From WOW to AHA

a Science Show workshop

Workbook compiled by

Rudi Horak & Helga Nordhoff

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Introduction

A Science Show can be described as a series of **thought-provoking** science demonstrations. Its aim is to utilise the imagination of the audience, to promote creative thinking and actively involve the audience. Science Shows should make science more accessible and introduce an element of wonder and surprise to the teaching activity.

A successful show has an element of magic. It should be fun, involve all the senses of the audience and encourage inquiry. It should also lead to an AHA-experience. The AHA-experience is defined as the moment of insight; the moment in which elements come together and a new concept is constructed.

A good science show

- makes things visible;
- shows things that can be done at home - in other words uses every day equipment;
- involves the audience and
- links to real-life situations.

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An example of an AHA-experience is Archimedes' discovery of the principle of buoyancy while he was taking a bath. He is reported to have jumped out of the bath and ran through the streets naked shouting "Eureka!"

About this booklet

This booklet was been compiled as a workbook for BSecEd students and "UP with Science" learners at the University of Pretoria to be used during Science Show Workshops.

No guidelines are given on "How to involve the audience" in the hope that the students and learners will come up with new and creative ways to involve their audience; and they always do!

Involving the audience is a very personal thing and it depends to a large extent on the acting skill of the presenter. The composition of the audience; their ages, gender, knowledge of science and previous exposures to Science Shows, all influence how they can and want to be involved. Generally scientist and teachers are not good actors. As Ian Russell pointed out:

> "*It is easier to teach an actor a little bit of science than to teach a scientist to act.*"

During our "Science Show" workshops we normally discuss different strategies to involve an audience and the advantages and disadvantages of each. Be adventurous, experiment, try new things; but always do, what feels comfortable to you.

It is advisable to select a set of tricks and activities around a theme.
The theme can be linked to a specific topic, such as surface tension, sound or gravity; or to a prop, "10 things to do with balloons", "Possibilities with paper"; or set in a place, "Science in the kitchen" or "Science at the dinner table". A Science Show can of course consist of a number of different themes. Try to find a way to link the themes.

Maintaining this collection is ongoing task; if you feel that we should add a specific demonstration to this booklet, or wish to share an experience with us, please e-mail your suggestion to helga.nordhoff@up.ac.za.

The Science Show as Teaching Tool

The science classroom is different to the language and social sciences classroom because learners are expected to do practical work. A consequence is that the educator has to look for real life applications of the theory that is taught. The nature of the subject makes it easy for the educator to use a variety of teaching tools, from the old-fashioned chalkboard to multimedia presentations on the computer and occasionally of course, a “Science Show”.

The “Science Show” has its own didactic rules and it is not necessary to make every lesson a “Science Show” or a WOW-experience, but all science teachers can learn something from an experienced “Science Show” presenter or edutainer. A successful science lesson should, as a Science Show, promote creative thinking and encourage inquiry.

Once you have mastered the art of presenting a “Science Show”, you can use the elements of a Show to make your lessons more interesting, to introduce a new theme in the classroom, or to “entertain” the parents on a parents evening.

We, Rudi Horak and Helga Nordhoff, your lecturers for the Educational Community Project have collected these simple tricks, demonstrations and experiments for you to practise and use in the classroom. Some experiments are more suitable for demonstrations, others are excellent activities for a “Science Show”. Often the presenter and his / her acting skills will determine if an experiment is more suited to a demonstration or to a WOW-experience.

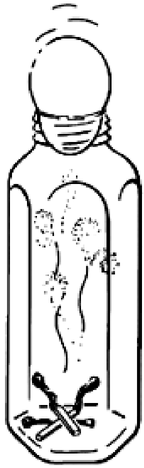
Practise, be enthusiastic, have fun, and remember:

“Give people facts and you feed their minds for an hour.
Awaken curiosity and they feed their own minds for a lifetime”

Ian Russell

Gases

Egg in a Bottle



You need:

- A glass bottle with a narrow neck
- A hard boiled egg, peeled
- Matches or a small amount of meths

How?
Drop three lit matches into the glass bottle or light a small amount of meths in the bottle. Quickly place the peeled, hard-boiled egg on the mouth of the bottle.

What happens?

How to involve the audience / learners?

What happens? Why?
The flames heat the air in the bottle. As the heated air expands, some of it escapes out the bottle. When the matches go out, the air inside the bottle cools and contracts, thus creating a lower pressure inside the bottle than outside. The greater pressure outside the bottle forces the egg into the bottle.
From: Newton's Apple.

Variation: Place the peeled end of a banana on the mouth of the bottle. The banana will peel itself.

Sucking Candle

You need:

- A candle and matches
- A deep saucer or shallow dish
- Water or better still a carbonated drink
- Empty jar with a wide mouth

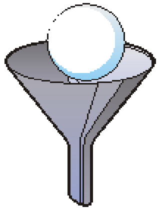
How?

Stand the lighted candle in the dish. It is best to fix it to the dish using some melted wax. Pour a small amount of liquid into the dish. Place the jar over the candle.
What happens?

How to involve the audience / learners?

What happens? Why?
The explanation normally given is: "*The candle flame will quickly burn up all the oxygen in the air in the bottle, and will then go out - the water in the saucer rising inside the bottle.*" (Goldstein-Jackson, 1976, p.130) This is incorrect.
Another explanation, that the water absorbs the CO_2 produced during the combustion process is also wrong. Try the experiment with a carbonated drink. It works just as well.
The true explanation uses Boyle's Law. The air above the flame is hot. Once the flame dies, the air cools and the air pressure inside the jar is lower than outside. The liquid rises in the jar until the pressures are equal.
What happens if you let it stand for a while?

“Blow, Johnny, Blow”



You need:

- 3 funnels of different sizes
- 3 ping-pong balls
- volunteers from the audience
- optional: drinking straws

How?

Demonstrate to the audience that you can keep a ping-pong ball floating above the drinking straw. Now challenge volunteers from the audience to see who can blow the ping-pong ball the highest using the 3 different funnels.

What happens?

How to involve the audience / learners?

What happens? Why?

“*Bernoulli’s principle of states that in fluid flow, an increase in velocity happens simultaneously with decrease in pressure*.” Wikipedia.

Smoke-ring Cannon

You need

- A large coffee tin or soup can
- Large piece of rubber or thin leather (half a balloon will also work)
-

How?

Cut a 3-5 cm hole in the centre of the bottom. Stretch and tape the rubber over the other end.
Gently whack the rubber-covered end of your canon to launch a ring of spinning air out of the hole. Aim the device at your face or arm to feel the puff of air hitting your skin. Place stick incense or dry ice into the can to make visible smoke rings.

How to involve the audience / learners?

What happens? Why?

When
Instead of smoke, place perfume into the can, choose a targets with sensitive noses and surprise them with a perfume bullet.

The Self-inflating Balloon

You need

- A large balloon
- Bicarbonate of soda
- Vinegar or diluted acetic acid

How?

Place a small amount of bicarbonate of soda into a large balloon before the show starts. During the show pour a small amount of vinegar into the balloon, close the opening.

Alternatively: Press a small amount of bicarbonate of soda into the lid of a 35 mm film container. Pour some vinegar into the container, replace the lid, shake it briefly, and ...

How to involve the audience / learners?

What happens? Why?

When the bicarbonate of soda dissolves in the vinegar (acid), carbon dioxide forms which inflates the balloon or pops open the film container.

$$NaHCO_3(aq) + CH_3\,COOH\,(aq) \rightarrow CH_3COONa(aq) + H_2\,CO_3\,(aq)$$

but since $H_2\,CO_3$ is unstable we get $H_2CO_3(aq) \rightarrow H_2O\,(l) + CO_2(g)$

The Non-inflating Balloon

You need

- 2 large (2l) plastic cooldrink bottles
- 2 large balloons

How?

Push a balloon into one bottle, stretching the mouthpiece of the balloon over the bottle opening. Blow hard into the balloon.
What do you find?
Now pierce the bottom of the second bottle with a sharp object, push the second balloon into the bottle, again stretching the mouthpiece over the bottle opening. Blow hard into the balloon.
What do you find?

How to involve the audience / learners?

What happens? Why?

The air in the bottle takes up a certain amount of space. As you try to inflate the balloon, the balloon 'squashes' the air in the bottle. In the first bottle the air cannot escape because the balloon is covering the opening. The air pressure inside the bottle becomes so great you cannot inflate the balloon beyond a certain size. In the second bottle the air can escape through the hole in the bottom and you should be able to inflate the balloon to fill the bottle.

The Non-popping Balloon

You need

- 2 or more balloons
- String
- Water and a funnel
- Candle and matches

How?

Inflate one balloon and tie it with a piece of string. Pour approximately 100 ml of water into another balloon. Inflate it and tie the top with another piece of string. Light the candle and hold the first balloon over the flame.
What happens? Now hold the second balloon over the flame.
What happens now?

How to involve the audience / learners?

What happens? Why?

Burning Money

You need

- R10 or R20 note (or a handkerchief)
- Glass with water
- Glass with rubbing alcohol and a pinch of copper sulfate.
- Tongs
- Candle and/or matches

How?

Hold the note with the tongs and dip it first into the water and then into the alcohol. Hold the bottom corner of the note into the candle flame. What happens?

How to involve the audience / learners?

What happens? Why?

When held into the flame the note will ignite, flames will burn, and then the flames will go out. You should be holding a nicely dried note in the tongs. The note does not burn because the vapourising water cools the paper. The copper sulfate added to the alcohol make the flames more visible since they burn blue.

Note: Keep a large container with water handy to dip the note into in case the flames don't go out.

More Balloon Stuff

- Strong Balloons:
  Blow up 8 - 10 balloons so that are the same size; tie them together in pairs and place them on a blanket. Place a plank (± 0.5 x 1 metre) on top and see how many people can stand on the plank.
- Pierce a balloon with a long needle without it popping.
- Balloon projectile:
  Push the top of a balloon through the cut-off neck of a plastic cooldrink bottle. Place a dried pea in the balloon, pull it backwards and shoot as you would with a sling.
- Show that air has mass.
- Static electricity.
- Bernoulli:
  Suspend two inflated balloons from a stick, blow between them What happens? Why?

Candle Stuff

- Try to extinguish a candle by blowing through a funnel.
- Place 3 burning candles of different height under an inverted glass jar. What happens? Why?
- Place a burning candle in a dish with water and cover it with an inverted glass jar. What happens? Why? See page 5.
- Demonstrate centripetal force.

Things that go BANG!

Children, and adults, love fireworks and things that go ... **BANG.**

Most of the following "tricks" are best done as demonstrations, with little active involvement from members of the audience.
Remember to take safety precautions ie. wear safety glasses and have a fire extinguisher ready.

Important: practise beforehand and clean up the mess afterwards.

Volcanoes

(only two types of volcanoes are discussed here)

A volcano's shape depends on the kind of lava or ash that it produces. There are many different types of lava. Some are sticky they hardly flow at all. Others are so runny that they flow a great distance at speeds up to 100 km/h, and we talk about the viscosity or lava's mobility. The more viscous the material, the greater its resistance to flow. Everyday liquids such as honey, washing-up liquid, shampoo, and toothpaste can demonstrate this.

Cinder volcano

Cinder cones are the smallest and are formed largely by the piling up of ash, cinders and rocks, all of which are called pyroclastic ("fire-broken") material. These materials have undergone a violent eruption and as they fall back to earth they pile up to form a symmetrical, steep-sided cone.

Composite volcano or stratovolcano

A composite volcano is built of lava flows inter-layered with pyroclastic material. The layering of the volcano represents a history of alternating explosive and quiet eruptions.

Make your own volcano

You need

- Tin can or small metal container
- and/or the upper half of a plastic cooldrink bottle
- Newspaper
- Flour
- Water
- Plaster of Paris (optional)
- Paint, various colours

How?

Decide what type of volcano you want to build.

Use the **metal container** for a **strato volcano or composite volcano** where the slopes of the volcano are gentler. The opening on top has to be big enough to put dry ice or liquid nitrogen in or to put a lid of a glass jar to cover the opening.

Glue or place the tin can or the cooldrink bottle on a piece of sturdy cardboard or wood. Cover the container with paper maché, leaving an opening at the top. After the paper maché has set and dried, cover it with a layer of plaster of paris to make it fire proof. Decorate your mountain by painting rocks, trees, etc. on the slopes.

To build a **cinder volcano**, which is symmetrical and steep sided, cover the upper half of a **cooldrink bottle** with paper maché and place this on top of your strato vulcano. Make sure the opening at the top is big enough to be covered by the cap of a beer bottle.

Demonstration

Put about 20ml of water into a film canister; then add a quarter or half of a tablet of Alka seltzer and quickly, but firmly put on the lid on. Stand back and wait to see what happens. (Practice first before doing it in front of an audience.)

Erupting cinder volcano

You need

- Ammonium dichromate
- Acetone or nail laquer remover
- Matches

How?

Place the metal lid (beer bottle lid) on the opening of the volcano. Put a small amount of ammonium dichromate (3-5ml) in the metal lid and pour a few drops of acetone or nail laquer remover over and light the mixture with a match. Now, watch your volcano spit out ash.

Erupting composite volcano

You need

- Dry ice or liquid nitrogen
- Red food colouring
- Bicarbonate of soda
- Vinegar or diluted hydrochloric acid

How?

Put dry ice or liquid nitrogen into the metal container and pour hot water over and watch your volcano ejecting steam. Afterwards just pour the water out.
Use the same volcano for the gentle eruption, but use the lid of a jar to be placed on the opening of the neck of the volcano. Put a small amount of bicarbonate of soda into the lid and pour a mixture of red food colouring and vinegar over. This resembles the more runny lava charged with gas and emission of gas.

From: Wiebke Grote, Department of Geology, University of Pretoria.

Exploding Custard

Mike Gore at Unizul Science Centre, 2003
Photo: Derek Fish

You need

- Custard powder
- A funnel
- Hose pipe, ± 1 m long
- Gas burner
- Safety glasses
- Fire extinguisher

How?

Place some custard powder on a teaspoon and hold it in the flame. What happens? Now pour some custard powder into the funnel connected to the hose. Forcefully blow the custard powder into the flame of the gas burner.

What happens? Why?

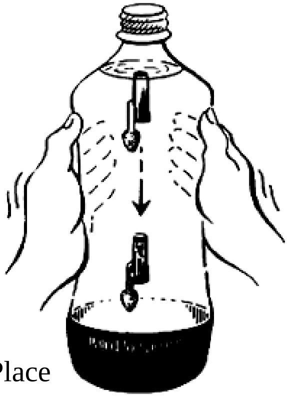
The custard goes up in a sheet of flame rather than a bang. This is an excellent example of a "dust explosion". The surface area of the material increases dramatically in the dust cloud and if it is exposed to an ignition source it will go **... whoosh**!
Flour, corn flour, fine sugar and coal dust all behave similarly.

Precautions: Make sure that the ceiling is high enough or better still, do it outside. Have somebody with a fire extinguisher on standby.

Alternative: You can also do this by injecting corn flour (Maizena) into the flame of a candle. It is not quite as spectacular, but also far less dangerous.

Liquids

The Submariner



You need

- A plastic bottle
- A plastic pen cap
- Prestik or clay
- Water

How?

Fill a plastic bottle with water. Attach a small piece of Prestik (or clay) to the arm of a plastic pen cap. Place the cap in the bottle so it floats. Then seal the bottle tightly. Squeeze the sides of the bottle.
What happens?

How to involve the audience / learners?

What happens? Why?
By squeezing the bottle, you increase the pressure inside, thus forcing more water up into the pen cap. The added water in the cap increases its weight and causes the cap to sink.
From: Newton's Apple.

Alternative: Instead of a bottle cap you can also use a tomato sauce or vinegar sachet, preferably with some air inside. Use paperclips to add weight if necessary.
When you increase the pressure, the air is compressed, the volume of the sachet decreases and it sinks.

Vanishing Water

You need

- 3 cups
- Sodium polyacrylate - this is found in most disposable nappies
- Water

How?

Place some of the sodium polyacrylate in one of the cups. Place the three cups so that the audience can see them. Then pour a bit of water into the cup containing the sodium polyacrylate. Make a big show of moving the cups around. Then ask the audience which cup contains the water. Hold the cup high and turn it upside down.

What happens?

How to involve the audience / learners?

What happens? Why?

Sodium polyacrylate, the compound that is found in most disposable nappies is a super water absorber. It can absorb 200 - 300 times its weight in tap water and up to 800 times its weight in distilled water. The water is held in it as a gooey gel.

Volcanic Water

You need

- 1 glass
- Sodawater, cooldrink or champagne
- Cooking oil or "Spray & Cook"
- Salt or granulated sugar

How?

Coat the inside of the glass with cooking oil. Pour a small amount of the "fizzy" drink into the glass. It should not fizz at all. Now add a teaspoon of sugar.
What happens?

How to involve the audience / learners?

What happens? Why?

> *"Fizzy drinks are liquids which are supersaturated with gas. Although thermodynamics favours the gas bubbling out of the dissolved state, bubble formation is unlikely since bubbles must start small. The pressure of these tiny bubbles can reach about 30 atmospheres in a bubble only 0.1 micrometres in diameter."* (New Scientist, online)

When pouring a fizzy drink into a glass with an absolutely smooth surface there will be little or no effervescence. This happens if you pour beer or champagne into a wet glass, rather than a dry one. In a dry glass dust particles, surface irregularities and scratches are nucleation sites, which are hydrophobic. They allow gas pockets to grow without first forming tiny bubbles. The addition of the sugar adds a few million centres of nucleation to the drink and it will foam over.

Dancing Raisins

You need

- A glass or bottle
- Carbonated water
- Raisins

How?
Fill a glass or bottle half full with carbonated water. Drop three to four raisins into the water. Wait.

What happens?

How to involve the audience / learners?

What happens? Why?
Carbonated water contains dissolved carbon dioxide gas that collects on the irregular surfaces on the raisins. Once enough gas has collected, it will actually lift the raisins to the surface where the gas is released into the air, causing the raisins to sink once again.

From: Newton's Apple.

Dancing Mothballs

You need

- A glass or bottle
- Water
- Baking soda
- Vinegar
- Mothballs

How?

Fill a glass or bottle half full with water. Add about a tablespoonful of baking soda and a tablespoonful of vinegar. Stir until the baking soda has dissolved.
Drop three to four mothballs into the mixture. Wait.

What happens?

How to involve the audience / learners?

What happens? Why?

Bubbles of carbon dioxide will collect on the mothballs. Once enough carbon dioxide surrounds a mothball, it will rise to the surface where the gas is released into the air, causing the mothball to sink once again.

Alternative: Colour "worm-size" pieces of cooked spaghetti purple with a few drops of red and blue food colouring. Drop these into the into the baking soda and vinegar mixture. The worms will seem to come to life!

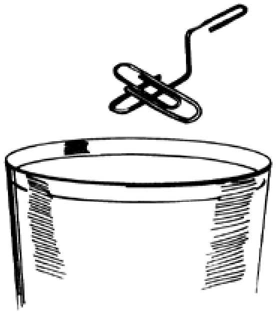
Float a Paperclip

You need

- 2 paperclips
- A glass of water

How?

Bend a paperclip into an "L" shape. Use this clip to gently lay another paperclip on the top of the water in a glass.



What happens?

How to involve the audience / learners?

What happens? Why?

The surface of the water bends around the paperclip like stretched rubber. This is because water has surface tension.

From: Newton’s Apple.

Density Stacker

You need

- Glass container
- Syrup
- Cooking oil
- Water
- Coin, grape and cork

How?

Pour one-third cup of syrup into a glass jar followed by one-third cup of cooking oil. Then pour in one-third cup of water. Drop in a coin, followed by a grape, followed by a small cork.

What happens?

How to involve the audience / learners?

What happens? Why?

The liquids have different densities. The most dense (syrup) will be at the bottom, the least dense (oil) will be at the top, with the water in-between. Each object will sink to the level of the liquid that has a greater density than the object. The object will then float on that layer.

From: Newton's Apple.

Ice Fishing

You need

- Glass of water
- Ice cubes
- Matches (or string)
- Salt

How?

Float the ice cubes in the glass of water. Carefully place 2 matches, head down, or one end of a piece of string on the ice cube.
Sprinkle the contact area with a pinch of salt; wait for about 30 seconds; then gently pick up the matches (string).

What happens?

How to involve the audience / learners?

What happens? Why?

Salt lowers the freezing point of water, so that the cold water absorbed by the matches (string) freezes again. This "glues" the matches to the ice so that you can lift it out of the glass.
A 10% salt solution freezes at -6 ˚C; a 20% salt solution freezes at -16 ˚C.

Try to do it with toothpicks. What happens? Why?

Half-full or Half-empty

You need

- 2 identical glasses with a narrow bottom and a wide top
- Water

How?

Half fill both glasses with water. Most people will say that the glasses are more than half full. Demonstrate that you can pour all the water from one glass into the other glass.

How to involve the audience / learners?

What happens? Why?

From Water to Wine

You need

- 3 glasses
- Water
- Sodium hydroxide solution
- Phenolphthalein solution
- Concentrated acid, such as ________________________

How?

Prepare a glass with slightly alkaline water, by adding a few drops of sodium hydroxide solution. Place a few drops of phenolphthalein solution in another glass; a wine glass works best and then put a few drops of a concentrated acid in a third glass.
Pour the alkaline water into the wine glass. What happens? Why?
Now pour the “wine” into the third glass. What happens? Why?

How to involve the audience / learners?

What happens? Why?

Phenolphthalein is an organic compound that is colourless in acidic and neutral solution, but has an intense red colour in alkaline solution.
When the "wine" is poured into the third glass, the acid neutralises the base, and the phenolphthalein is converted back into its colourless form.

Warning: Don’t drink the “wine”.

Red Cabbage Juice

You need

- 1 red cabbage
- Casserole, water
- Small glasses

How?

Cut the cabbage into slices, put them into a casserole, add enough water to cover the cabbage and boil for 30 minutes. Pour the blue-violet liquid into a container to cool and eat the cabbage. ;-)
Pour some of the blue-violet liquid into two small clear containers; then add vinegar or lemon juice to one and a baking soda solution to the other.
What happens? Why?

How to involve the audience / learners?

What happens? Why?

Instructions for making your own red cabbage pH papers can be found online at the "***Fun Science Gallery***" at:
www.funsci.com/fun3_en/acids/acids.htm

More Indicator Stuff

- **Mood lipstick**
  Get some "mood lipstick", apply it to some strips of absorbent paper and soak the paper strips in different solutions such as vinegar and a baking soda solution. The acid-base indicators in the lipstick change colour according to the pH of their base.

- **Bleeding Paper**
  Prepare some special golden paper (coffee filters should work well) by soaking it in a solution of 100 ml rubbing alcohol and 5 ml turmeric powder. Dilute 5 ml of baking soda in 15ml of water and use it as ink. What happens? Why?
  You can also write on the paper with a candle and then rub ammonia water across its surface. What happens? Why?

- **Disappearing and invisible inks**
  - Write a message in colourless phenolthalein, then spray the paper with a dilute NaOH solution and the letters appear in pink.
  - Write a message with a Q-tip in citrus juice on a sheet of white paper. Heat the paper with an iron or a light bulb.

- **"Voice activated" chemical reaction**
  This is from on: General Chemistry Online! What are some novel ways to use indicators (besides titrations)? By Fred Senese:
  > *"Making a "voice activated" chemical reaction. (a solution of phenol red in very slightly alkaline water will turn from red to yellow, if you talk to it for a while :)*
  > *Carbon dioxide from your breath neutralizes the solution and causes the colour change.*
  > *The recipe can be found in L. R. Summerlin and J. L. Ealy's Chemical Demonstrations, v. 1, p. 40 (ACS Press, 1985)."*

- **From water to juice to coke?** Find out how to do this.

Racing Jars

You need

- 2 empty jars of the same size, with tight fitting lids
- Water
- A ramp ie. a large empty file

How?

Fill one jar with water, then close both jars. Place the jars on their sides at the top of the ramp. Release them at the same time, and watch them go! Let them roll off the ramp and across the tabletop. Which jar wins the race?

How to involve the audience / learners?

Why?

The water-filled jar gets to the bottom of the ramp first, but things start to change when the jars reach the tabletop. The water in the jar rubs against the jar walls, slowing it down. The air-filled jar doesn't experience this friction and zooms ahead.

The Bad Egg

You need

- Glass containers
- 2 eggs
- Water
- Salt

How?

What happens? Why?

In a slightly saline solution (10 ml salt dissolved in ± 300 ml water), a fresh egg (up to three days old) will stay at the bottom of the water, a might-be-bad egg will float just below the surface or the water and the rotten egg will float on the surface. If you add more salt to the water, the good egg will start to float.

More Egg Stuff

- Raw and boiled eggs behave quite differently.
  Spin a raw and a boiled egg. How do they behave?
  Why?
- Let a raw and a boiled egg role down a slope. Which egg will reach the bottom first?
- Rising egg: place a boiled egg in a tall glass filled with water. Place the glass under a running tap. What happens? Why?
- Place a raw egg in a glass or cup, then pour in enough vinegar to cover the entire egg. Leave the egg in the vinegar overnight. Carefully remove the egg from the cup the next day and rinse it off. What does the egg look and feel like? Why?

More Activities with Liquids

- Hot & cold liquids - do they mix?
- Ask members of the audience to predict if the water poured into a funnel will rotate clockwise or anti-clockwise. This relates to the old bathwater problem.
- Melting ice:
  Place a few ice cubes into a glass with water. The water level rises. Will the water level rise, drop or stay the same once all the ice has melted? Why?
- Pour some hot water, dyed with food colouring, in a glass. Fill the glass with ice cold water. What will happen? Why?
- Liquids changing colour - see "Water to Wine" on page 18.
- Pour blue "Energade" into a yellow plastic glass. What did you see? Why?
- Red cabbage indicator: page24.

Surface Tension

The Match Speedboat

You need:

- Matches
- Dishwashing liquid
- A bowl with water

How?

Split the end of a match with a sharp knife. Put a drop of dishwashing liquid in the split and carefully place the match in the bowl of water.

How to involve the audience / learners?

What happens? Why?

The match will move forwards rapidly once it is placed into the water because the dishwashing liquid breaks the surface tension of the water.

More Surface Tension Stuff

- **Sticky water**
  Fill two glasses under water, put them together and place them on the table with one glass upside down exactly on top of the other. Slip a small coin between the glasses without spilling any water.

- **Wet or dry? Middle or edge?**
  Float small pieces of dry and wet cork on the surface of an egg cup filled to the brim with water. What happens? Why?

- **Pepper-moving soap**
  Sprinkle pepper on the surface of water in a shallow soup plate. Carefully place a drop or two of liquid soap in the water. What happens? Why?

- **Perfect circles**
  Drop blobs of ink or food colouring onto the surface of some cooking oil. What happens? Why?

The last two demonstrations can be shown very effectively to a large group by using glass containers on the overhead projector.

Liquid Nitrogen

Introduction

Nitrogen makes up about 78% of our atmosphere. It is a colourless, odourless gas that liquefies at -195˚C. Liquid nitrogen is readily available commercially and is often used in science laboratories. Doctors use it to freeze warts and minor skin abnormalities.

Demonstrations with liquid nitrogen are always great fun because the dense vapours that surround the rapidly boiling liquid create a fascinating atmosphere.

IF you adhere to the safety precautions the following experiments will pose no danger to the audience and everybody will enjoy them.

Banana Hammer

You need

- 1 banana
- A metal container, large bucket or stainless steel bowl
- Liquid nitrogen, ± 250 ml
- Wooden plank plus nail

How?

Pour the liquid nitrogen into the container and carefully add the banana. Carefully remove the banana with gloved hand once it is frozen and use it to knock the nail into the plank.

Soap Explosion

You need

- Hot soap solution, approximately 1 litre
- A metal container, large bucket or stainless steel bowl
- Liquid nitrogen, ± 250 ml

How?

Pour the liquid nitrogen into the container containing the soap solution, stand back and enjoy. (If the container doesn't overflow over with a cascade of soap bubbles, stir the mixture with a wooden spoon.)

What happens?

What happens? Why?

The liquid nitrogen is much colder than the water; it evaporates, producing gaseous nitrogen which forms huge, expanding bubbles in the soapy water.

How to involve the audience / learners?

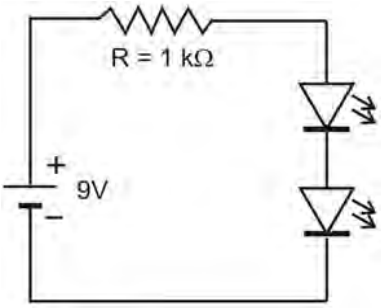
Chameleon LED

You need

- 2 green LEDs (light-emitting diodes) with clear lenses
- 1 resistor of ± 1 kΩ
- 9 V battery
- Cables with crocodile clips
- Glass beaker filled with liquid nitrogen

How?

Connect the LEDs and the resistor to the battery as shown in the circuit diagram. Make sure that you connect the LED correctly. The flat side on LED (or the shorter lead) corresponds to line on diagram (this is the negative terminal called the cathode).



Now carefully put one of the LEDs into the liquid nitrogen in the beaker.
What happens?

What happens? Why?

The colour of the LEDs (light-emitting diodes) changes from green to a bright yellow because of changes in the band gap. (Is this true?)

Instant Ice Cream

You need

- Safety goggles
- A pair of gloves (not plastic - you gardening gloves or oven mittens will do)
- Stainless steel bowl
- Wooden spoon
- Ingredients for the ice cream
  - 1 tin (400 g) sweetened condensed milk
  - 1 tin (410 g) evaporated milk - cold
  - 250 ml cream, also cold
  - 5 ml vanilla essence
  - approx. 2 l liquid nitrogen

Method

Photo: Helga Nordhoff

Beat the evaporated milk until thick and creamy.
Add the sweetened condensed milk and vanilla essence to the evaporated milk.
Beat the cream until thick and creamy.
Fold cream into mixture and place mixture into a large metal container.
Put on your gloves and slowly and gradually add the nitrogen and stir well until mixture is frozen.

How to involve the audience / learners?

Strawberry Ice Cream

You need

- 400-500 g strawberries or 6 ripe kiwis or 3 ripe bananas or any other suitable fruit
- 2 tablespoons (30 ml) sugar
- 1 cup (250 ml) sugar
- 2 large eggs
- 2 cups (500 ml) cream

Method

- Wash the strawberries, remove the stems, slice and mash.
- Add the 2 tablespoons of sugar to the puree and cool for ± 1 hour.
- Beat the eggs until thick and creamy (1-2 minutes). Continue beating while gradually adding the 500 ml of sugar. Beat for another minute.
- Add the cream and mix well.
- Add the strawberry puree, mix well; then pour mixture into a large metal container.
- Put on your gloves and slowly and gradually add the nitrogen and stir well until mixture is frozen.

Remark

You can also use your favourite ice cream recipe for this demonstration. The two recipes above can of course be used in a home ice cream maker.

More “Freezing activities”

Photo: Helga Nordhoff

- Make funny ice patterns by squirting water into a basin filled with liquid nitrogen.
- Freeze a flower (carnations and roses are best) in liquid nitrogen and see how they shatter if tapped with a stick.
- Pour a little bit of “the cold stuff” into a plastic film container, snap the lid on and ... (Don’t try this with large containers or containers with screw-on lids.)
- Place an inflated balloon into some liquid nitrogen and watch it deflate. Take it out and watch how it inflates again as it warms up.
- Freeze a lead bell and listen to the new ringing tone.
- Bounce a soft hollow ball, i.e. tennis ball in front of the audience. Now freeze the ball and then try to bounce it again. The shattering of the ball will be accompanied by a loud bang.
- Freeze a raw egg in its shell. Once it’s frozen, smash it with a hammer. The egg will appear to be cooked. As it thaws it will return to its raw state.
- Pour liquid nitrogen into a “whistling kettle” and it will boil and whistle away at room temperature.
- Wind a long piece of thin (thinnest you can get <0.1 mm) enamelled copper wire around the end of a wooden stick, so that wire has significant resistance. Use some glue to keep the ends of the wire in place. Connect in series with a light bulb and battery. When placed in LN2, resistance of wire decreases and lightbulb brightens up.

Take a Guess

Volumes

You need

- 2 A4 sheets of clear plastic - overhead transparencies are perfect
- Sellotape
- Dried beans or maize
- A large shallow glass bowl

How?

Show the audience that the 2 sheets are exactly the same size. Use the tape to make two cylinders; one by taping together the short edges of the one sheet the other by taping together the long edges of the second sheet. Place the cylinders into each other in the bowl. Fill the tall narrow cylinder with beans. Carefully remove the cylinder.
What happens?

How to involve the audience / learners?

What happens? Why?

The beans that completely filled the tall cylinder, don't fill the wider cylinder, although the surface areas of the two cylinders are the same. Cylinders with the same surface area don't have the same volume.
The area of the base of a cylinder = πr^2. The volume of a cylinder = $\pi r^2 h$.
The volume will increase/decrease more rapidly with a radius change (r^2) than with a height change.

Circumference vs. Height

You need

- A tall narrow glass
- A piece of string

How?

Ask the audience which is longer, the height of the glass or its circumference? What happens?

How to involve the audience / learners?

What happens? Why?

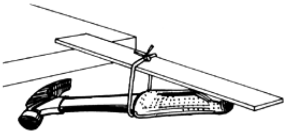
Centre of Mass

Balance the Hammer

You need

- 1 hammer
- 1 ruler
- a piece of string

How?



Tie a string in a loop and slip it over a ruler. The other end should twist into a loop and slide over the handle of a hammer resting at the end of its rubber grip. Place the ruler's edge with the hammer head underneath on the edge of a table. The hammer handle should rest against the other end of the ruler.

What happens?

How to involve the audience / learners?

What happens? Why?

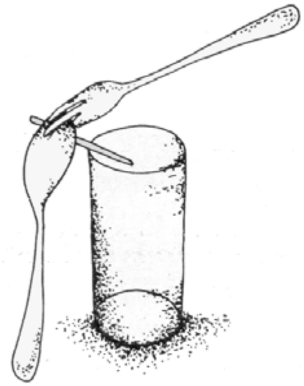
All objects have a centre of gravity that acts as if all the weight of the object were balanced there. The centre of gravity of the ruler is in the middle, but the hammer moves the centre of gravity of the system to under the table's edge which keeps it from falling.

From: Newton's Apple.

Balancing Fork and Spoon

You need

- 1 Glass
- Dessert spoon
- Table fork
- Toothpick



Challenge

Balance the dessert spoon and table fork on the rim of the glass with the aid of the toothpick.

How?

Arrange dessert spoon, table fork and toothpick as shown in the figure on the right.

How to involve the audience / learners?

What happens? Why?

It's the centre of gravity again! Where would you say is the centre of gravity in the above set-up?

From: Newton's Apple.

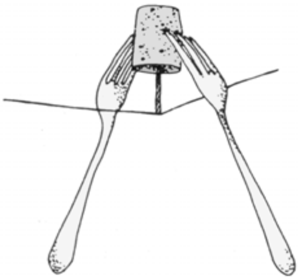
Balancing Forks

You need

- A taut piece of string
- 2 table forks
- A cork
- Matchstick

Challenge

Balance the cork, forks and matchstick on a taut piece of string.



How?

Insert the matchstick into the base of the cork. Then insert the two forks in opposite sides of the cork Balance the contraption on the string as shown in the figure on the right.

How to involve the audience / learners?

What happens? Why?

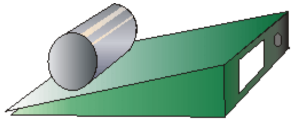
It’s the centre of gravity again! Where would you say is the centre of gravity in the above set-up?

From: Newton’s Apple.

Rolling Uphill

You need

- A ramp or a thick, empty file
- 1 large coffee tin with lid
- Weight or magnet



How?

Glue the weight (or attach the magnet) to the inside of the tin. Place the tin on the low side of your ramp with the weight situated just past the centre of the tin on the uphill side.

How to involve the audience / learners?

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What happens? Why?

Balancing Nails

You need

- 1 wooden plank
- 11 large nails
- A hammer - optional

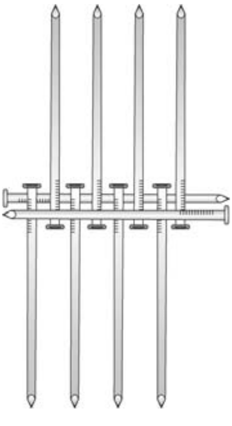
Challenge

Hit one nail into the wooden plank. Can you balance the remaining 10 nails on the head of the one nail in the plank.

How to involve the audience / learners?

How?

Place one nail on the table. Now arrange eight nails on top of the nails as shown in the figure. Finally place the last nail on top. Carefully pick up the nails by the left and right end pieces and balance them on the one nail in the plank.

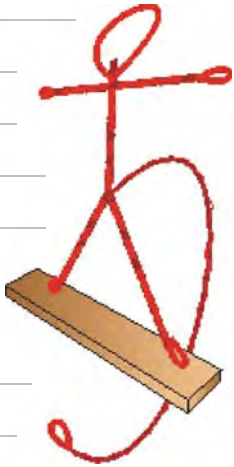


More ‘Centre of Mass’ activities

- **Money left lying around**
  Pick up a R20 note while standing with your heels against the wall. The feet must stay on the ground and knees may not be bent.

- **Balancing wire figure**
  Construct a figure with a long tail from a long piece of wire. Try to balance the figure on the edge of a table.

- **Balancing “M”**
  Cut out a large M from cardboard, put paperclips on each of the two “legs” of the M and try to balance it on the top of a pencil.



Forces

Supporting Eggs

You need

- 4 eggs
- Sellotape
- Books

How?

Carefully break off the small end of four eggs and pour out the insides. Wind a piece of Sellotape around the centre of each eggshell. Cut through the centre of the tape to make four dome-shaped shells (discard the broken end of each shell). Lay the four domes on a table with the cut sides down arranged in the shape of a rectangle. Next, guess how many telephone books you can lay on top of the shells before they break. Try it!
What happens?

How to involve the audience / learners?

What happens? Why?

Arches--even those made of eggshells--are strong because they exert horizontal as well as vertical forces to resist the pressure of heavy loads. The crown of an eggshell can support heavy books because the weight is distributed evenly along the structure of the egg.

From

Newton's Apple: www.ktca.org/newtons/tryits/index.html

Strong Rice

You need

- Uncooked rice
- Tall jar or goldfish bowl
- Large knife

How?

Fill the glass with rice. Push the knife into the rice a few times until the resistance is very high. Then push the knife down in the centre as far as it will go. Carefully lift the knife. What happens?

How to involve the audience / learners?

What happens? Why?

The rice becomes packed very tightly by the knife's pumping movements. The grains of rice push against the sides of the container as well as against the sides of the knife, thus wedging the knife into the rice.

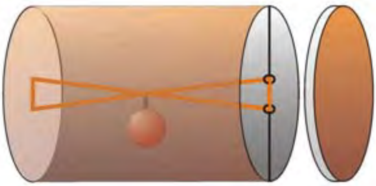
From: Newton's Apple.

Obedient Tin

You need

- 1 large coffee tin with lid
- Thick elastic band
- Weight
- Paper to cover tin

How?



Thread the weight through the elastic band and secure one end of the band to the bottom of the tin and the other end to the lid of the tin. Roll the tin along the floor or table top. What happens?

How to involve the audience / learners?

What happens? Why?

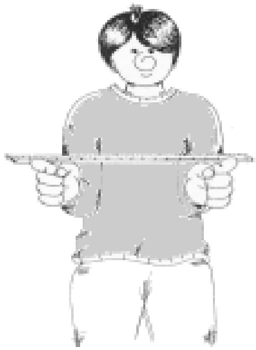
The tin will roll in the direction it was pushed, stop and then come back to you. Why?

The rolling tin stores energy in the elastic, because the weight always hangs down as the tin rolls in one direction.

Friction

Static and Kinetic Friction

You need
A ruler, metre stick, or any other long object.



How?
Balance it horizontally on top of your left and right index fingers (see figure). Then start moving the fingers towards each other. Without any control by the instructor, the fingers will only slide against the ruler one at a time and the two fingers will meet under the centre of mass.

How to involve the audience / learners?

What happens? Why?
When one finger moves, an increasing part of the weight will be supported by that finger as it gets closer to the centre of mass, so friction increases and the other finger will start moving until it stops and so the process repeats itself..

From
Ed and Rosea van den Berg. Fifty plus 'Two Minute' Demonstrations for Large Classes

Falling Cup

You need

- 1 porcelain cup with a handle
- A short broomstick or thick pen
- Piece of string, a bit longer than the distance between your hands if your arms are stretched out sideways.
- Weight such as a bunch of keys

How?

Tie the cup to one end of the string and the bunch of keys to the other end. Hold the keys in one hand, the stick in the other hand with the string running over the stick and the cup dangling from the string close to the stick. What will happen when you let go of the keys? Will the cup shatter on the floor?

How to involve the audience / learners?

What happens? Why?

What! No glue!

You need

- 2 books, preferably paperbacks - telephone directories work well too.

How?

Place the two books next to each other with their open sides facing each other. Using both hands, simultaneously fan the sheets of each book, allowing them to interlock (this is like shuffling cards). Push the books a bit closer together. Now invite two members of the audience to pull them apart.

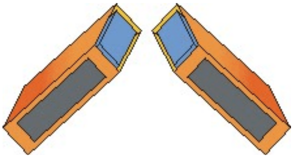
How to involve the audience / learners?

What happens? Why?

This is a great demonstration of the force of friction. It was easy to push the two books together, but it is impossible to pull the two books apart! Why? While the books are being pushed together, the pages separate a little and the reduced contact area results in little friction. But the magnitude of the friction increases with an increase in the area of the surfaces in contact.

Magnetism

Magnet Tricks



- **Balancing matchboxes**
  Put a magnet into each of two matchboxes and balance them as shown in the figure.

- **Magnet cut-off**
  Tie a paperclip to a piece of thread ± 20 cm long. Stick one end of the thread to the table top. Hold a magnet above the paperclip so that the thread is stretched taught with a gap between the paperclip and the magnet. “Cut” the air between the magnet and paperclip. What happens? Why?

- **Game**
  Place nine nails on their heads in three rows of three nails, about 1 cm apart. Try to remove one nail at a time using a horseshoe magnet, without disturbing any of the other nails. If another nail falls or moves, it is the next person’s turn.

- **And the winner is ...**
  Drop 2 identical magnets through a copper and a plastic pipe. Which one falls out first? Why?

Magnetic Demonstrations

Magnetic phenomena can easily be shown to a large audience using the overhead projector.

- **Magnetic fields**
  Patterns formed by iron filings around different types of magnets. Remember to place a clear transparence between the magnet and the iron filings.

- **Bearded Man**
  Place a few pinches of iron filings on a picture. Slide a horseshoe or bar magnet underneath the picture to arrange the filings into hair, eyebrows, moustache or beard. The iron filings will stand or move.

- **Magnetic racing**
  Trace a race track on a piece of cardboard. Construct 2 racing cars from paper and paperclips. Get two people to race against each other, using a magnet each on the underside of the cardboard track as motor for the cars.

Sound

Listen to Vibrations

You need

- A spoon
- String
- Rubber band

How?

Use a rubber band to secure a metal spoon to the midpoint of a 60 cm piece of string. Wrap the ends of the string around your index fingers. Put your index fingers in your ears. Rock your body so that the spoon taps against the side of a table. What do you hear?

How to involve the audience / learners?

What happens? Why?

When the metal spoon taps against the table, it sends a vibration up the string, through your fingers, and into your ears. Your eardrums pick up the vibrations and send them to your brain where they are translated into sound.

From: Newton's Apple.

Braying Straws

You need

- Plastic drinking straws
- Scissors

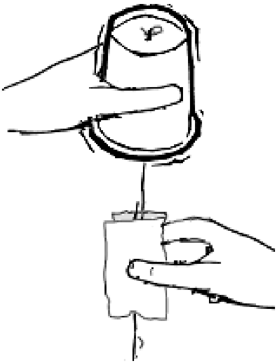
How?

Flatten one end of the straw between your thumb and index finger. Cut the end into a V-shape. Blow through this end of the straw. Different lengths will produce different tones.

How to involve the audience / learners?

What happens? Why?

Singing Cups



You need

- Styrofoam cups
- String
- Paper cloth

How?

Thread a piece of string through the bottom of the Styrofoam cup. Cut the cloth into small squares and wet them slightly with water. Hold the cup upside down in one hand, fold the cloth around the string hanging from the cup and while squeezing the cloth between thumb and forefinger gently pull the cloth downward.

How to involve the audience / learners?

What happens? Why?

Whispering Umbrellas

You need

- 2 large dome-shaped umbrellas
- A sound source

How?

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How to involve the audience / learners?

What happens? Why?

More Sound Stuff

- Blow over a bottle.
- Swing swimming pool pipes.
- Make patters on a metal plate covered with salt using a violin bow.
- Play music with a long needle fixed to a paper cup that rests lightly on a spinning record - use an old record.

Light

Reflections

You need

- A mirror ± A4 size

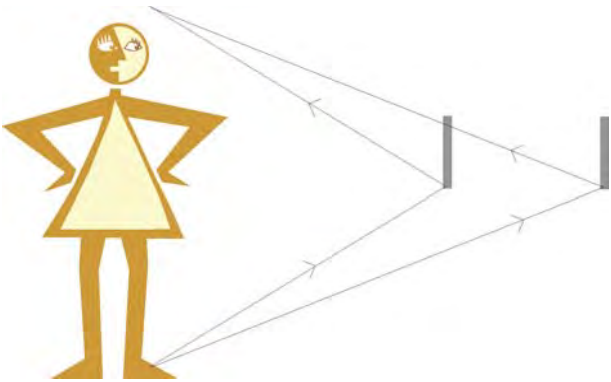
The Challenge

Hold the mirror, vertically, at chest height. Get somebody to stand in front of the mirror. Can they see their feet? What must they do to see their feet?

How to involve the audience / learners?

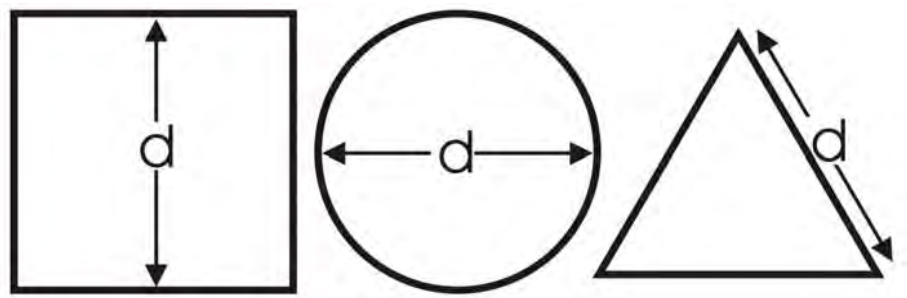
Why?

Most people will say that the person should move further away from the mirror.



Shadows or "From 3D to 2D"

What would an object look like that would fit perfectly through the following three holes in a piece of cardboard?



How?

Try to image an object that would cast three different shadows; a square shadow if the light rays are projected along the x-axis, a triangular shadow if the light rays are projected along they-axis and a round shadow if the light rays are projected along the z-axis.

What does your shadow look like in these three projections?

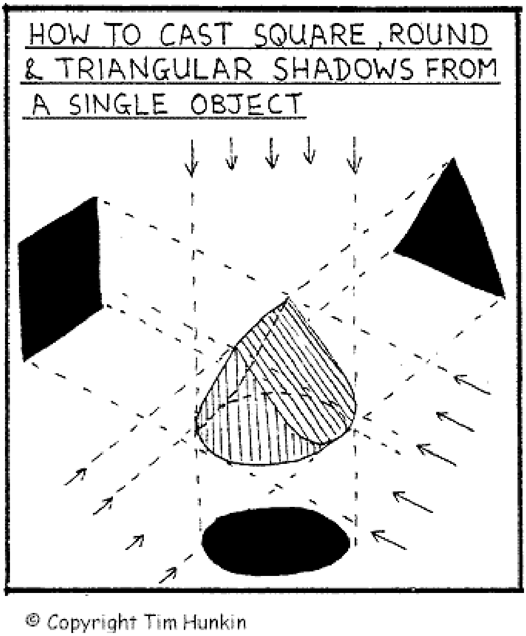
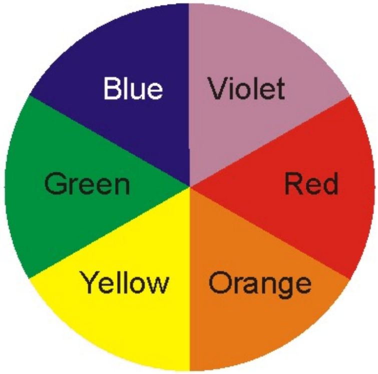


Illustration:© Tim Hunkin. Permission to use has been requested.

Changing Colours

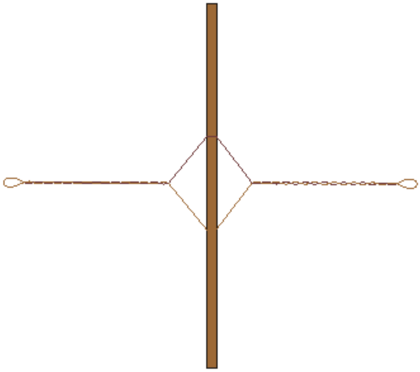
You need

- A piece of sturdy cardboard
- Paint
- String



How?

Cut a circle from the cardboard, divide it into 6 equal segments and paint the segments as shown in the figure.
Make two holes in the card and tread the piece of string through the holes.
Turn the circle until the tread is twisted as shown in the figure below. Gently pull the thread to make the card spin.
What happens?



What happens? Why?

The colours will merge to produce white because daylight is a combination of the colours Red, Orange, Yellow, Green, Blue and Violet.

How to involve the audience / learners?

Mason’s Disk

Copy the disk below and stick it on a piece of thick cardboard. Make two holes in the card, tread the piece of string through the holes and spin it as described for the “Changing Colour” wheel on the previous page.

What happens? Why?

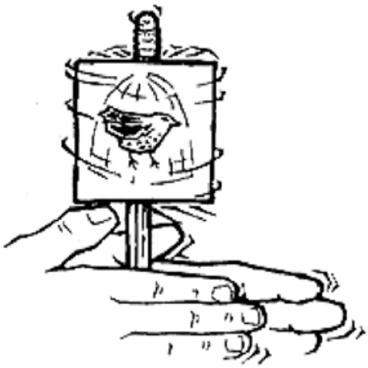
Various colours appear and nobody has been able to explain why.

Catch a Bird

You need

- 2 index cards
- 1 pencil or pen

How?



Draw a picture of your favourite bird on a small index card. On another card the same size, draw a cage. Now tape the two cards, drawing sides out, on opposite sides of a pen or pencil. Spin the pen between your hands or fingers. Is your bird still free or did you catch it and put it in the cage?

How to involve the audience / learners?

Why does the bird appear to be in the cage?
It appears to be caged because of how your eyes and brain work. When you see the image of the bird, your brain holds onto the image for a short time--even though the image appears and disappears quickly. The same thing happens with the image of the cage. The two images actually overlap in your brain so the bird appears to be in the cage.

From: Newton's Apple.

Tom, Dick & Harry

You need

- Piece of cardboard
- Different colours of felt pens
- Clear glass bottle with screw top

How?

Fill the bottle with water so that no air bubbles remain and screw on the top. In different colours print on the cardboard:

TOM

DICK

HARRY

In this case TOM is blue, DICK black and HARRY green. Read each word through the bottle - the bottle should be about 10 -20 cm from the board. What happens?

How to involve the audience / learners?

What happens? Why?

The water-filled bottle acts like a lens and turns the words upside down. DICK is symmetrical around the x-axis and looks the same when it is inverted.

Other words to use are: BED vs. WORK, CHOICE vs. QUALITY.

This activity can expose quite a few misconceptions about light and colour, such as black text behaves differently to coloured text because it absorbs all the light.

Optical Illusions

Overview

The eyes feed the brain with information. This information is in the form of of electrical impulses which represent objects we see.
We can compare the process with the written language: the letters and words on a page are not pictures, but they have certain meanings, to those who know the language.

The brain is continually interpreting the information, looking for known objects. Sometimes a few lines are all that is needed to “see” a figure.

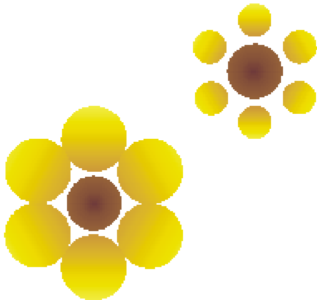
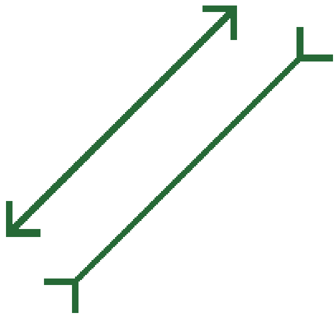
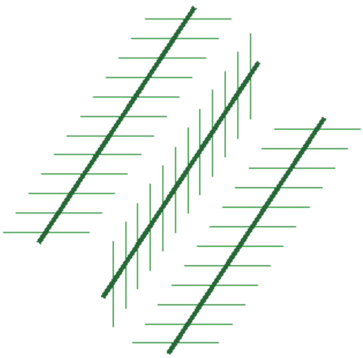
What do you see in the figure on the right?

Just a few lines?

or ...

a woman washing the floor?

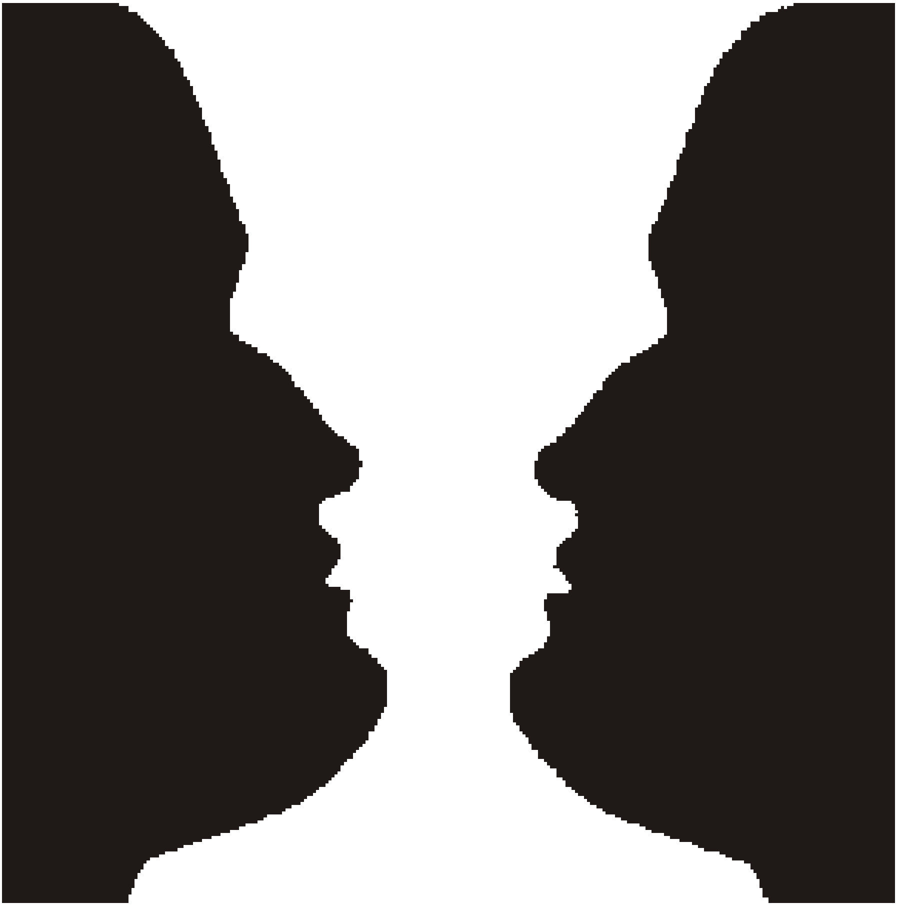
Big or Small, Long or Short, Straight or Skew?

Which flower has the bigger centre? The one with the small petals or the one with the larger petals?	
Which line is longer?	
Are the three green lines parallel, converging or diverging? Use a ruler to check your answers.	

Face or Vase?

The figure below is well known and can be seen as two (black) faces or as a white vase.

What do you see?



Why?

Figures which alternate between 'object' and 'background' give rise to different perceptions.

What do you see?

How?

Concentrate on the 4 dots in the middle of the picture below for 30 seconds. Then close your eyes and tilt back your head. Keep your eyes closed. You will see a circle of light; continue looking at the circle.
What do you see?

Figure from: Grand Illusions: Fun & Games. www.grand-illusions.com/

How to involve the audience / learners?

Coloured Words

Look at the text below; then say the colour of the word, not the word itself.

Blue Yellow Green
Green Red Black
Yellow Blue Purple
Red Purple Blue
Purple Black Pink
Orange Blue Red

How to involve the audience / learners?

Why are you finding it difficult to do?
The left half of your brain is reading the word, while the right half of your brain is trying to say the colour.
Note: this works best if the words are written in the home language of the audience.

Touch

Slimy Creatures

You need

- 2 minute noodles
- Opaque box

How?

Prepare the noodles according to the instructions on the packet - it is not necessary to add the flavouring. Drain and allow to cool. Place them into an opaque container so that they can be handled without being seen. Ask a volunteer from the audience to put his/her hand into the box and describe what he/she is feeling. Repeat with other slimy, prickly of yucky stuff.

How to involve the audience / learners?

What happens? Why?

A Touching Experience

- Pairs face each other and place their opposite hands together.
- Taking turns, each person rubs the fingers of the hands that are placed together with his/her thumb and index or middle finger.

Result: a sensation that part of the hand is asleep.

How to involve the audience / learners?

What happens? Why?

Taste

Tasteless Jelly Beans

You need

- Jelly beans

How?

Circulate the bowl with jelly beans amongst the audience and ask them to choose a few jelly beans of their favourite flavour. Before they place the jellybeans into their mouths, they must close their noses between thumb and forefinger.

How to involve the audience / learners?

What happens? Why?

As the members of the audience start to chew the jelly beans they will notice that they do not taste the flavour of the jelly bean. When they let go of their noses, they should experience a sudden rush of flavour. Often what we assume to be 'taste' actually is related to our sense of smell.

Coke or Sodawater?

You need

- 3 glasses
- Coke, Sprite or Fanta & Sodawater
- Blindfold

How?

Pour a small amount of each of the three cooldrinks into the three glasses. Blindfold a volunteer from the audience and ask him/her to taste the three cooldrinks while pinching his/her nose closed. Will he/she be able to tell which is the coke?

How to involve the audience / learners?

What happens? Why?

Paper Stuff

A Circle for 3 People

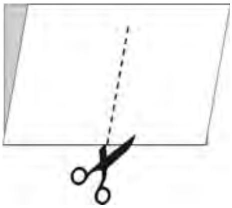
You need

- A sheet of A4 paper
- Scissors

The Challenge

Cut the A4 sheet of paper so that it forms a ‘ring’ large enough to surround three people.

How?



Fold the paper in half (A5) and cut it in the middle from the fold to within 1 cm of the edge. Now fold the paper along the cut and cut narrow strips alternately from left and right. Practise before you do it with an audience.

How to involve the audience / learners?

Taking Both Sides

You need

- Newspaper
- Pen or pencil
- Scissors

How?

Cut a 5-cm strip lengthwise from an old newspaper. Holding the strip out straight, give it a half twist (180˚) and attach the two ends together. Take a pen and carefully draw a line along the centre of the strip. Where do you end up? Is the line drawn on the inside or outside of the paper? Now cut the strip along the line you drew. How many chains do you get?

What happens? Why?

Your chain is called a Möbius strip, which is a shape described by a branch of mathematics called topology. When you twisted your strip, the inside and outside became one continuous surface. And when you cut the strip, it became one longer chain but still had only one continuous surface. (Try the experiment again and give the paper a full twist. You'll be surprised by the results.)

How to involve the audience / learners?

From: Newton's Apple.

Folding Paper

You need

- 1 A4 sheet of paper
- 1 large sheet of newspaper

Challenge

Can you fold an A4 sheet of paper to the size of a stamp? How many times **can** you fold a A4 sheet of paper? If you take a larger sheet, can you fold it more often?

How to involve the audience / learners?

What happens? Why?

After folding the paper once, there are two layers; after the second fold, there are 4 layers; after the third fold there are 8 layers and after the fourth fold there are 16 layers. This is an example of exponential growth. It is impossible to fold a sheet of paper more than 7 or 8 times. After 8 folds there are $2^8 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 256$ layers of paper. Even if the paper is extremely thin, it becomes impossible to fold.

Supporting Paper

You need

- 4 A4 sheets of paper
- Sellotape
- Wooden plank
- Books or any other heavy object

How?

Roll the paper into thin columns to form the 4 legs of your table. Place the wooden plank on top of the legs. Now test how many telephone books you can place on your table. Will it carry you? Try it!

What happens?

How to involve the audience / learners?

What happens? Why?

More Paper Stuff

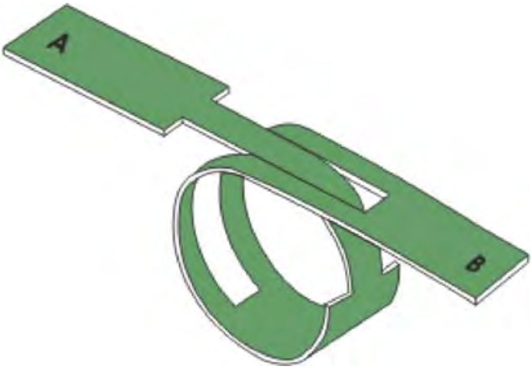
- Parting Paper
- Toilet paper experiments
  - Does the toilet paper roll towards or away from you when tugged?
  - The toilet paper time line. Use a roll of toilet paper to illustrate the history of mathematics, science or any other topic you fancy.

Topological Problems

The Looped Band

Cut a band, shaped as in the drawing on the left, out of a sheet of paper or other flexible material.

Tape the end A to a table top or any large object. Manipulate the strip into the configuration shown below without removing end A from the table / object.



Problem from:
Gardner, Martin. 1972. Mathematical Games. Scientific American, volume 226, no. 4, p. 100.

Magic R10 note

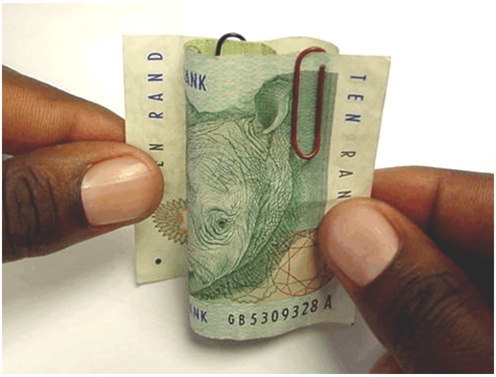
You need

- 2 paperclips
- 1 R10 note - other dominations will work too

How?

Fold the note twice, as shown in the photo; then clip the centre fold to the back fold with one paperclip and the front fold to the centre fold with the second paperclip. Push the paperclips down.

Now take hold of the two end of the note and pull them apart.



What happens? Why?

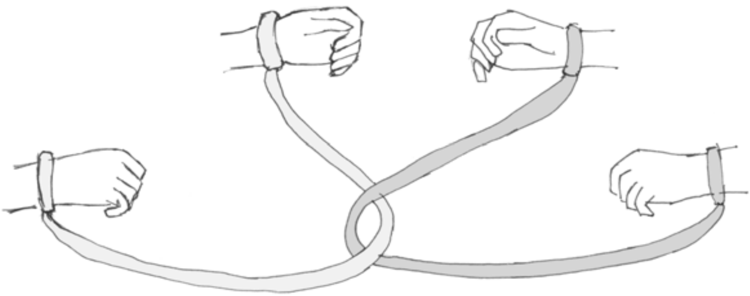
The Wrist Twist

You need

- 2 fairly long pieces of string with loose loops at both ends.

How?

Interlink the two pieces of string as shown in the picture below and place them around the wrists of two people. Can they separate themselves from one another?



How to involve the audience / learners?

Scissors and String

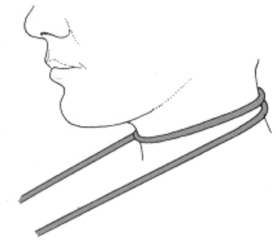
You need

- A pair of scissors
- Cord

How?

Thread the cord through the scissors as shown in the illustration on the right. If the ends of the cord are tied to a chair, can the scissors be released without cutting the cord?

The Loose Noose

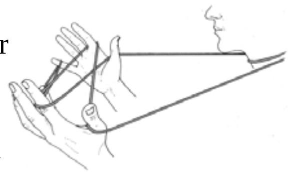


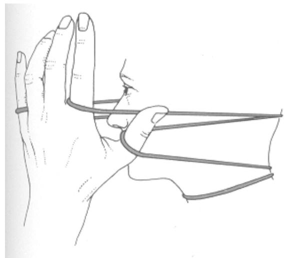
You need

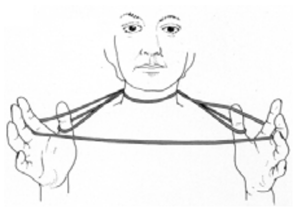
- About 4 m of string, ends tied

How?

Loop the cord around your neck and let it hang in front of you. Loop the right side of the string around your neck once.
Loop each side of the string across the palm of your three middle fingers. Now pick up cord across your left palm with your right index finger and vice versa. Pull your hands apart and put your head through the loop made by your index fingers. Carefully remove your hands.
If you pull the loop hanging in front of you now, the string should fall free of your neck.







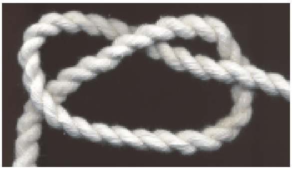
Tie a Knot

You need

- Piece of string

How?

Can you take hold of the two ends of a piece of a string and, without letting go of either end, tie a knot in the middle of the string?



More String Stuff

- **Slack string**
  Tie a heavy book to the middle of a long thin rope. Ask a "strong" friend to help you to pull the string straight. What happens? Why?

- **Two strings**
  Tie fairly thick string to your thick book again and let the book hang from it. Tie a thin string or thread to the bottom of the book. Which string will break first if
  - the thin string is pulled steadily downward?
  - the thin string is given a quick downward jerk?

  What happens? Why?

Mathematical Magic

Proof that 2 = 1

There are a few different ways to proof this; here are two.
Proof 1:

Let	$\mathbf{x = y}$
Multiply both sides by a	$\mathbf{x^2 = xy}$
Add $(x^2 - 2xy)$ to both sides	$\mathbf{x^2 + x^2 - 2xy = xy + x^2 - 2xy}$
Factor the left, and collect like terms on the right	$\mathbf{2(x^2 - xy) = x^2 - xy}$
Divide both sides by $(x^2 - xy)$	$\mathbf{2 = 1}$

Proof 2

Let	$\mathbf{a = b}$
Therefore	$\mathbf{a - b = 0}$
And	$\mathbf{2a - 2b = 0}$
Therefore	$\mathbf{2a - 2b = a - b}$
Factor the left,	$\mathbf{2(a - b) = (a - b)}$
Divide both sides by (a - b)	$\mathbf{2 = 1}$

Why? What is wrong?
In both proofs the erroneous step is dividing both sides by 0, since $(x^2 - xy) = 0$, and $(a - b) = 0$.

Proof that “Women (girls) are evil”

Women cost take up time and money:	**women = time ✘money**
Everyone knows that time is money:	**time = money**
Substitute time with money:	**women = money ✘money**
Something times itself, is something squared:	**women = $money^2$**
But we also know that money is the root of all evil:	**money = $\sqrt{}$(evil)**
If we now substitute, we have:	**women = $\sqrt{}(evil)^2$**

Since the root of something squared is something we have:

women = evil

Warning
Be careful - not all audiences will appreciate this one.

The Orange Kangaroo

How?

1. Ask the audience to think of a number between one and nine, but not say it aloud.
2. Then ask them to multiply their number by nine, add the digits and subtract five from the sum.
3. Now let them take the answer and assign it a letter using the following: A=1, B=2, C=3 etc.
4. Name a country which starts with this letter.
5. Now take the last letter of this country and find a land animal that starts with this letter.
6. Finally let them think of a colour starting with the last letter of their animal.
7. And the answer will probably be: “ A **O**range **K**angaroo from **D**enmark”.

How it works

This trick relies on the fact that the digits of a multiple of nine add up to nine. This means that the audience should end up with the figure 4 after step 2. The obvious choice for a country starting with the letter D is “Denmark” and for an animal starting with K “kangaroo”.
This can be used to learn the nine times table in a fun way.

Remark: This works with English as language of communication. It won’t necessarily work if your audience uses another language.

Variation: The Elephant

In step two ask the audience to subtract four from their sum, do the letter allocation as in step 3 and ask for an animal that starts with that letter (E).

Pick-a-number

You need

- The 5 number cards below

How?

Ask the audience to think of any number between 1 and 31.
Choose one person, show him / her each card in turn and ask if the number is on that card.

To find the secret number: add the top left-hand numbers of all the cards on which the secret number appeared.				**1**	**3**	**5**	**7**
				9	**11**	**13**	**15**
				17	**19**	**21**	**23**
				25	**27**	**29**	**31**
2	**3**	**6**	**7**	**4**	**5**	**6**	**7**
10	**11**	**14**	**15**	**12**	**13**	**14**	**15**
18	**19**	**22**	**23**	**20**	**21**	**22**	**23**
26	**27**	**30**	**31**	**28**	**29**	**30**	**31**
8	**9**	**10**	**11**	**16**	**17**	**18**	**19**
12	**13**	**14**	**15**	**20**	**21**	**22**	**23**
24	**25**	**26**	**27**	**24**	**25**	**26**	**27**
28	**29**	**30**	**31**	**28**	**29**	**30**	**31**

How it works

The numbers in the top left corner of each card are all powers of 2, i.e. 1, 2, 4, 8 and 16. Any number from 1 to 31 can be obtained by adding these five numbers. Can you see a pattern in these cards?

A Magic Square

You need

- A large version of the square below.

7	1	9	3
10	4	12	14
13	7	15	9
11	5	13	7

- 4 crayons or transparency pens of different colours, let's say red, green, blue and black.
- The number **33** on a piece of paper in a sealed envelope.

How?

Print this square on a large piece of cardboard or on an overhead transparency. Hand the sealed envelope to a member in the audience. Draw a red line through one row and one column, then a green line through one of the remaining rows and columns, followed by a blue and then black lines.
Now add the numbers in the four squares where the lines of the same colour cross. The total will be? **33!**

How to involve the audience / learners?

How it works

The magic square is constructed by placing 8 numbers outside the grid that add up to 33. The grid is completed by adding the number at the top to the number on the left for each cell.
Choose a different "magic" number if you prefer.

	6	0	8	2
1				
4				
7				
5				

The Power of "9"

9

You need

- Chalk and a chalkboard or an overhead projector with a transparency and a transparency marker.
- Calculator (optional). You may need this if you want somebody in the audience to check the answers.

How?

a. Take any large (5 or 7 or 9 digit) number. Rearrange the digits to get another large number with the same number of digits. Now subtract the smaller number from the larger number. The digital root of the answer will be 9.

b. Write down a large number. Add all the digits of the number and subtract this sum from the large number. The digital root of the answer will be 9.

How to involve the audience / learners?

How it works

The **digital root** of a number is the single digit that remains after adding all the digits of the number. If the sum has more than one digit, add them again, until you are left with one digit only.

All multiples of 9 have a digital root of 9 and all numbers with a digital root of 9 are multiples of 9.

You can do some amazing calculations and mind reading tricks with this knowledge.

Boring Numbers

You need

- A calculator
- 5 cards with the numbers: 3, 7, 11, 13, 37

How?

Ask a volunteer to choose a number between 1 and 9. Shuffle the cards and ask the volunteer to select one card and multiply her secret number by the number on the card. Ask her to choose another card and to multiply the result of the previous multiplication by that number. Do this for all the cards. The final result will be her secret number repeated 6 times on the calculator.

How to involve the audience / learners?

How it works

3, 7, 11, 13, 37 are all prime numbers and their product is 111111. Any number between 1 and 9 multiplied by 111111 will appear six times in the answer window of the calculator.

Variation “How old are you?”

You can do this with any two digit number if you use the four cards with the numbers: 3, 7, 13, 37. The secret number (age) will appear three times in the calculator window, because 3 x 7 x 13 x 37 = 10101.

Plants

Buzz Pollination

You need

- A flower from a *Solanum* species, blueberries, cranberries, chili peppers, eggplants, kiwi fruits or tomatoes
- Tuning fork

How?

How to involve the audience / learners?

How it works

Digger bees and Bumble bees have a special mode of pollination behaviour called "buzz pollination". They turn themselves into living tuning forks in that they vibrate their body in high frequency to shake the pollen loose from flowers. You can imitate this with a real tuning fork.

A Red-and-Blue Rose

You need

- A white rose, white dahlia or white carnation
- Red ink or red food colouring
- Blue ink or blue food colouring

How?

In one container, mix red ink with water and in another container mix blue ink with water. (Dilute approximately 1 part ink with 3 parts water.)
Split the stem of your flower and place one half of the stem in the blue liquid. Let it stand for a few hours.

How to involve the audience / learners?

What happens?

The veins in the rose will be coloured by the inks. After a few hours the rose will be half red and half blue, because the colour will have remained in the petals while the water evaporated.

Red into White Rose

You need

- A red rose
- Glass jar with lid
- Sulphur
- Long-handled soup spoon
- Teaspoon
- String

How?

Tie a piece of string to the rose and lower it into the jar. Place the sulphur into the spoon, light it and put the spoon inside the jar. Put the lid on.

How to involve the audience / learners?

What happens?

The red rose will get paler and, within a few minutes, turn white.

Sulphur dioxide, the gas that is formed if sulphur is burned, has a bleaching effect and destroys the colour in the rose.

Soils

Flocculation

You need:

- Loamy soil
- Water
- Beaker
- Baking soda (Sodium carbonate: Na_2CO_3)
- Calcium carbonate: $CaCl_2$
- Droppers

How?

Add the water to the soil in the beaker; stir. A murky suspension will form.
Add a few drops of sodium carbonate to the mixture.
What happens?
Then add a few drops of calcium carbonate to this mixture. What happens now?

How to involve the audience / learners?

What happens? Why?

When you add sodium carbonate to the mixture, the soil particles go into suspension in the water. This is known as deflocculation. If you then add calcium carbonate to the mixture, the soil particles will flocculate and all fall to the bottom of the beaker, leaving the water clear.

Using the Overhead Projector

The overhead projector should not limited to displaying transparencies. Realia, three-dimensional objects, can be used to explain and illustrate many concepts to large groups. The objects will be enlarged and the only limiting factor is your creativity. Opaque objects will project black, but transparent objects, such as glass, test tubes, petri dishes etc. will be shown indifferent shades of grey. A few ideas are listed below.

Mathematics

- The abacus
- Areas
- Geometric forms
- Paperclips, beans, buttons, etc. to teach illustrate set theory
- Plastic rulers with different units
- Shapes to illustrate fractions

Science

- Crystalline growth
- Gear ratios
- Insects and bugs
- Leaf shapes
- Magnetism
- Mixing colours - use colour separations used in printing
- Old x-rays to discuss anatomy.
- Opacity, translucency and transparency
- The solar system
- Wave motion
- Weather symbols

Safety Precautions

General

- Keep a safe distance between any hazard and the audience.
- If the audience is involved, make sure they understand what they have to do.

Chemicals

- Always use safety glasses if you work with chemicals.
- Never taste chemicals or solutions.
- Do not smell chemicals directly.
- When diluting concentrated acids or bases always add the concentrated acid or base to water (never the reverse), while stirring the solution. Be extremely careful when handling sulphuric acid.
- All bottles should be clearly labelled. Read the label before removing any chemical from a container.
- If you are not sure if you are using the correct chemical for what you plan to do, ask an expert.
- Don’t use broken or chipped glassware.
- Have water readily available if you are working with corrosive chemicals so that you can rinse spillages.
- Have a cloth ready to wipe up any spillages.

Electricity

- Don’t use equipment with broken plugs or torn electrical cords.
- Never pull a plug out by the cord.
- Switch off equipment after use.

Fire

- If an experiment uses matches and / or candles, take the necessary precautions. Children should be under adult supervision.
- Never leave an open flame unattended.
- Know where the fire extinguisher is and how to use it.

Liquid nitrogen

- Always wear gloves when handling liquid nitrogen and safety goggles when pouring it.
- Do not touch the liquid nitrogen or any frozen items with bare hands.
- Treat freeze burns immediately with tepid water.
- A container with liquid nitrogen should **never** be tightly sealed.
- **Do not** douse the carpet or linoleum floor with liquid nitrogen - the frozen floor cracks easily.

First Aid

- Know where the first aid kit is kept.
- Treat burns immediately with cold water and freeze burns with tepid water.
- Rinse acid and bases off skin immediately.

Disclaimer

All the experiments and tricks described in this booklet are safe if they are done with the necessary precautions and safety measures. Neither the authors, nor the University of Pretoria, can be held liable for any injuries or damages incurred while performing these experiments. Children should however get permission from a parent or other responsible adult before trying to do any of them. Experiments that make use of acids, matches, candles and liquid nitrogen are best done under supervision of a knowledgeable adult.

Glossary

Acetic acid	CH_3 COOH (aq)
AHA	used to express surprise, pleasure, or triumph.
AHA experience	is the moment of insight; the moment in which elements come together and a new concept is constructed.
Bicarbonate of soda	$NaHCO_3$
Edutainer	a person that aims to educate people of all ages through entertainment.
Floral sonication	buzz pollination
Prime number	a number that has 1 and itself as factors.
Science Show	a series of thought-provoking science demonstrations.
Sodium polyacrylate	$--CH_2--CH(CO_2Na)--$
WOW	used to express wonder, amazement, or great pleasure.

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  www.pitara.com/discover/eureka/online.asp?story=107

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Some Science Centres on the Web

- Sci-Enza (University of Pretoria)
  www.sci-enza.up.ac.za/
- Exploratorium: the museum of science, art and human perception.
  www.exploratorium.com/
- Interactive Science Ltd.
  www.interactives.co.uk/
- MTN SCIENCENTRE.
  www.mtnsciencentre.org.za/
- SAASTEC: Southern African Association of Science and Technology Centres
  www.saastec.co.za/
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- Science North
  sciencenorth.on.ca/
- Questacon. The Australian National Science and Technology Centre.
  www.questacon.edu.au/
- Tom Tits Experiment
  www.tomtit.se/

Notes

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Rudi Horak is the Manager and Curator of the Science Centre at the University of Pretoria. After completing her BEd she taught Physical Science to secondary school learners for 16 years. For the past 10 years she has presented Science Shows and Science Demonstrations to visitors of the Science Centre.

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Together we hope to make science interesting, less intimidating and more accessible to all the visitors to our Science Centres.

We would also like to thank the students and learners who in the last two years attended our workshops. They never cease to surprise us with new and innovative ways to involve the audience and thereby show us that we can still learn from them.

What will happen?

Derek Fish in action at the official opening of the Discovery Centre, now Sci-Enza, at the University of Pretoria.

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