used to have a Perspex door in the opening to minimize the water splashing but it fell off and we have not replaced it as this is primarily an outdoor summer activity.

**BLAST OFF!**

Originally submitted to Cheapbook Three by Olle Nordberg

# Pop Bottle Speaker

**Description**
A 2-liter plastic pop bottle is used to make a working speaker. A modified low cost "boom box" is used to drive the speaker to produce recognizable music. Students will learn about sound and electromagnetism and how the two principles are related in a speaker.

Sound results from mechanical vibration. A vibrating object vibrates nearby air molecules, which further vibrates neighboring air molecules, and so on. This eventually results in vibration of the listener's eardrum, causing a person to perceive sound. To make a pop bottle function as a speaker, the pop bottle must vibrate. Let the explorer listen to a tuning fork and then discover that the tuning fork vibrates by touching it.

When electrons move through a wire, a magnetic field is created around the wire. Manipulate a permanent magnet near a compass, and notice that the compass needle responds to the nearby magnetic field. Then, hold a wire near the compass and notice that it has no effect on the needle. Hold each end of the wire to the two ends of a battery (be careful - the wire gets hot) and hold the wire near the compass. Notice that the needle now responds to the magnetic field created by the motion of the electrons through the wire.

The strength of a magnetic field is increased by winding a wire into a coil. The direction of the north and south poles of the coil depends on the direction of flow of the electrons through the wire. With the coil placed over a permanent disk magnet, the permanent magnet attracts or repels the coil depending on the direction of the motion of the electrons through the coil. If the direction of the current alternates the coil vibrates. If the resulting vibration of the neighboring air is between about 20 and 20,000 times a second, an audible sound is produced. If the wire is rigidly attached to a plastic pop bottle, the pop bottle vibrates, producing a louder sound. The two speaker wires of a cheap radio provide an electrical signal to the pop bottle to produce the sound of speech and music.

**Materials**
- empty 2 liter pop bottle
- disk magnet, about 3 in. diameter, with a 1 in. diameter hole
- Thin wire -- Enamel Coated Magnet Wire, 30 gauge
- 20 gauge wire, Solid Hook Up Wire
- small "boom box" radio
- soldering iron & solder
- fine grit sandpaper
- wire stripper
- alligator clips
- magnetic compass
- tuning fork
- battery

## **Construction**

*Preparation of the Speaker*

1. Remove the cap from a 2-liter pop bottle and cut the top off just below the “domed” portion of the bottle, about 3-4 inches from the top.

2. Wrap 250 turns of thin wire around the narrow part of the bottle at its very top where the cap screws on. Firmly tape the wire in place. Use sandpaper to strip the insulation off of the ends of the thin wire.

3. Turn the top of the bottle upside down and place the pop bottle top in the center of a large disk magnet.

*Preparation of the Radio*

1. Purchase a simple boom-box radio. A device purchased at a deep-discount store works fine. A simple radio does not produce a strong enough current to produce an electric shock. Powerful radios and amplifiers should be avoided. On the other hand, the electrical signal from an earphone jack does not provide a strong enough signal.

2. Open the back of the radio and find the two lead wires connected to the speaker. Unsolder the two wires from the speaker and solder several feet of 20 gauge wire to each of the two speaker wires (not the speaker). If the radio is a stereo radio, unsolder one of the leads from the second speaker to deactivate it. Find a hole in the radio and feed the two new longer speaker wires out of the radio. Optionally solder alligator clips to the ends of these wires. Reattach the back of the radio.

3. Turn the radio on and connect the alligator clips to the two wires of the pop bottle. Tune to your favorite radio station and enjoy the vibrations!

**Notes:**

Check out www.howstuffworks.com for more information about magnets and speakers.

1. What happens if you take the pop bottle away from the permanent magnet? Where should you place the pop bottle with respect to the disk magnet to get the loudest volume?

2. Does it matter which way you connect the leads from the radio to the pop bottle? If you reverse the leads, do you still hear sound? Why or why not?

3. Try wrapping wire around other objects and holding them near the permanent magnet. What properties of the pop bottle make it a good candidate for a speaker cone?

Originally submitted to Cheapbook Three by Scott Heydinger

# Simple Surface Tension

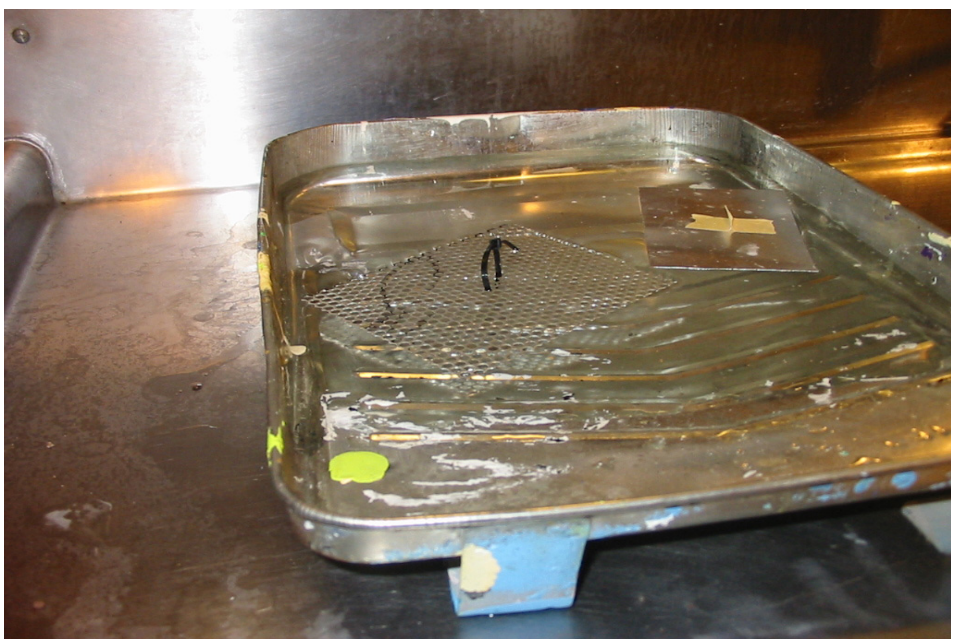
## Description and Methods

A while ago I worked on some exhibits about surface tension at Explora! in Albuquerque with Tim Wedgewood. I suppose we have all heard about floating a needle or a razor blade on water. It is kind of tricky to do that though. I found, however, that it is really easy to float a thin aluminum plate on water.

A 3" square of aluminum flashing works very well. The aluminum thickness should be .030" or so and should be fairly flat. A handle to hold the sheet can be quickly made from a piece of masking or duct tape.

A little experimenting showed that the force that floats the sheet is more or less proportional to the area of the sheet. I think this means the aluminum becomes a boat whose sides are made of water, and the sides are held back by the surface tension forces.

I happened to also find a piece of aluminum "perf stock" that was 1/16" thick. That floats quite well also. Again, you need a handle. I used a cable tie.



Testing materials out in a paint roller tray.

Originally submitted to Cheapbook Three by Richard Gagnon

## Slowpoke Magnets

### Description

A moving magnet falls very slowly (20-30 seconds) through a copper tube and falls down a clear plastic tube in less than a second. This demonstrates that moving magnetic fields generate electric currents.


### Materials

<u>MAGNETS:</u> we used 3/4” diameter x 1/8” thick neodynium ring magnets; they have a hole in the middle, and corresponding tubing. You could also use 1” diameter. magnets and bigger diameter tubing.

Cheap source for magnets: Lee Valley Tools < www.leevalley.com > “ring neodymium magnets.” The ring magnets are a recent addition to the catalog and work much better than those without the holes—in the past, we drilled holes through the disk magnets which significantly reduced their strength, and many of them broke during this process (of course it was fun too, as the dust on the drill bit burst into flame as you pulled it out of the jig holding the magnet)

COPPER TUBING:

Originally (1997) purchased 0.822” ID, 1.050” OD 6’ long piece of thick-walled copper electrical bus tubing from McMaster-Carr. They no longer sell that size; they will order the 1.063“ ID, 1.315” OD tubing for you, with a delivery of 2 weeks.

You can order both sizes directly from the manufacturer-- United States Brass and Copper, < https://usbrassandcopper.com >

You could also try thick-walled aluminum tubing. Regular copper tubing for plumbing works okay, but the magnet rods fall a lot more slowly through the thicker walled tubing.

You need close tolerances, or the effect is not that noticeable.

PLASTIC TUBING: any clear tubing of about 0.8” ID will work. We ordered from McMaster-Carr, part #8585K14 for 8’ length of polycarbonate tubing with 7/8” ID and 1” OD.

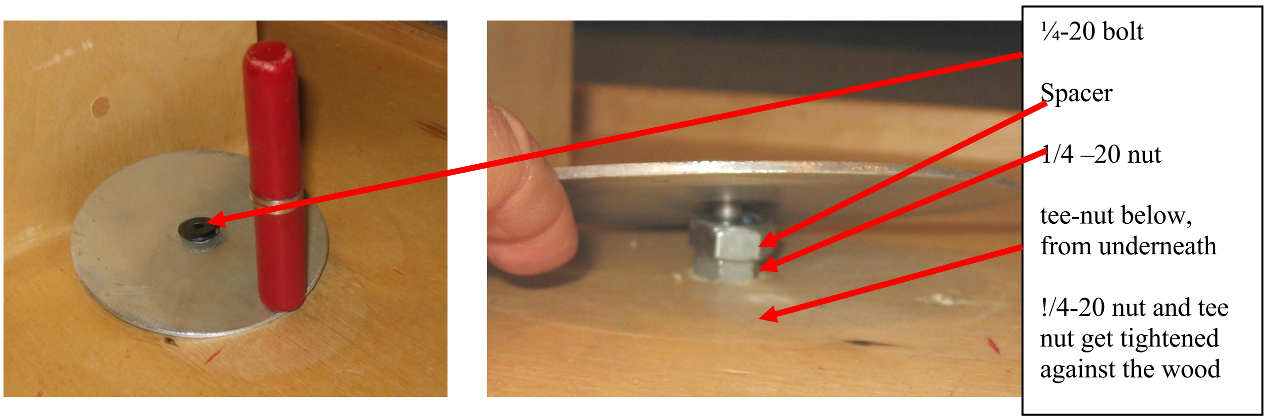
**Construction**

1. We milled two long slots most of the way along the copper tube, except for the top and bottom, so visitors can see the magnet rod fall slowly. This does cause the magnet rods to fall faster. Suggestion: drill a bunch of small holes as the magnet rods would fall more slowly, and still be visible—and it is easier to do.

2. Wood for frame. You can make either a freestanding size, or a much smaller version that is portable.

3. Rods: one of the two is just plain a wood dowel painted red. The magnet rod is made of two neodymium ring magnets, with threaded 8-32 rod going through the holes into both sides of the red wood dowel by about 1 ½"; drill tap-size hole into wood and run tap into dowels. As you run threaded rod in, add a dab of 5-minute epoxy between the magnets and the dowels, and on the thread. This is all to keep the magnet rods together, as we didn't want visitors to find loose magnets and potentially swallow them.

4. Striker: for fun, you can let the rods make a noise when they hit the bottom. The service bells sold at office supply houses make a nice noise, but we found they kept breaking and got stepped on. So we made an aluminum disk that is suspended above the exhibit bottom; it makes a satisfying ping when the rods strike it.




### *Sample Sign text:*

**What's going on:**

The moving magnet generates an electric current in the metal of the nearby pipe. The current then creates a magnetic field inside the pipe. This field pushes up on the magnet and slows it down.

Plastic does not conduct electricity, so an electric current is not generated as the magnet falls.

(Exhibit built by Charles Trautmann and Eric Trautmann, based on an idea shared by Jim Hardesty of ArcsandSparcs.com)

Originally submitted to Cheapbook Three by Kathleen R. Krafft

# Solar Windmill

**Description and Methods**

This is a very popular and simple exhibit.
It is made of plastic bars and also plastic nuts and bolts. It has two small solar panels. When lighted they make electricity that moves the fan. (See photos below for details).

**Materials**

- Small solar cells
- Plastic "nuts and bolts" building toys
- 50 watts dichroic lamp(s)
- Adhesive to affix solar cells to plastic units


We mount these exhibits in different places in a simple way like on a table. The most difficult thing is that you have to attach the light very firmly to the table and need a switch.

The windmill is not attached to the table, so you can touch or move it. It is really a hands-on exhibit!

**Notes:**
The light comes from one (or better two) 50 watt dichroic lamps, with a cage to prevent visitors from touching the bulb directly and burning their hands.

Originally submitted to Cheapbook Three by Joaquin Fargas

# Tactile Wardrobe

**Description**

Tactile wardrobe is a miniature version of a child's wardrobe that is also a magnetic matching game. While blindfolded, children match tops and bottoms based on the fabric's textures, buttons, and Braille labels. It shows, on a small scale, how people who are visually impaired might match clothing. The idea was developed when we were trying to design a life-sized closet in a bedroom for a child who is blind. We did not have the space in the exhibit for a full sized closet, so we came up with the idea of condensing it into a miniature clothes-matching game. This was just one of the many interactive exhibits that we designed for a children's gallery about disabilities.

**Materials and tools**

- Fabrics with varying textures and patterns
- Buttons of various shapes
- Thread
- Sewing machine
- Braille labels
- Magnetic strips
- Felt
- Spray adhesive
- 1/8'' Sintra
- Wall mounted magnet board

**Construction**

1) Paper templates of the clothing were created (pants, shorts, skirts, and long and short sleeved shirts).
2) The templates were used to cut the shapes out of Sintra.
3) Then felt was cut out from the same templates.
4) The felt was then glued onto the Sintra pieces with spray adhesive.
5) The fabric was then chosen and cut to the right shape using the template.
6) The Braille labels and any buttons or clothing details such as bows or zippers were then sewn onto the front of the fabric.
7) The fabric was glued on over the felt using spray adhesive.
8) Each piece was then stitched on a sewing machine through all three materials (Sintra, felt, and fabric) along all the edges to seal the materials together.
9) Self-adhesive magnetic strips were then placed on the back.
10) The magnet board was mounted to the wall and the Tactile Wardrobe was ready to be used.

**Notes:**
This exhibit was created after conducting extensive research as to how people with varying degrees of visual impairments managed to match their clothing each day.

Whether it was blindness, color blindness, or partial blindness, we wondered how people with these disabilities managed not to mix clashing colors and patterns.

We found out that there were many different methods, and each person had their own unique system. Some people had separate shelves for different styles or colors and remembered where each clothing piece went. Some people ripped tags, folded shirt sleeves, or just knew the clothing by its texture or number of buttons.

There are many marking systems, and to illustrate this we combined three of these methods to incorporate into our exhibit: textures, buttons, and Braille labels.

Originally submitted to Cheapbook Three by Jennifer Sumner and Kim Wagner Nolan.

# Thermal Impressions

**Description**

Colorful thermal patterns appear as heat sensitive liquid crystal film is heated and cooled on various textured surfaces.

The exhibit consists of a heated plate mounted in the rear center of a small tabletop made of perforated aluminum. The warm plate is topped with a piece of perforated metal with several larger holes punched out of it. The table has a rail all the way around to contain the loose LC film and various metal pieces. The textured warm plate and the perforated metal tabletop are important so that the visitor always gets a pattern whichever way they place the warming or cooling film.

The loose metal objects on my exhibit are a piece of perforated aluminum with a different hole pattern than the tabletop, a cross sectional slice of a large aluminum heatsink, a piece of diamond plate aluminum, and a piece of copper with several different sized holes punched out of it. But you could use anything that conducts heat and leaves an interesting pattern in the LC film as it cools.

**Construction**

The heater is a 150 watt heater available from Grainger (#2E919). I control the heater with a Ranco model ETC-111000-000 electronic temperature control available also from Grainger (#3ZP77). Most thermostats will allow the object to cool down 5-10 degrees before turning the heat on again. This is a problem because the LC film only has a 5-degree sensitivity range. So the trick is to find a thermostat with a small (1 degree) differential. The Ranco model has an adjustable differential. These beauties are maybe a bit prohibitively priced for some, but are really great.

I made my warm plate out of a 12”x12”x ½” aluminum plate. To the underside of this plate, you need to bolt the strip heater and a small block of aluminum drilled out with a ¼” hole for the thermostat’s temperature probe. Heat sink grease will help both the heater and the probe maintain a good thermal connection to the plate. I topped this plate with a piece of perf-stock with several holes punched out of it, but you could cut grooves, drill shallow holes, engrave it or create texture in some other way.

I mounted this plate at the rear center of the table raised a couple of inches from the tabletop as a little warm island. I might, however, suggest mounting it flush with the tabletop. Coloring it red, using a copper plate instead of aluminum, or some other way to really set it off from the rest of the tabletop would be a good idea (an essential idea). Good lighting is also important for the full visual impact of the colored heat patterns.

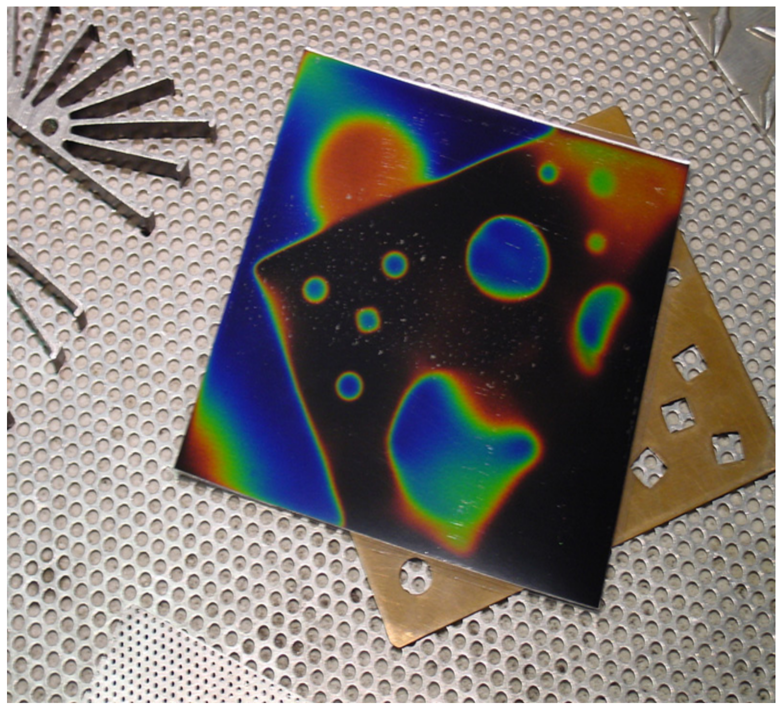
A nice trick is to use heavy gauge perf-stock for the tabletop so that you can avoid having any underlying support. This lets debris and dust fall through the holes where it can be vacuumed or swept up from the floor.

**Construction** (continued)
The warm plate should be kept below 100 degrees F. Small children will blister at temperatures as low as 105 degrees F.

You want to use Liquid Crystal film in the 30-35 degree-C range. I cut these sheets into four 6" squares. I laminate them with a printed paper label on the backside saying, "Heat sensitive film, other side up." We leave these sheets and the metal objects untethered and have had basically no problem with theft. The laminated LC sheets last about 3 weeks before they are so scratched and crumpled that they need replacing. I only put two 6x6 inch squares out at once, one old and one new; there is nothing so pleasing as a clean new sheet of LC film!

**Notes:**

A problem with the exhibit is that people often place objects on top of the LC film rather than the film on top of objects. The problem with this is that the object obscures the changing colors of the LC film and it hastens the inevitable scratching of the film.
A solution might be to bolt the metal objects down so that only the film is moveable. I have always resisted this but over the years the strength of this conviction has waned. Another subtle suggestion is to not title the exhibit "Thermal Impressions." The word "impression" suggests a stamping sort of activity. Instead you might try "Heat or Thermal Patterns." Lastly, I have always wanted to rebuild the exhibit coffee table size and place it between 2 benches. I think this could improve visitor dwell time at the exhibit.



Originally submitted to Cheapbook Three by Charles Sowers

# Thunder Barrel

**Description**
A fun and simple way to explore resonance. By gently pulling on the end of a spring mounted to a trash barrel the visitor can create a sound like thunder.

**Materials**

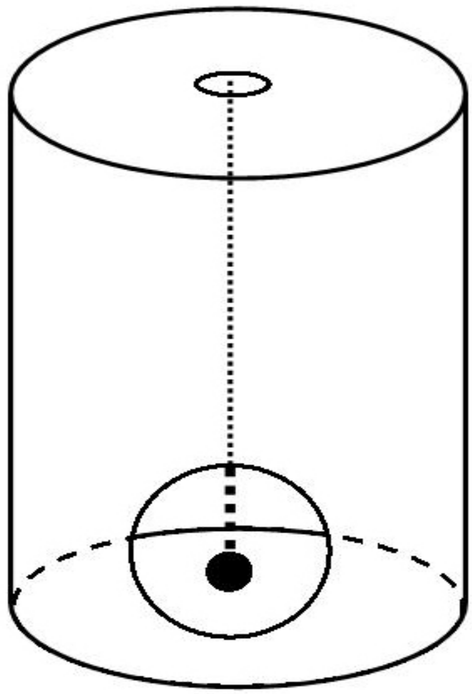
- 30 gallon plastic trash barrel. We use a standard Rubber Maid one like you would use at home for bringing out the trash to the curb. Hardware stores sell them.
- Screen door spring. We use a 5/16 diameter spring but anything close should work. Available at most hardware stores.
- I inch diameter ball. This could be wood, plastic or a rubber ball such as a "super ball"
- 2 - 1 ½ inch O.D. fender washers
- 4 - # 10 washers
- 1 - #10 bolt, 1 inch length
- 1 - #10 bolt, 1 ½ inch length
- 2 - # 10 nylon lock nut

**Construction**

*The Barrel:* Cut a 9 inch hole in the side of the trash barrel three to four inches below the rim. Drill a 3/16 inch hole centered in the bottom of the trash barrel.

*The spring:* Cut the door spring in half. Using pliers, bend the cut end to look like the other end. (with a loop perpendicular to the spring)
Stretch the spring so there is some space between the coils. Do this by stepping on it and pulling it gently to stretch it. It does not have to be evenly spaced. Use Gloves! The end result should be about 18 inches long.
Drill a 3/16 hole through the center of the ball. To mount the ball on the spring, assemble in this order. Put a #10 washer on the #10 1½ inch bolt. Then put the ball on the bolt followed by the spring loop, washer and nylon lock nut.

*Assembly:* Place a #10 washer on the one inch bolt, then a fender washer. Place these through the bottom of the barrel from the outside. Place a fender washer over the bolt on the inside. Then place the spring over the bolt followed by the #10 washer and nylon stop nut. Place the barrel "upside down" on a table. The spring will need a little bending to get it to hang straight down. You can mount the barrel on any type base you like. To hold it in place, screw it to your base with four sheet metal screws.



**Notes:**
To play, reach through the hole and gently pull down on the rubber ball and release. The sound is more dramatic the closer your ear is to the hole.

When making the spring assembly, I suggest you use the second half of the door spring to make a second spring set up. Inevitably, some visitor will pull it so hard that it will stretch too long, and you will need to replace it. The bolted ball may seem like over kill but we have found that it helps give a starting reference point for the visitor. “Gently tap the ball” or “Gently pull the ball and let go” work well.

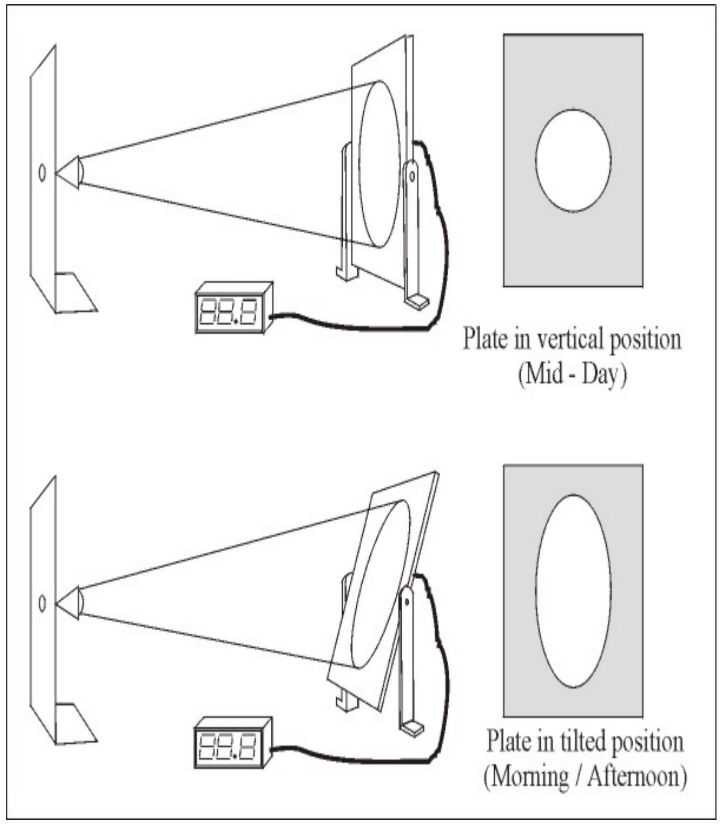
With some creativity this could be modified in many ways such as using different barrels or buckets and different springs.

Originally submitted to Cheapbook Three by Geoff Nelson

## WHY IS IT HOTTER AT MID-DAY?

**Description**

A rectangular thin metal plate (preferably aluminium or copper) pivoted at the centre is connected to a digital thermometer. Light from an electric lamp is allowed to fall on the plate either normally or at an angle. Difference in the rate of rise of surface temperature of the plate is easily noticed.




**Materials**

- One thin metal plate of size 10” x 8” of either aluminium or copper.
- One 150 Watt electric lamp with reflector and lamp holder.
- One digital thermometer (with probe) of 0.1 degree centigrade sensitivity.
- Two numbers of wooden stands for holding the plate.
- One 2’ x 1’ platform of suitable height for mounting the set up.
- One push button switch for operating the lamp.
- One wooden post for mounting the lamp.

**Construction**

Mount the metal plate as shown in the figure such that it can be tilted about horizontal axis. Mount the electric lamp on the wooden post at a height equal to that of the centre of the plate and connect the lamp to the power supply through the switch. Solder the sensing end of the probe at the middle of the plate on its back and connect its other end to the digital thermometer.

**Note:**

The front surface of the plate may be blackened for better results.

Originally submitted to Cheapbook Three by Ingit K. Mukhopadhyay