

**Air Pressure**

**activity**

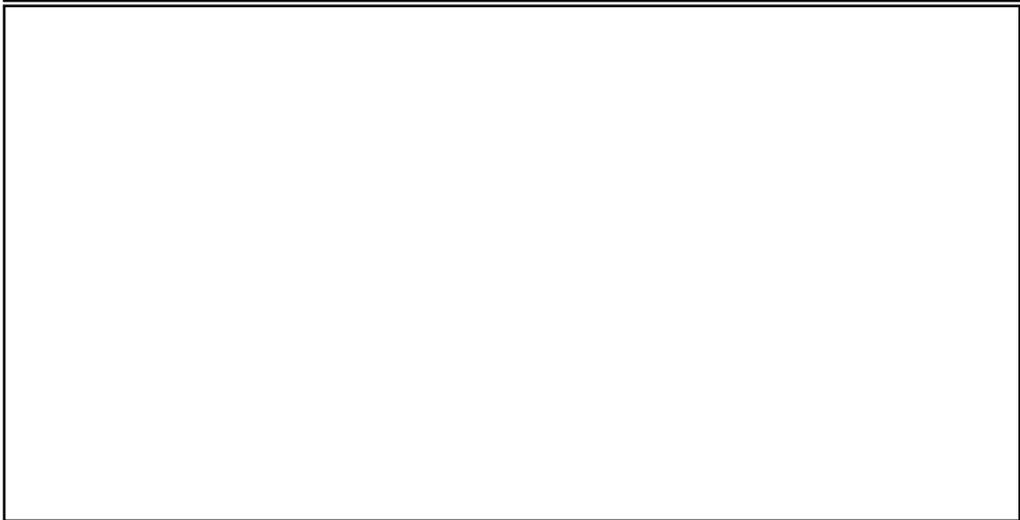
There are two setups for this. Ask for assistance putting them together.

**Blowing up a balloon**  
 Pump the syringe attached to the container holding the balloon.  
 What happens to the balloon?  
 Is the syringe attached to the balloon?  
 Are you pushing air in or pulling air out?

**Magdeburg Spheres**  
 This was originally done with metal hemispheres sealed with grease.  
 However, acrylic plates sealed with an o-ring works quite well. This really requires two people, at least briefly. One person should hold the two plates with big, black handles on them together with the thick o-ring between them. The other person should pump the syringe.  
 Try to pull the two plates apart after you've pumped once or twice. Can you?

**Air Pressure -- Explanation**

We mostly are not aware of the normal atmospheric air pressure around us. These activities highlight its existence by removing air – creating a vacuum – from a small region so the pressure does not exist. In the case of the balloon, removing air from around the balloon permits the air within the balloon to expand to occupy the space abandoned by the air we've removed. In the case of the Magdeburg spheres, removing the air between the plates removes the balance of pressures on the two sides of each plate resulting in a very large force from the air outside the plates pressing the plates together.



item	storage	packing
3 acrylic plates (2 w/ handles) and an acrylic cylinder	pressure box	pressure ▼
3 large o-rings	pressure box	pressure ▼
balloons and small plastic cup	pressure box	pressure ▼
large, plastic syringe (no needle)	pressure box	pressure ▼
plastic tubing with connectors and valves	pressure box	pressure ▼

**tips** See photo.

- electricity
- darkness

Are Slugs Making Them Sluggish?

**activity**

Pick two of the three cylinders. Which one do you think will win a race down the incline? Try it. Were you right? Are there slugs inside the slow one?

Try another pair of the cylinders.

What is the connection between the way the cylinders behave and what happens in "Going for a Spin"?

Are Slugs Making Them Sluggish? -- Explanation

Where the mass is affects how things roll. The closer the mass is to the center, the less energy it takes to get it rolling.

The noisy one is about 1/2 full of salt. The salt slides around and steals energy from the rolling so it goes slower.

**item**

ramp

**storage**

by prep room door to hallway

**packing**

no box ▼

hoops, solid disk, salt-filled disk ( blue tape)

zip-lock bag in Optics I

optics I ▼

blocks for propping ramp up

oscillations box

oscillation ▼

▼

"snake" - purple flannel filled with plastic beads (short with no head or tail)

double pendulum

dbl pend. ▼

**tips** See photo. Snake goes at bottom of ramp to stop things.

- electricity
- darkness

Blowing Up a Really Big Balloon

activity

Put your fist around the open end of the sack and hold it up close to your mouth and blow in like blowing up a balloon. How many times to you have to blow to blow the whole thing up.

Now use two hands to hold the bag all the way open and away from your face. Now blow towards the opening of the bag. What happens? How many times do you have to blow to blow it up completely?

Can you explain why one way works better than the other?

Blowing Up a Really Big Balloon -- Explanation

When you blow directly into the bag, all the air in it has to come out of you. That takes a lot of huffing and puffing. When you hold it out away from you, you create a current that pulls more air in with it. This is like the draft in your shower (especially when you're not standing in the water blocking the flow). The air you blow, tugs on the air immediately next to it which tugs on the air next to it and so on.

item

plastic "sack" about 6' long and 1' diameter

storage

optics 2

packing

optics 2 ▼

▼

▼

▼

▼

tips

- electricity
- darkness

**Boiling by Hand**

**activity**

Hold the ball with more liquid in it in the palm of your hand. What happens? How do you undo it?  
Does it work upside down?  
How about sideways?  
If nothing happens, you may have cold hands, or the liquid may already be well-heated from someone else's hands.

**Boiling by Hand -- Explanation**

The liquid in the glass has a very low boiling point - much lower than water. The boiling point is low enough that the heat from your body will cause the liquid to boil. The liquid that boils away turns into gas that fills the rest of the bulb. The gas pushes the remaining liquid out into the other bulb the same way that you can push all the liquid out of a straw by blowing air (a gas) through the straw.

**item**

blown glass with colored liquid inside

**storage**

optics 2

**packing**

optics 2 ▼

▼

▼

▼

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**tips** Mount some way so its not so breakable? Avoid with small children? Have broom and dustpan handy?

Not good outside if hot (too little temperature contrast) or windy (blows over).

- electricity
- darkness

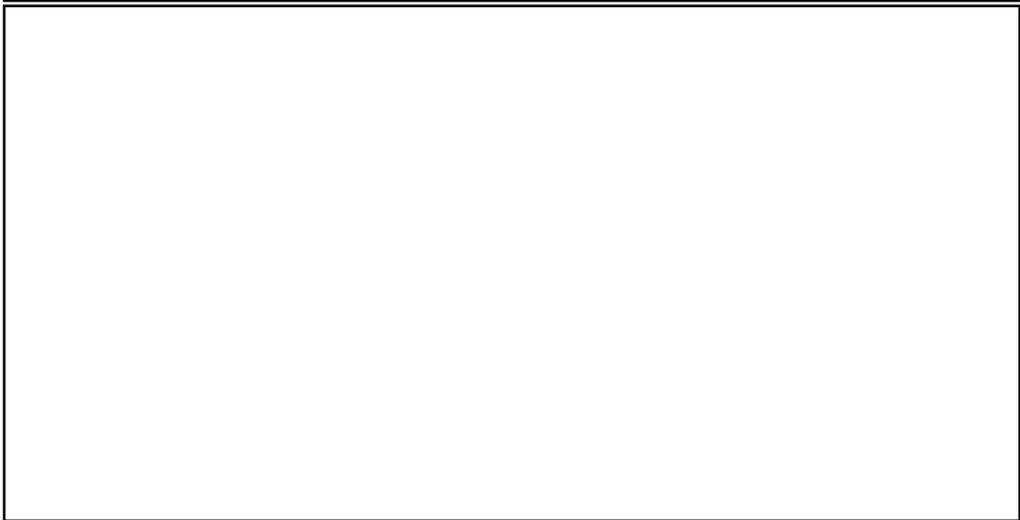
Bouncing Magnets

Bouncing Magnets -- Explanation

**activity**

See if you can stack the magnets so that they don't stick to one another. How many magnets can you stack so none of them touch each other? What happens when you jiggle the stack up and down? Try making pairs of magnets not stick to other pairs of magnets. Is the spacing the same as with single magnets?

Magnets have two sides called poles (usually labeled North and South for geographic reasons). Like poles repel and opposite poles attract. Magnets have poles because there are electrons going around in little circles inside the material.



**item**

3 dowel rods on a wooden base - painted white and red

**storage**

E&M shelves - usually up high

**packing**

van de Graaff ▼

plastic covered donut magnets

zip-lock back in optics I

optics I ▼

▼

▼

▼

**tips**

- electricity
- darkness

Bug's Eye View of the World

activity

Look through the set of small squares.  
 What do you see when you hold it very close to your face? What do you see if you hold it farther away? What happens if you look at things close up? What happens if you look at things far away? Try rotating the sheet as you look at someone or something. Try gently bending the sheet as you look at something.

Now try looking through the large rectangle on the sheet.  
 What do you see when you hold it very close to your face? What do you see if you hold it farther away? What happens if you look at things close up? What happens if you look at things far away? Try rotating the sheet as you look at someone or something. Try gently bending the sheet as you look at something.

Is there a difference between the front side and the back side of the sheet? Try bending the sheet enough so that you can look through both the large rectangle and the squares at the same time (one behind the other). What do you see?

Bug's Eye View of the World -- Explanation

Looking through the squares you see multiple copies of the same thing. This is the way most insects see the world through their compound eyes.

Looking through the squares, things are right-side-up and smaller. This is what a concave lens does. (Concave means it is hollowed out on one or both sides instead of being flat.)

Looking through the rectangle, things are up-side-down and somewhat smaller when your eyes are far from the sheet. If you get up close to the rectangle, things will appear right-side-up and big. This is what a convex lens does. (Convex means it bulges on one or both sides instead of being flat.)

Notice above that the lenses aren't supposed to be flat, but the plastic sheet is definitely flat. Feel the sheet. These are Fresnel lenses, the thin ridges you can feel as roughness on one side of the plastic are little slices of a curved lens

item

~8.5x11 plastic sheet of Fresnel lenses

storage

Lenore/ optics 1

packing

optics 1 ▼
▼
▼
▼
▼

tips

--

- electricity
- darkness

Capture Your Shadow

**activity**

Put your hand over the paper, and then move it away. What happens? Does it matter how long you leave your hand there? Does it matter if you're touching the paper?

How do you think it works? What do you think the light is for?

Take a look at "Ghostwriting" and "Glow-in-the-Dark Pictures." How are they similar? How are they different?

Capture Your Shadow -- Explanation

The paper is glow-in-the-dark paper. When you shine light on it, it keeps the light, so the paper glows. Your hand blocks the light and stops the paper from glowing, until the light from the lamp recharges it.

**item**

Green "paper" mounted on board

**storage**

optics 1 box

**packing**

optics 1 ▼

Desk lamp with UV CF bulb

lights box

lights ▼

▼

▼

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**tips**

- electricity
- darkness

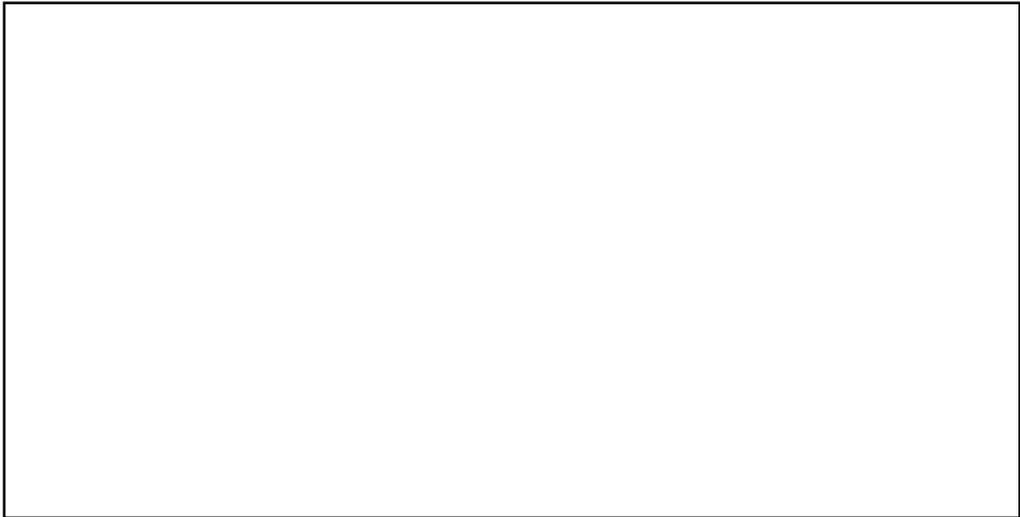
Cartesian Divers

Cartesian Divers -- Explanation

**activity**

Squeeze the bottle.  
 What happens to the colored "fish" inside?  
 Can you make one hover?  
 What causes the up and down motion? Look at what happens to the shape of the fish when you squeeze the bottle.

Water doesn't squeeze very well, so when you squeeze the bottle, the genies get squished a tiny bit. This squishing reduces the space the air occupies inside the fish. This makes the genie heavier relative to its size than it used to be. It now sinks. If you squeeze just right, you can make a genie hover in the middle of the bottle. You can try this effect at home with balls of aluminum foil. You will probably have to work a bit to get the fish's weight and size correct. Some fish have air sacs. The fish can use its muscles to change the size of the air sacs which changes the buoyancy of the fish so it can swim down or up easily.



item	storage	packing
soda bottle with 3 colored fish inside	fluids shelf/pressure box	pressure ▼
		▼
		▼
		▼
		▼

**tips**

- electricity
- darkness

Casper the Friendly Ghost

Casper the Friendly Ghost -- Explanation

**activity**

BE CAREFUL NOT TO HIT PEOPLE AROUND YOU WHILE DOING THIS.  
 Wave the wooden wand with a black tip vertically over the blue tape line on the floor. Stand so that you are on the same side of the wand as the projector.  
 What do you see? What do people standing other places in the room see?  
 Does it matter how fast you move the wand?  
 What happens if you move closer to the projector or farther from it?  
 How do you think this works?

The projector is showing a slide of Casper. The light bounces off the wand and back to your eyes. You see the whole image instead of just a slice of it because your eye retains information for a little while (persistence of vision).

**item**

Casper slide

Slide projector no carousel or control cords needed

wooden pointer

**storage**

notebook

metal cabinet by hall door

lights box

**packing**

notebook ▼

oscillation ▼

lights ▼

▼

▼

**tips**

- electricity
- darkness

Climbing a Sand Dune

**activity**

Hold the tube vertical like a telephone pole with the ball bearing at the bottom of the tube. Can you make the ball bearing climb to the top of the sand? (It's no fair just turning the tube over!)

Climbing a Sand Dune -- Explanation

This is one of many examples of large objects rising to the top of a collection when shaking. It's a little surprising because the ball bearing is definitely heavier than the grains of sand. However, it's also much larger so the sand can fall down in holes made by the big ball bearing, but the big bearing is unlikely to find a hole made by the sand's movement that is big enough for it to fall down.

**item**

~12" long tube filled with green sand and a ball-bearing

**storage**

oscillations in tube with standing wave bars

**packing**

oscillation ▼

▼

▼

▼

▼

**tips**

This is another good one for the adults.

- electricity
- darkness

Corralling Your Voice

Corralling Your Voice -- Explanation

**activity**

Find both ends of the phone (wooden pieces attached to a red tube).  
 Find someone to use the phone with you.  
 Try talking one at a time. How softly can you talk and still be heard? Can you hear if you talk this softly without the phone?  
 Try talking at the same time. Can you still hear each other?

The air in the room carries your voice. (Could you talk to someone on the moon without a radio?) Normally, when you speak your voice fills the room. By speaking through the tube, your voice only has to fill a small space, so the person on the other end can here you whispering.  
 When Mark Twain worked on steam ships, "speaking tubes" were used so that the captain at the top of the boat could send orders to the engineer three stories down at the bottom of the boat.

**item**

two wooden handles with few meters of corrugated red plastic tubing

**storage**

Tom

**packing**

optics 2 ▼

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**tips** Separate the two ends of the phone and put two sets of instructions out.

- electricity
- darkness

Crazy Mirrors

Crazy Mirrors -- Explanation

**activity**

Stand a polished pipe section near various objects, including the cartoons on the table.

How does the image in the pipe compare to the real object?

What happens if you tip a pipe a little?

What happens if you turn a pipe on its side?

When light hits a polished surface like these pipes it bounces off at the same angle it hit – like a ball bounced off the floor. Because the pipes are curved, this sends light in strange directions so the image is distorted. This distortion is related to the distortion produced by making a flat map of the Earth, which is really round.

**item**

Chrome pipe about 1.5” diameter and 8” long – up to 4 sections

**storage**

optics 1 box

**packing**

optics 1 ▼

4 Halloween images that will come out “normal” reflected in the pipe

notebook

notebook ▼

▼

▼

▼

**tips**

- electricity
- darkness

Dead Ball

Dead Ball -- Explanation

**activity**

Which ball doesn't act like a ball you'd want to play baseball with?

Are there any other differences you can detect between the two balls (without breaking them or anyone or anything)?

In general, what sorts of things just lie there when you drop them on the ground? What sorts of things bounce? What does this tell you about the insides of the balls?

The ball that doesn't bounce is slushy inside. When part of it is ready to bounce back from the floor, the other part is still heading toward the floor. the two parts get tangled up and the ball doesn't get anywhere (sort of like when your feet can't decide which way they're going).

The ball that does bounce is hard inside. When part of it is ready to bounce back up from the floor, the other part knows this and bounces back too (sort of like when two dancers both know where they're going next).

**item**

pair of black bouncing and non-bouncing balls

**storage**

own zip-lock bag in ball section

**packing**

optics 1 ▼

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**tips** The bouncing ball bounces quite well, so watch out for it straying or breaking things.

- electricity
- darkness

Disappearing Colors

**activity**

Take the front sheet of gray plastic and rotate (as though it were the hand of a clock) it in front of the jar slowly.

What happens to the light coming through the two gray sheets around the bottle?

What happens to the light coming through the bottle?

Disappearing Colors -- Explanation

The gray sheets are polarizers. They only let light through if it's lined up the right way like picking up a long stick through a picket fence and trying to bring it back through. When the sheets are at right angles to each other almost no light gets through. When they are lined up the same direction, all the light that gets through the first sheet also gets through the second sheet.

The fluid in the beaker is corn syrup - dextrose. It rotates the light the way you rotate your hand to pull a stick through a picket fence. The corn syrup rotates different colors of light different amounts. The color that is lined up with the sheet in your hand is the one you see because more of it gets through. As you rotate the sheet, different colors are lined up so you see different colors.

**item**

jar of Karo without a label and with lid taped on with blue tape (straw-colored)

**storage**

optics 1 box

**packing**

optics 1 ▼

2 polarizers - heavy, gray plastic

optics 1 box

optics 1 ▼

desk lamp with CF bulb

lights box

lights ▼

▼

▼

**tips** Tape back polarizer to bottle. Even with CF bulb, try not to have the bulb too close to the polarizer lest it melt. Prop the other polarizer in front of the bottle.

**See photo.**

- electricity
- darkness

# Doppelgangers

## activity

Use the protractor at the top of the mirrors to set the mirrors 90° apart.  
How many dice do you see?

Which direction are the dots: all the same, opposite, rotated?

Bring the mirrors closer together. What happens to the number and direction?

Move the mirrors back farther apart. Now what happens?

Look at "Seeing Infinity." What differences do you see? What similarities do you see?

## Doppelgangers -- Explanation

Light from the room bounces off the dice and hits one of the mirrors. Some of the light that bounces off that mirror then hits the other mirror. Since the mirrors aren't exactly opposite each other, the image runs off the edge. How fast depends on the angle between them.

## item

protractor

## storage

optics 1

## packing

optics 1 ▼

2 square mirrors taped together at one edge

optics 1

optics 1 ▼

pig or ghost

zip-lock bag in optics 1

optics 1 ▼

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**tips** Balance the protractor on the top of the mirrors.

Mirrors store in flannel sack.

**See photo.**

electricity

darkness

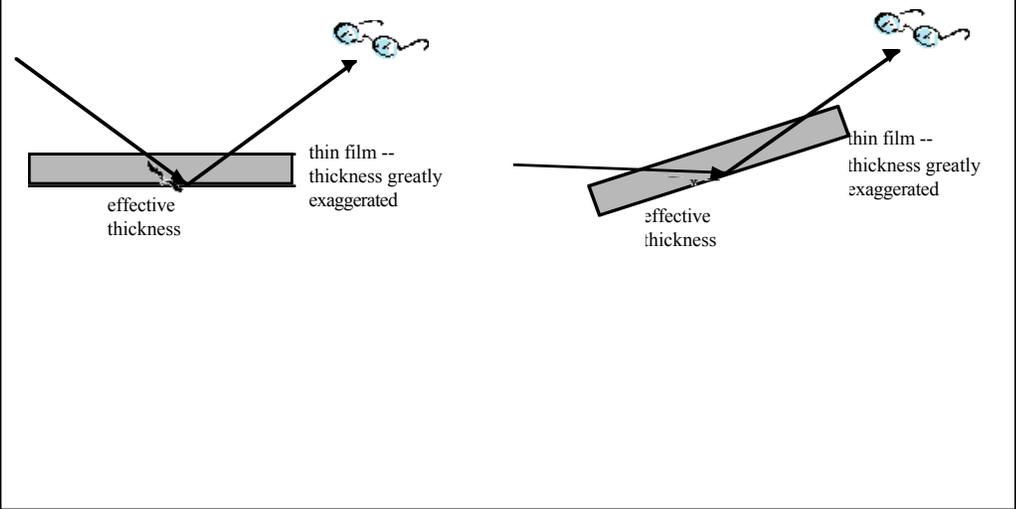
# Evanescent Colors

## activity

Pick up the pompom. Tilt it around in the light while you're looking at it. What do you see? Is it the same all the time? Where are the colors coming from? Try to figure out how the colors you see are related to what you're doing with the pompom.

# Evanescent Colors -- Explanation

These colors come from iridescence. Ordinary, white, light is made of many colors. When the light hits a thin layer of something, like oil on water in the street after it rains, some colors bounce towards your eye and some don't and you see colors. Iridescence is often evanescent (fleeting) because the angle you look at the film from changes its apparent thickness.



## item

hand sized plastic pompom

## storage

optics 1

## packing

optics 1 ▼

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## tips

- electricity
- darkness

Eye of the Storm

**activity**

DON'T TOUCH THE GLASS SPHERE WITH METAL.

Move your fingers around near the surface of the sphere. What happens to the colored lines?

Put your hand behind the globe? What do you see?

Snap, clap, say "Boo." What happens?

Hold the fluorescent tube up to the globe. Does it matter where you hold the tube?

Eye of the Storm -- Explanation

This works like lightning. The globe is filled with gases. Small sparks jump from the ball at the center to the outer globe. As they run into the gas molecules, they cause them to emit light. The lines tend to be attracted to your hand because you're standing on the ground and making the jump easier for the sparks.

**item**

Eye of the Storm

**storage**

optics 2 box in its own foam nest

**packing**

optics 2 ▼

fluorescent tube

optics 2 box in pipe insulation

optics 2 ▼

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**tips** Watch out for kids waving the tube around.

- electricity
- darkness

Fan Control

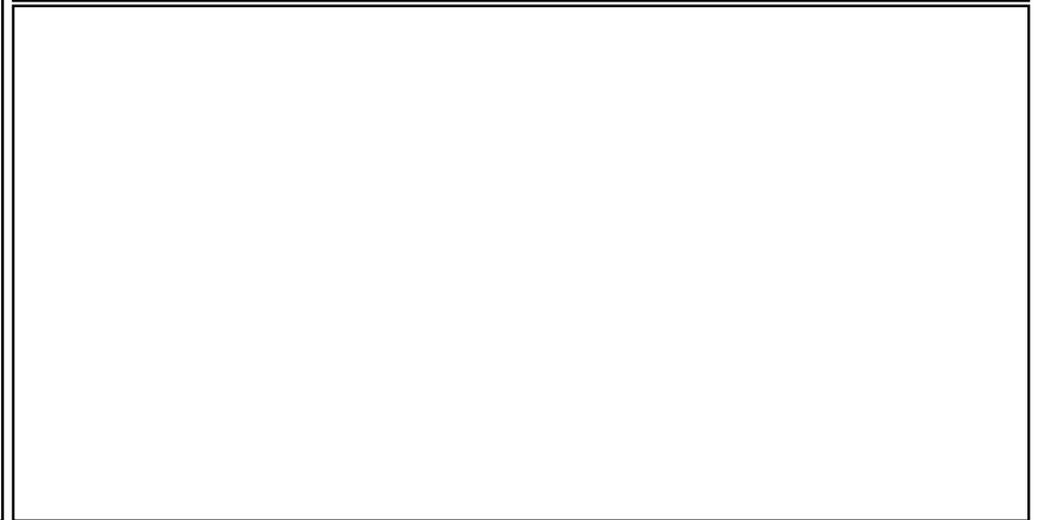
**activity**

By adjusting the strobe light but not touching the fan:

Can you change the fan's direction?  
 Can you make it go forwards, backwards, forwards?  
 Can you make it stop?

Fan Control -- Explanation

You can only see when there's light. Strobe lights turn on and off very quickly. Your eye can't see that fast. (This is why motion pictures are possible.) If the strobe light matches the fan's speed, you will always see the blades in the same position so it looks like it's standing still. However, you can still feel the air being moved by the fan, so you know the fan is still running. If the strobe light is a little slower, the fan appears to spin forward slowly because the light turns on when the fan has moved past its previous position. If the strobe is a little faster, the fan appears to spin backwards slowly. This is why car wheels in movies often seem to go the wrong way.



**item**

strobe light

fan cart (or box fan)

**storage**

light sources

shelves over carts

**packing**

oscillation ▼

oscillation ▼

▼

▼

▼

**tips**

The strobe is less annoying in a lit room.

- electricity
- darkness

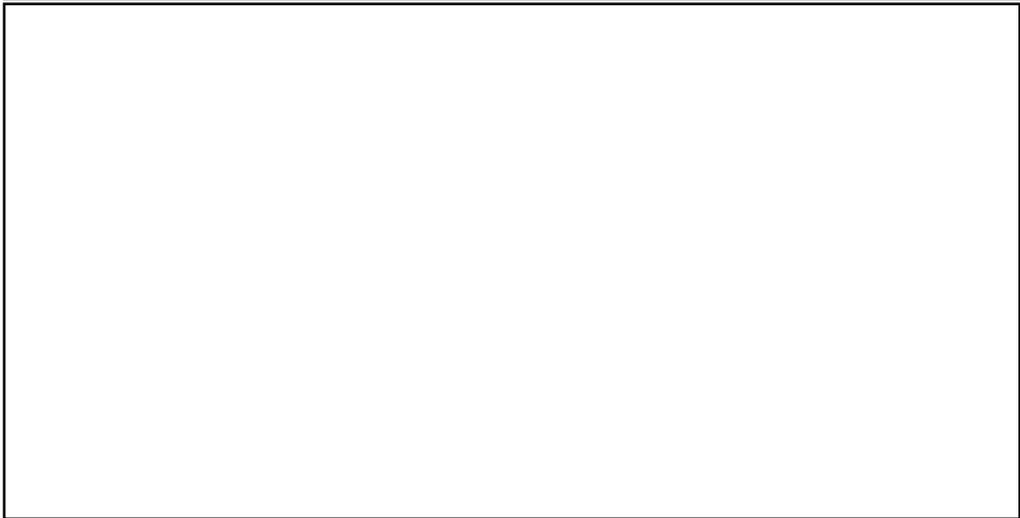
Firefly

Firefly -- Explanation

**activity**

Pick up the green stick in your hand. Is it hot, warm, or cool? Can you see it in the dark? Can you see it in the light? Can you see to read with it?

This is called chemiluminescence meaning chemical light. The name shows its difference from ordinary light bulbs and firelight. Chemiluminescence produces visible light without heat. The most famous example of it is the firefly or lightning bug. So far people are poor imitators of the firefly: fireflies are 88% efficient but so far the best people can do is 23% efficiency.



**item**

glow stick

**storage**

top of shelves near PPLAY stuff

**packing**

optics 1 ▼

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▼

**tips** Stock up on glow sticks around Halloween although they can usually be found with camping stuff.  
Break the stick at the beginning of the event; one stick should last plenty long.

- electricity
- darkness

Floating Face

**activity**

Start out by standing directly in front of the face. Now walk from side-to-side while watching the face.

How does the face look as you move?

Where do the eyes appear to be looking as you stand in different spots?

Now try the same things with one eye shut (or covered). Do you get the same effects?

Floating Face -- Explanation

The face is reversed from a real face (the nose is farthest from you) and the light placed below it so that the shadows change in ways we aren't used to seeing. This gives the illusion of the eyes watching wherever we stand.

**item**

Floating face - self contained in own box

**storage**

optics 1 box

**packing**

optics 1 ▼

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**tips** The bulb in this has been known to wander from its socket in transport. You'll hear it rattling if this has happened. Unscrew the back plate and retrieve as necessary.

- electricity
- darkness

Freezing a Liquid with a Magnet

activity

Pick the jar up and tilt and shake it. What do you observe?

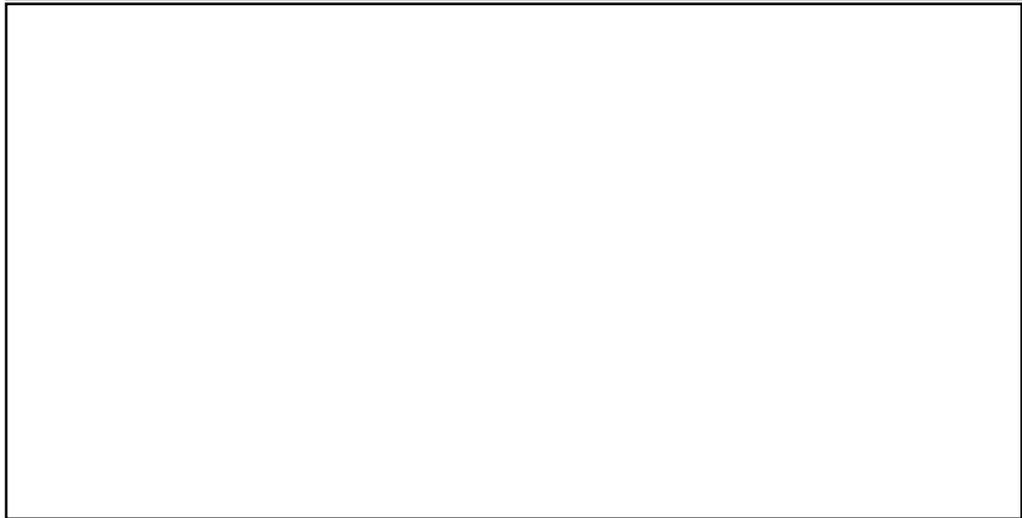
Now hold the magnet against the jar and tilt and shake again. How does the stuff in the jar behave now?

What happens if you rub the magnet around against the side of the jar?  
What happens to the surface?

Freezing a Liquid with a Magnet -- Explanation

The jar contains oil (motor oil) mixed with tiny pieces of iron. In the Earth's weak magnetic field, the mixture flows like a liquid - there is enough oil that the bits of iron slide by each other easily. When you put the magnet near the jar, the filings line up and are attracted to each other because the magnet magnetises them. If you move the magnet around, the iron bits move around some too and can line themselves up better so you can see patterns like you can sometimes see in ice.

Generally, the iron bits don't stay magnetized when you move the magnet away, but if they have been held in position for a long time, they may stay a little magnetized - like paperclips holding on to each other briefly after you remove the magnet you used to pick them up.



item

small glass jar (fountain pen ink jar) with sludge at bottom

storage

optics 1

packing

optics 1 ▼

moderately strong magnet

optics 1

optics 1 ▼

▼

▼

▼

tips Shake this up when you set it out as the iron filings will settle and not move much until they get stirred back into the oil.

- electricity
- darkness

Ghostwriting

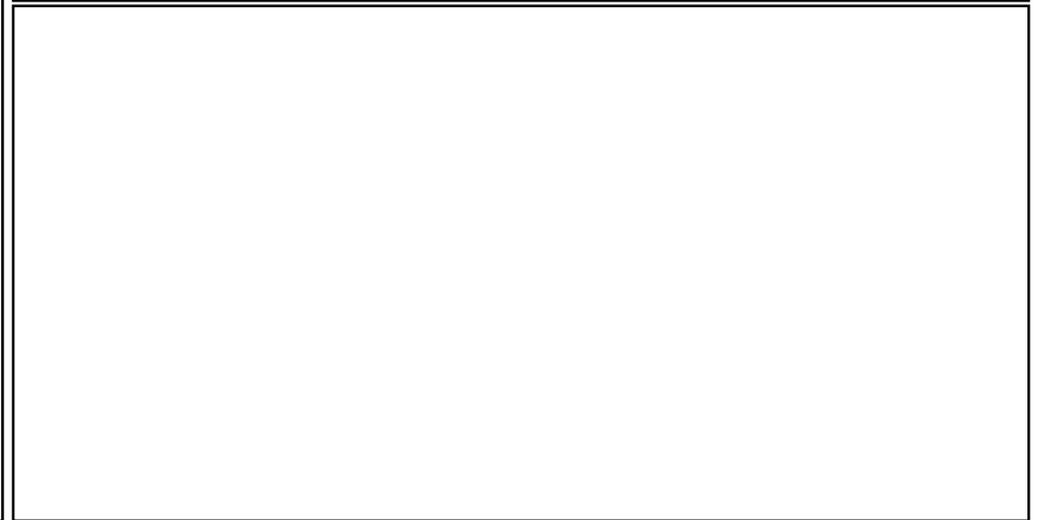
**activity**

Hold the flashlight vertically over the paper and write with it.  
 Can you leave a mark on the page?  
 Can you write your name?  
 Does it matter how fast you move the flashlight?  
 Why do you think we have this in the dark room?  
 How do you think it works?

Take a look at “Capture Your Shadow” and “Glow-in-the-Dark Pictures.” How is it similar? How is it different?

Ghostwriting -- Explanation

The light from the flashlight is stored in the coating on the paper. The coating emits light (not necessarily the same color) later. The longer you hold the flashlight in one place, the more light is absorbed so that the spot will glow brighter and longer after you move the pointer away. If the paper were in a brightly lit room, all of it would be charged up and then releasing the light so you couldn't tell a difference between where the flashlight had been and where it hadn't been. Notice that the flashlight shines very blue. Blue light is more energetic than the red light of a laser pointer and so works better to stimulate the paper.



item	storage	packing
blue flashlight with blue LED in it	optics 1 box	optics 1 ▼
Green “paper” attached to board	optics 1 box	optics 1 ▼
batteries	optics 1	optics 1 ▼
		▼
		▼

**tips**

- electricity
- darkness

## Glow-in-the-Dark Pictures

### activity

Take the crayons and draw a picture on a piece of white paper. Hold your picture under the light bulb.

What happens to your drawing?

What colors show best?

What happens to the white paper?

What happens to white clothing?

Compare this to “Capture Your Shadow” and “Ghostwriting”. How are they similar? How are they different?

## Glow-in-the-Dark Pictures -- Explanation

The crayons contain a material that stores light and releases it as a different color light. The black light bulb is sending out ultraviolet light. Human eyes don't detect ultraviolet light, so it gets called black light. Some insects do detect ultraviolet light. The crayon in your drawing stores the ultraviolet light and then releases it as light that we can see.

The crayons and the paper for Ghostwriting and Capture Your Shadow work on similar principles. The primary difference is how long the light is stored. As soon as you take your drawing out from under the black light, it stops glowing.

### item

Stack of ordinary paper

### storage

optics 1

### packing

optics 1 ▼

UV crayons

zip-lock bag in optics 1 box

optics 1 ▼

desk lamp with UV CF bulb

lights box

lights ▼

### tips

- electricity
- darkness

Going for a Spin

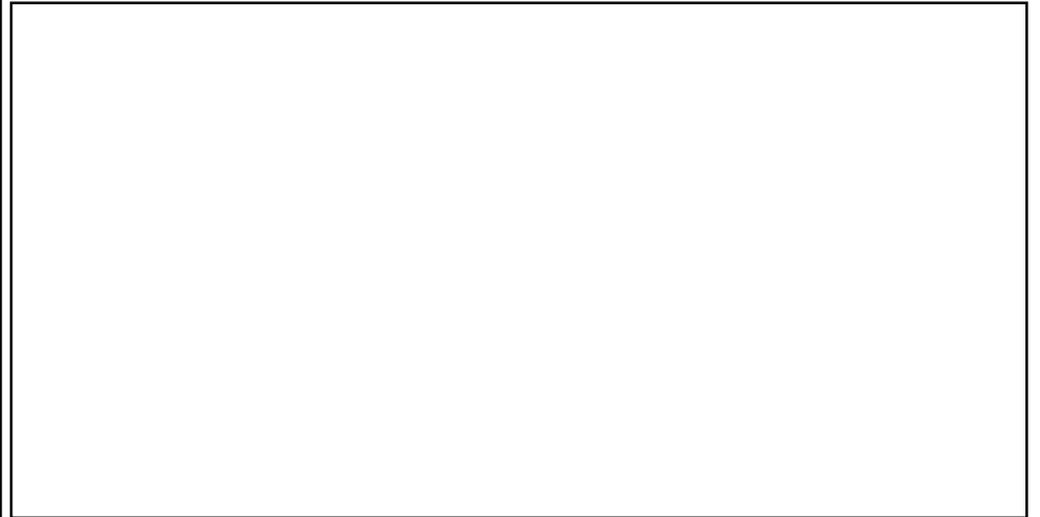
activity

**Part 1:**  
 Stand on the platform.  
 Hold the bicycle wheel upright by its two handles and have someone get it spinning for you.  
 Slowly, tip the wheel to one side. What do you feel? What happens to you?  
 Tip the wheel back. What happens?

**Part 2:**  
 Now sit on the platform with one weight in each hand in your lap.  
 Have someone give you a gentle spin.  
 Now raise your hands, with the weights in them, away from your body slowly. What happens?  
 What happens when you put your hands back in your lap?

Going for a Spin -- Explanation

Both of these activities depend on conservation of angular momentum. Angular momentum is a combination of your shape and your spin. In part 1, while you have no spin, the wheel does have spin. When you change the direction it is spinning, you have to spin the opposite way to balance things out. In part 2, changing your shape forces a change in your spin.



item	storage	packing
Bicycle wheel with handles	rotational motion shelves	no box ▼
Spinning platform (the cast iron one is better)	rotational motion shelves (bottom shelf!)	no box ▼
Hand weights - purple for little kids, blue-green for the rest	rotational motion shelves	heavy stuff ▼
		▼
		▼

**tips** Have small kids and the timid sit down to do this rather than standing. For small people who are strong enough to hold the wheel but whose arms aren't long enough, have them hold one handle with both hands with the axle perpendicular to their body and then raise the wheel over their heads so the axle is vertical to make themselves spin.

- electricity
- darkness

## Have the Borrowers Stolen Your Pellet?

### activity

Race the pellets through the two copper tubes. What happens? (Have patience!)

Does either pellet stick to the copper pipes?

Does either pellet stick to the base holding the copper pipes?

Drop the two side by side over the foam, but not through pipes. What happens?

Hold the green strip along one of the pipes. What do you see when each pellet falls through that pipe?

Compare this to “Jumping Rings.”

## Have the Borrowers Stolen Your Pellet? -- Explanation

One of the pellets is a strong magnet and the other is not. As the magnet moves through the copper tube it causes electrons in the copper to move in circles around the pipe. The moving electrons behave like a second magnet, which pushes the first magnet back up the tube so that it falls much more slowly. Without the tube, the magnet falls the same way the non-magnet does. Try it.

### item

2 copper tubes attached to blue blocks mounted on a ring stand slugs stored in capped

large gray square of foam with a hole in its middle

blue, Cenco ring stand base

magnetic field imaging film - long green strip about 1” wide in white box

### storage

magnetism

van de Graaff box

ring stand bases

optics 1

### packing

heavy stuff ▼

van de Graaff ▼

heavy stuff ▼

optics 1 ▼

▼

**tips** Check that pipes are both vertical or the slugs may hang up inside.

Unscrew the pipe from its base, thread the foam onto the pipe and reattach to base.

electricity

darkness

Invisible Lake
<b>activity</b>
Blow bubbles over the opening to the box and let them fall into it. What happens? Compare the behavior of the bubbles before they get into the box and after they get into the box. What makes things float?  What happens to the bubbles inside the box over time? What do they look like just before they break?

Invisible Lake -- Explanation
Carbon dioxide is natural and you exhale it all the time. Usually it makes up a small fraction of the air. At the bottom of the tank there is a layer of air that is almost pure carbon dioxide. Like a boat floating in water, the bubbles, which weigh less than the carbon dioxide, float on the layer of carbon dioxide. Eventually the bubbles will freeze and most of them break then, but a few survive.

--

item	storage	packing
dry ice	chemistry freezer	oscillation ▼
bubble stuff and anti-spill bubble containers	cooler pocket oscillation box	oscillation ▼
2 AA batteries	optics 1	optics 1 ▼
small flashlight with tilting head	cooler pocket oscillaiton box	oscillation ▼
soft-sided cooler to transport all of the above	oscillation	oscillation ▼

**tips** Set up in the Lights box with one side of the lid closed. Make sure kids don't touch the dry ice. If they blow into the container, it will take a while for the carbon dioxide to accumulate. Use the hammer in the tool kit to break up the dry ice if necessary. A cooler full will usually easily last for 3-4 hours.

electricity  
 darkness

Jumping Balls
<b>activity</b>
Rub the rabbit fur, fur side down, on the clear top of the box. Rub fairly fast.
What do the balls inside do?
What happens if you pick the fur up and move it over a ball but not touching the box?
What happens if you put a finger over a ball but not touching the box?
What happens if you touch the top of the box with your finger?
Do the balls attract or repel each other?

Jumping Balls -- Explanation

Rubbing the fur generates static electricity (like walking on carpet in the winter). The rubbing moves charges between the plastic of the box and the fur so that both end up charged. The styrofoam beads become polarized - one side positively charged and the other negatively charged. They are attracted to the charged plastic and jump up to hang from it (because they are very light weight). Touching the plastic uncharges it where you touch it which causes the balls to move around.

--

item	storage	packing
~1ft square, 1.5" deep wooden box with plexiglas lid taped on and grey beads inside	oscillations box	oscillation ▼
ziploc bag with rabbit fur	oscillations box	oscillation ▼
		▼
		▼
		▼

**tips** This works better in dry weather. It can become too charged so that nothing more happens. Try wiping with a hand.

- electricity
- darkness

## Jumping Rings

### activity

RINGS MAY BE HOT  
DO THIS ONLY WITH ADULT SUPERVISION.  
DO NOT FIDDLE WITH ANY OF THE ELECTRICAL CONNECTIONS.  
WATCH OUT FOR FALLING RINGS.  
Find the dial with numbers around it.  
Turn the dial.  
What happens to the rings?  
Try turning the dial to the same setting at different speeds.  
Try turning the dial to different settings at the same speed.  
Try different rings.  
Can you make a ring hover?  
  
Hold a piece or two of broken magnet towards where the rings jump from.  
What do you feel?  
  
Compare this to "Have the Borrowers Stolen your Pellet?"

## Jumping Rings -- Explanation

When you turn the dial, you send electrons through the green cord. This makes an electromagnet - a magnet made from moving electrons instead of specially treated iron or other material. This kind of magnet can be turned on and off. As the magnet is turned on and off, it pushes electrons in the aluminum rings around the rings in circles (one direction for on and the other for off). The electrons push back, but since the magnet is sitting on the table, the magnet doesn't move and the rings do. This is like pushing off from the wall of the swimming pool - you push on the wall and it doesn't move and instead you move away from the wall. If the dial is at the right setting, the rings push themselves up just as much as gravity pulls them down, so they hover. Notice that the ring that doesn't jump has a break in it. This prevents the electrons from going around in circles, so that ring doesn't jump.

### item

metal, plastic, and cut rings
green electromagnet with its cord
round, green variac power supply
broken magnets

### storage

electricity stuff
electricity stuff
electricity stuff
ziploc bag in optics 1

### packing

heavy stuff ▼
heavy stuff ▼
heavy stuff ▼
optics 1 ▼
▼

**tips** The iron core of the electromagnet can be extended or retracted. The rings can be stored trapped on the core when it is retracted. Needs an adult to monitor since it uses 110V with exposed plugs and connection and the rings can get hot enough to burn.  
**See photo.**

electricity  
 darkness

Newton's Pendulum

Newton's Pendulum -- Explanation

**activity**

Start by making sure the 5 balls are not moving.  
Pull one ball away from the others and let it go. What happens?  
Pull two balls away from the others and let it go. What happens?  
Pull three balls away from the others and let it go. What happens?

This is like bouncing balls off the floor. If you drop one ball, one ball will come back up to your hand. If you drop two balls, you would expect two to bounce back up. In this case the balls in the middle acts like the "floor"; they move instead of staying still like a regular floor though, so the balls come out the other side.

**item**

Wooden cradle with 5 steel balls suspended

**storage**

mechanics shelves

**packing**

van de Graaff ▼

▼

▼

▼

▼

**tips** See photo.

- electricity
- darkness

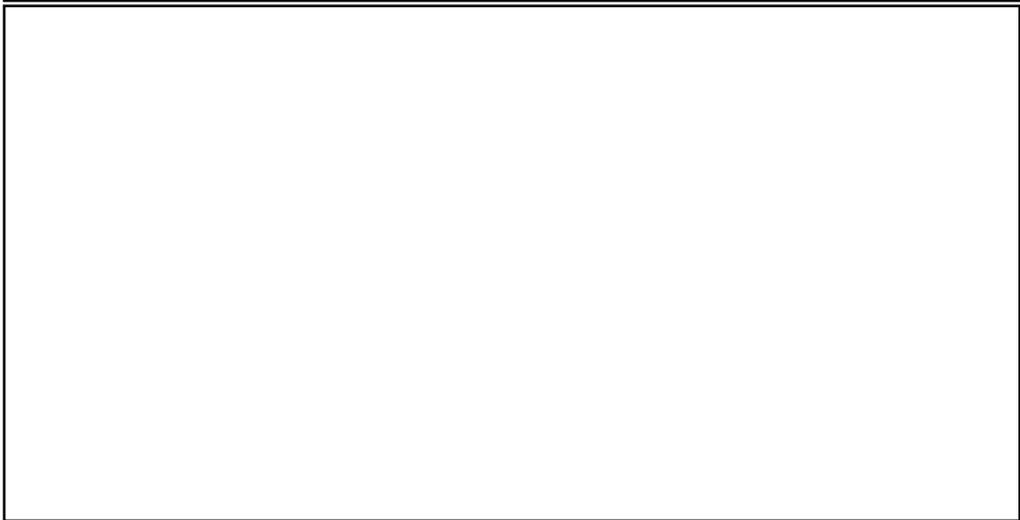
Phantom Ghost

Phantom Ghost -- Explanation

**activity**

Try to pick up the ghost or pig. (Can you find where it is hiding?)  
Look inside the saucer. What are the inside walls made of? Why do you think you see a ghost on top? What do you think the ghost on top is made of?

The inside of the saucer is made of curved mirrors. The mirrors reflect the light from the plastic ghost to the top to form a new ghost made out of light.  
Do you think this will work with any object?



**item**

black flying-saucer shape mirrored on inside

**storage**

optics 1

**packing**

optics 1 ▼

small pig

zip-lock bag in optics 1

optics 1 ▼

small ghost

zip-lock bag in optics 1

optics 1 ▼

▼

▼

**tips**

Transport mirror with top flipped over and a square of flannel between two halves.

- electricity
- darkness

Rattlebacks

**activity**

Set one of the rattlebacks curved surface down. Give it a spin? When it stops spinning, spin it the other direction. What do you notice?

Does it matter which hand you use?

Try rocking the rattleback. What happens?

Now turn the rattleback over, flat side down, and put it over the words on this page. What do you notice about the words? What does this tell you about the shape of the Rattleback?

Rattlebacks -- Explanation

Now turn the rattleback over, flat side down, and put it over the words on this page. What do you notice about the words?

**item**

Rattleback(s): transparent plastic, ~3" long, ovalish shape sliced through the middle

**storage**

zip-lock bag in optics 1

**packing**

optics 1 ▼

▼

▼

▼

▼

**tips** Place on a smooth surface for best results.

- electricity
- darkness

Running in Circles

**activity**

(This requires a bit of a knack, so try several times. If you still can't get it to work, ask a volunteer for help.)

Hold the large ring in one hand.

Give the colored rings a good spin with your free hand.

Assuming one or more start really spinning, walk the big ring around by grabbing its top and pulling towards you. You don't need to do this very fast. Try to keep the colored rings about half way up the far side.

Can you do this with the colored rings spinning either direction?

Do they keep spinning if you don't keep rotating the ring?

Running in Circles -- Explanation

Once the colored rings are spinning, they wobble like a top or a frisbee. This makes them rub against the big ring. The colored rings keep going because you keep putting energy into them by lifting them with every rotation of the big ring.

**item**

Large steel ring with much smaller colored rings threaded on it

**storage**

optics 1

**packing**

optics 1 ▼

▼

▼

▼

▼

**tips**

- electricity
- darkness

Seeing Infinity

**activity**

Put your head into the box enough to look into one of the mirrors. What do you see? How many of you are there?  
Gently tilt one of the mirrors up/down and front/back. What happens to what you see in the mirror? When can you see the most copies of yourself?  
How is this related to Doppelgangers?

Seeing Infinity -- Explanation

The light in the room bounces off you. Some of it hits one mirror. The light bounces back off the mirror and some of it hits the other mirror. Back and forth the light goes like an endless ping-pong game. Each time some of the light also hits your eyes - this is why you see the images of yourself.

**item**

2 square mirrors

**storage**

optics 1 box

**packing**

optics 1 ▼

▼

▼

▼

▼

**tips** Set up in the empty Optics box. Mirrors store in flannel sack.  
See photo.

- electricity
- darkness

Shrinking Penny

Shrinking Penny -- Explanation

**activity**

Drop a penny inside the box. What happens to it? Is this possible?

Trying to figure out how this works:

With the penny inside, tip the box gently front to back. What happens to the penny? Now tip the box gently upside down so that the penny disappears again. Tip the box around gently this way and try to determine the shape of the area the penny can move around in.

Look very carefully at the corners of the box and at the patterns there. What do you notice?

There are two mirrors running diagonally from the back corners of the box to meet at the center of the box. You aren't seeing the entire inside of the box even though it looks like you are.

**item**

a few pennies

**storage**

inside box

**packing**

optics 1 ▼

small, rectangular, plastic box with silver funnel inside and coin slot on top

optics 1

optics 1 ▼

▼

▼

▼

**tips**

This is an especially good one to encourage adults to work on figuring out by tipping the box around.

- electricity
- darkness

Smoke Rings

Smoke Rings -- Explanation

**activity**

Flip the switch to "on" until you see the chamber fill with smoke.  
Turn the switch back off.  
Pull the small trigger to release the smoke rings.  
How big a smoke ring can you make?  
Watch how the smoke rings fall apart.

Pulling the trigger thumps the drum, which sends a smooth puff of air out. The air drags some smoke with it. As smoke comes through yellow hole in the front, some of it gets caught on the edge and curls under, forming the smoke ring. The wind in the room mixes the smoke up so the ring disappears.

**item**

smoke gun - bulky pistolish, transparent plastic

**storage**

van de Graaff

**packing**

van de Graaff ▼

smoke fluid - hand-sized, rectangular, translucent white, plastic, bottle

van de Graaff

van de Graaff ▼

AA batteries

optics 1

optics 1 ▼

▼

▼

**tips**

- electricity
- darkness

## Standing Waves

### activity

There should be a wire loop or a set of thin metal strips attached to a machine to shake them. You can control how hard and how fast they are shaken by adjusting the left two knobs on the attached signal generator (blue box). How fast is the left knob. You can see how many times per second they are being shaken on the display screen. If you turn this knob fast, that number will change quickly too. If you turn it slowly, the number will change slowly. The knob labeled amplitude controls how hard they are shaken. You probably don't need to adjust this knob. Try adjusting the left knob until you see interesting patterns.

Can you get the ring to show three lobes? How many different ways can you get this to happen? Does the ring always move the same direction it is being pushed?

## Standing Waves -- Explanation

The interesting patterns show up at resonance. This is the same things as what you do automatically when you push someone else in a swing at the park: you only push forwards as they start to move forwards – otherwise you make them stop instead of making them go higher.

### item

generator and its power cord

osculoop and oscillator bars

oscillator

2 banana to banana wires

### storage

oscillations shelves or E&M stuff

oscillation box

oscillation shelves

wire rack by door to 0210

### packing

oscillation ▼

oscillation ▼

oscillation ▼

oscillation ▼

▼

### tips

The loop works better than the bars.  $\sim 19\text{Hz}$  and  $\sim 78\text{Hz}$  are interesting for horizontal forcing of vertical loop. A bright light (e.g. the sun) reflecting off an antinode will show the trajectory of the wire (a double figure 8 at 78Hz). Put stand on top of generator to get height to clear table. **See photo.**

- electricity  
 darkness

Standing Waves II

Standing Waves II -- Explanation

**activity**

Gently hold the base of the goblet with one hand. Dip a finger of the other hand in the water and then run your finger around the rim. Experiment with speed and pressure until you get a sound. Change the amount of water in the goblet. What happens to the sound? Look at the water carefully while you're making the goblet ring. What do you see?

The interesting patterns show up at resonance. This is the same things as what you do automatically when you push someone else in a swing at the park: you only push forwards as they start to move forwards - otherwise you make them stop instead of making them go higher. Your finger sticks and then slides (stick-slip). When it does so at the correct frequency it sets up a wave in the goblet which in turn sets up a wave in the air which you hear.



item	storage	packing
goblet	optics 2	optics 2 ▼
		▼
		▼
		▼
		▼

**tips** Goblet has foam nest and bubble wrap in the oscillation box.

- electricity
- darkness

Step Right Up and Shake Your Own Hand

Step Right Up and Shake Your Own Hand -- Explanation

**activity**

Stand (or kneel) on the tape line. Get your head centered in the mirror. Reach your hand out toward the mirror as though shaking hands. What happens?  
Can you shake hands?

The mirror is a concave mirror. Concave means that the middle is carved out like looking into a cave. The point where your hand gets blurry and changes from being right-side-up to up-side-down is the focal point which defines how curved the mirror is.

**item**

large concave mirror with its own base

**storage**

top of optics shelves

**packing**

no box ▼

▼

▼

▼

▼

**tips** Don't take this out in the wind - it can crack the mounting as well as tip over.  
Still needs a box - or just reinforce the current box and use it.

- electricity
- darkness

Tandem Swings

Tandem Swings -- Explanation

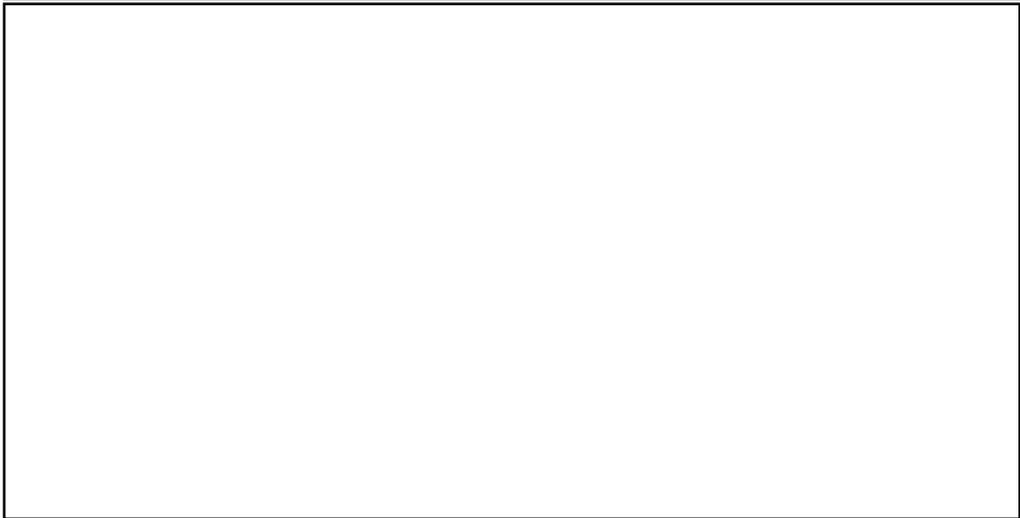
**activity**

Gently hold one hanging rod still as it hangs straight down. Equally gently, pull the other rod back a little and let it go of both rods. Do not let the rods hit each other. What happens? Watch for a while and see if you can see a pattern.

Try moving the elastic band up or down on the rods. What happens now when you swing one rod? What happens if you tighten or loosen the band?

Now try moving the big washers so they don't match on the two rods if they did before or so they do match if they didn't before. To do this twist the wing nuts to loosen them and then adjust one up or down then tighten the other against it with the washers centered. What happens now if you swing one rod?

The swinging mass pulls on the other mass through the elastic band. The other mass pulls back, slowing the first mass down. Eventually the second mass will be swinging and the first mass will be at rest. Then the process repeats itself. The position and tightness of the band controls how strongly the swinging rod pulls on the non-swinging one. The location of the washers controls the time it takes the rod to make one swing - if the two rods aren't matched well it's like pushing someone on a swing at the wrong time.



**item**

coupled pendulum assembly - wooden frame with metal rods

**storage**

under PPLAY table

**packing**

no box ▼

▼

▼

▼

▼

**tips**

- electricity
- darkness

Taz's Tops

**activity**

They spin like crazy, just like the Tasmanian devil in cartoons. If you spin these tops quickly enough, they will tip themselves over and then stand back up again -- up-side-down.  
Start with a top round end down and give it a good spin. If you're lucky it will turn upside down without running off the edge of the table or into something first.

Taz's Tops -- Explanation

Have you ever tried to throw a Frisbee up-side-down? If you have, you know it doesn't spin very well. Some things, based on their shape, have a preferred direction to spin. These tops like to spin looking like mushrooms -- so much so that they will stand on their heads to do so.

If you'd like a more detailed explanation, ask one of the volunteers

**item**

tops: small sliced-off spheres with dowel rods

snake to corral the tops (purple with stars)

**storage**

zip-lock bag in optics 1

van de Graaff box

**packing**

optics 1 ▼

van de Graaff ▼

▼

▼

▼

**tips**

The smoother the surface these spin on, the better.

- electricity
- darkness

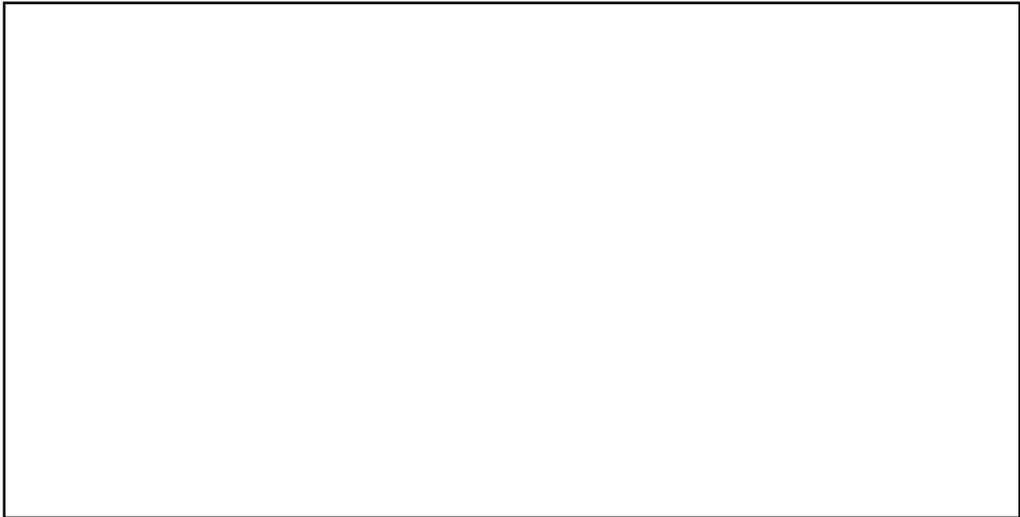
Tilt-a-Reed

Tilt-a-Reed -- Explanation

**activity**

Pick up one tube and tilt it. What happens?  
 Pick up a different tube and tilt it. Are the results the same or different?  
 Try tilting 2 or more tubes at the same time.  
 Can you change how loud the sound is?  
 Can you change the pitch other than by using a different tube?  
 Look inside the tube? What can you see? How do you think this works?

Each tube has a thin sheet of material (the reed) inside stretched across a ring. When you tilt the tube, the ring slides down the tube. This pushes air past the thin sheet (like waving your hands in the air to dry them) which makes the sheet vibrate. The tube makes it easier to hear this vibration, which is fast enough that humans hear a pitch rather than a rattle.



**item**

plastic tubes over a foot long

**storage**

music shelves

**packing**

optics 2 ▼

▼

▼

▼

▼

**tips**

- electricity
- darkness

van de Graaff

**activity**

Use plastic grabber to manipulate the small ball on a stalk.

Turn on and off with small ball touching large ball. Turn off to set things on sphere.

Move small ball away to see small lightning.

Move away and towards slowly to make bat flap wings. If day is dry, bat may be induced to “fly” off.

Tape pompom to top of big sphere. Move small sphere away and watch “hair” stand on end.

Stack aluminum pans on top of large sphere. Pull small sphere away slowly and watch pans float up and fly away.

van de Graaff -- Explanation

Electrostatic repulsion of like charges.

item	storage	packing
van de Graaff	wooden shelves	van de Graaff ▼
fur bat, blue pompom	wooden shelves near van de Graaff	van de Graaff ▼
small aluminum pie pans	wooden shelves near van de Graaff	van de Graaff ▼
plastic grabber	wooden shelves w/ van de Graaff	van de Graaff ▼
high voltage sign	wooden shelves w/ van de Graaff	van de Graaff ▼

**tips** This is a demo lest kids get shocked.

- electricity
- darkness

Vanishing Bulb

**activity**

Hold the white button down until the light bulb lights up.  
 Release the button and gently unscrew the light bulb.  
 Look through the eye hole. Hold down the white button. Do you see a light bulb?  
 What happens if move your head around?  
 Put the bulb back in and look through the eye hole while holding the button down. Does it look the same as before?  
 See if you can figure out how you can see something that isn't there.

Vanishing Bulb -- Explanation

There is a second bulb mounted up-side-down directly below the visible bulb. When you look through the eye hole, you see the reflection of the second bulb in the mirror exactly where the first bulb ought to be. If you move your head around, the positioning isn't quite so good.

**item**

Wooden cube w/ 2 sides open and 2 light sockets

**storage**

optics shelves

**packing**



concave mirror

on top of optics shelves



two **identical** light bulbs

light sources on optics shelves



**tips**

Needs to be rebuilt before it can be used.  
 This needs to be adjusted for both height and distance so that the effect works. The viewer's height matters too (?).

- electricity
- darkness

What Color is Your Shadow?

**activity**

DON'T LOOK DIRECTLY AT THE LIGHTS FOR LONG. DON'T TOUCH THE LIGHTS OR TOUCH THINGS TO THEM.

Stand with a hand very close to the wall. Move your hand around and look at the shadows it creates. How many colors can you get? Try changing the space between your fingers and the distance of your hand from the wall.

Try standing closer to the lights and in front of each one. What color shadows does this produce?

What Color is Your Shadow? -- Explanation

White light is made up of many colors. Here we make white light with just three colors: red, green, and blue. When you stand in front of one color, you block this color from reaching the wall so your shadow is a combination of the two remaining colors. How many different colors can you make on the wall?

**item**

red, blue, and green bulbs mounted on bases (aluminum reflectors)

**storage**

lights box

**packing**

lights ▼

▼

▼

▼

▼

**tips** Set up the lamps so the center of the field is as close to white as possible. These get quite hot, so try to place them out of the traffic path. See photo.

- electricity
- darkness

ZZ new experiments

ZZ new experiments -- Explanation

**activity**

magic wand (magnet through coil)  
hand generator  
corn starch and water  
tape tree for polarizers  
lucite force to squeeze between polarizers  
ramp version of newton's pendulum  
revise bug's eye view to use two lenses  
chatter stones

Empty rectangular box for notes or explanation.

Empty rectangular box for notes or explanation.

**item**

**storage**

**packing**

Empty input field for item name.

Empty input field for storage location.

Dropdown menu for packing type.

Empty input field for item name.

Empty input field for storage location.

Dropdown menu for packing type.

Empty input field for item name.

Empty input field for storage location.

Dropdown menu for packing type.

Empty input field for item name.

Empty input field for storage location.

Dropdown menu for packing type.

Empty input field for item name.

Empty input field for storage location.

Dropdown menu for packing type.

**tips**

Large empty rectangular box for tips.

- electricity
- darkness

ZZ Stuff not to forget

ZZ Stuff not to forget -- Explanation

**activity**

**item**

tool kit (black plastic box), notebook

**storage**

PPLAY stuff

**packing**

no box ▼

1 white extension cord - 2 wire

lights box

lights ▼

1 orange and 3 white extension cords - 3 wire, 3 plugs

lights box

lights ▼

1 white power strip

lights box

lights ▼

blue tape, electric tape

tape shelf

heavy stuff ▼

**tips**

- electricity
- darkness