SCIENCE

on Stage 2015

Demonstrations and teaching ideas

selected by the Irish team

Organisers and Sponsors

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London, July 2015

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Observation is not enough, and it seems to me that in science, as in the arts, there is very little worth having that does not require the exercise of intuition as well as of intelligence, the use of imagination as well as of information.

Kathleen Lonsdale

The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge.

Stephen Hawking

Blushing is the most peculiar and most human of all expressions.

Charles Darwin

Scientists should never claim that something is absolutely true. You should never claim perfect, or total, or 100% because you never ever get there.

Jocelyn Bell Burnell

Disclaimer

The National Steering Committee for Science on Stage has made every effort to ensure the high quality of the information presented in this publication. Teachers should ensure the safety of the demonstrations in their own laboratories. This document has been produced by volunteers and, thanks to our sponsors, is distributed free of charge. It is intended as a resource for science teachers and is not published for profit. SonS (Science on Stage) permits educational organisations to reproduce material from this book without prior notification, provided that it is for educational use and is not for profit and that suitable acknowledgement is given to SonS. We would be grateful to receive a copy of any other publication using material reproduced from this booklet.

Any comments or suggestions would be welcomed by the committee and can be sent to the Chairperson: Dr. Eilish McLoughlin, Science on Stage, CASTeL, School of Physical Sciences, Dublin City University, Dublin 9.

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CONTENTS

Foreword

It is a pleasure to introduce this science teaching resource which presents demonstrations and teaching ideas prepared and selected by the Irish Science on Stage team that attended the European Science on Stage festival held in Queen Mary, University London on the 17-20 June 2015. Under the motto “Illuminating Science Education” 350 primary and secondary school teachers from all over Europe shared experiments and teaching ideas for science, technology and mathematics education at stands, in workshop and on stage over four days in London.

The Science on Stage programme (www.science-on-stage.eu/) is an innovative, pan-European science education activity, designed to foster a renewal of science teaching in Europe by encouraging the exchange of new concepts and best practice among teachers from all over the continent. It follows from the success of the three editions of the Physics on Stage programme from 2000 to 2003. Innovative and inspirational science teaching is seen as a key factor in encouraging young people to engage with scientific issues, whether or not they finally choose a career in science. Hence, Science on Stage is a network of and for STEM teachers of all school levels, it provides a European platform for the exchange of teaching ideas and serves to highlight the importance of science and technology in schools and among the public. Each programme culminates in a four-day long festival, combining a science teaching fair with onstage activities, parallel sessions and workshops. The teaching fair provides an array of vibrant and stimulating displays from thirty countries across Europe with a multitude of languages and enthusiastic participants who take every opportunity to exchange teaching materials and ideas.

This project was made possible by the coordination and support of CASTeL at Dublin City University and The Institute of Physics in Ireland. Science on Stage Ireland gratefully acknowledges funding support received from the Science Foundation Ireland 2015 Discover Programme.

The gratitude of the thousands of teachers and educators who receive this free booklet of demonstrations and teaching ideas must principally go to the very hard-working team of 2015 contributors: Brigid Corrigan, David Doherty, Patrick Dundon, Dorothy Fox, Rory Geoghegan, David Keenehan, Eilish McLoughlin, Niamh Minton, Richie Moynihan, Paul Nugent. In particular, sincere thanks to Rory Geoghegan for his tremendous work in the arduous task of proofing and editing this booklet and working on it right through to the final stages of production. All of these teachers work full time, yet, despite this, they tested and produced this excellent collection of demonstrations selected from the Science on Stage conferences and this publication would not have happened without their very professional commitment.

It has been our pleasure to work with these inspiring science teachers and educators in co-ordinating the SonS2015 programme and producing this booklet, which we hope you will find an invaluable classroom resource. For further information on Science on Stage in Ireland and for electronic copies of all the POS/SonS booklets, please visit: www.scienceonstage.ie/

Dr. Eilish McLoughlin
Chair Science on Stage Ireland
CASTeL, Dublin City University

Paul Nugent
co-Chair Science on Stage Ireland
IOP Physics Teacher Coordinator

The Irish Team at SonS 2015

A team of thirteen delegates represented Ireland at the European Science Teaching Festival "Illuminating Science Education" in Queen Mary University London on the 17-20 June 2015. The team consisted of Eilish McLoughlin, CASTeL, Dublin City University; Paul Nugent, The Institute of Physics in Ireland; Brigid Corrigan, Mount Sackville Secondary School, Dublin; David Doherty, Coláiste na Carraige, Donegal; Patrick Dundon, Castletroy College, Co. Limerick; Dorothy Fox, Scoil Chonglais, Wicklow; Rory Geoghegan, PDST Science; Leanne Hawthorne, Belfast Boys Model School, Belfast; David Keenehan, Gonzaga College, Dublin; Niamh Minton, Ballinteer Community School, Dublin; Richie Moynihan, O'Carolan College, Co. Meath; Helen Ní Chríódáin, Gael-Choláiste Chill Dara, Kildare; Maria Sheehan Saint Caimin's Community School, Co. Clare.

At the 2015 festival, Eilish McLoughlin and Paul Nugent were invited as festival judges and David Keenahan was invited to present a workshop on the theme of Rotation.

The Irish team at Science on Stage in London, July 2015

Back row:(l-r)	Rory Geoghegan, Patrick.Dundon, Richard Moynihan, Brigid Corrigan, Paul Nugent
Middle row:(l-r)	Dorothy Fox, David Keenahan
Front row:(l-r)	Eilish McLoughlin, Helen Creedon, Maria Sheehan, Niamh Minton, David Doherty

Fat-binding products

Background

In our research, we have tested the real effects of some fat binding products usually sold at chemists. The experiment originated in Spain by Sagrario García-Zafra.

You will need...

- ✓ Pestle and mortar
- ✓ 3 graduated cylinders
- ✓ 3 pieces of filter paper (preferably thin)
- ✓ 3 funnels
- ✓ 3 beakers
- ✓ Magnetic stirrer
- ✓ Vegetable oil – 25 cm^3 × 3
- ✓ 2 different products of fat binding tablets labelled A & B.
- ✓ A natural fat binding product (e.g. sea shells)
- ✓ Electric hand blender
- ✓ Gloves and safety goggles

Follow these steps

1. Grind up 4 tablets of each fat binding product separately, add to separate beakers.
2. Grind up the natural fat binding product (sea shells), use the blender and take precaution (goggles), add to another beaker.
3. Add 25 cm^3 to each of the three beakers.
4. Place each beaker on the magnetic stirrer for equal times and at equal speed to ensure it is well mixed.
5. Place a piece of filter paper in each of the three funnels. Put each funnel over a graduated cylinder and add the mixtures.

So what happened?

After leaving the graduated cylinders overnight, our findings were that the fat binding tablets of A (XLS – Medical) left a lot of residue in the filter paper but very little oil, just under 2mls, nothing compared to how much oil we started with, 25mls. The fat binding tablets of B (Xipisan) left nearly no residue in the filter paper but just over 2 cm^3 of oil, still a very low amount. Unfortunately, we didn't prove our sea shells to be a naturally fat binding product, as all of the oil overflowed into the cylinder and we were left with a lot of residue on our filter paper. These results show us that the best fat binding product is XLS-Medical with its small amount of left over oil. In relation to the body, it would be very little fat from that remainder oil to be absorbed into the bloodstream.

What next?

To continue this experiment, we would be very interested in finding a natural fat binding product and would like to try crab shells. The natural fat binder versus the pharmaceutical product would be very interesting to look in to. We would also be interested in changing the oil type to test the effectiveness of fat binders on oils that may have more or less fat.

Biology

Genetic Whispers

A model for genetic drift (Ireland)

Background

This activity is a nice way to show how mutations come about in evolution is inspired by a game known as Chinese Whispers. The nice thing about this is that it can be done with all years, is always enjoyed and can explain various depths of the concepts to students of various years.

You will need...

- ✓ Pens
- ✓ A class set of card / paper cut squares, roughly 8 cm × 8 cm

Follow these steps

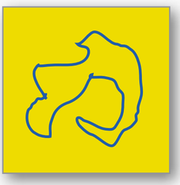
1. Hand every student a square.
2. Draw a simple shape on the first card, e.g, a line, circle, square.
3. Hand it to the first student and get them to copy the picture that you did, exactly as you did it. If there are any mistakes on the picture, they have to copy them.
4. When this student is finished, they pass their card to the next student and they copy exactly what they see onto their card. Any mistakes must also be copied.

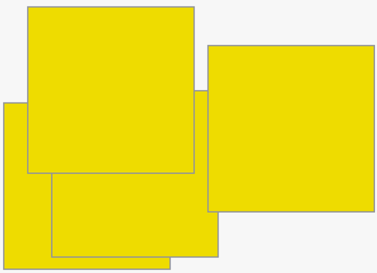
So what happened?

As the card goes around, the shapes will start to diverge from their original form. This can be used as an analogue to talk about how mistakes can be carried through our genes and cause variation in genetic codes, and after many generations, evolve one species into another species.

What next?

Pass three or four cards of the same shape around the room. Compare and contrast them when the activity is over, referencing our relationship to primates on the evolutionary ladder.





Disc ‘Rotography’

LEDs and their light trails (Germany)

Background

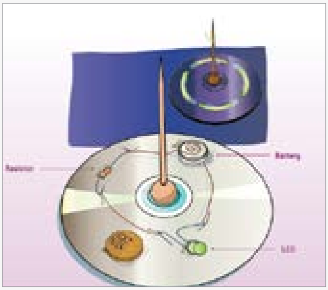
Light trails or ‘Persistence of vision’ is the commonly used term to describe the optical illusion whereby multiple discrete images blend into a single image in the human mind. It is believed to be the explanation for motion perception in cinema and animated films. Physicist, Otto Lührs, was extremely interested in this phenomenon and created the following experiment.

You will need...

- ✓ 1 Disc
- ✓ 1 Light Emitting Diode (LED)
- ✓ 1 Battery
- ✓ 1 Wooden ball (with hole drilled half way through it)
- ✓ 1 Toothpick (blunted at one end)
- ✓ 2 Short wires (8 cm each)
- ✓ 1 Longer wire (18 cm)
- ✓ 1 Coin (10 c)
- ✓ Double sided sticky tape, sticky tape, glue, scissors and a ruler.

Follow these steps

1. Set up the apparatus as shown (a resistor is not necessary). Place the toothpick into the wooden ball and glue it in place through the hole in the disc.
2. Place some double sided tape on to the disc and place a coil of wire onto it. Press the battery onto the wire coil and stick one of the shorter wires onto the battery with some sticky tape.



3. Now, glue the resistor to the disc and attach it to the short wire (connected to the battery). Connect the other short wire to the free end of the resistor. Connect the LED to complete the circuit. (Ensure the LED terminals are positioned correctly before gluing).
4. Secure a coin across from the battery to ensure the disc is balanced.
5. Spin the disc at various speeds. A trail of light should be seen as a continuous circle when the disc is spun fast enough.

So what happened?

As the disc spins slowly the LEDs can be seen individually. As they begin to spin faster the LEDs appear to blur together and create a continuous circle of light. This phenomenon is known as ‘Persistence of Vision’ as your brain retains a perception of the LED light for a fraction of a second in your sensory memory. This gives rise to the trail of light that can be seen.

What next?

1. White light could be explored and a Newton’s colour wheel could be created.
2. Explore the effect of using more than one LED and varying the colours used.
3. Photographs of the discs can be taken and students can research how exposure time effects the photos produced. The physics of photography could be linked to this experiment.

Biology

Natural alternatives to antiseptics

Antibacterial effects of plants (United Kingdom)

Background

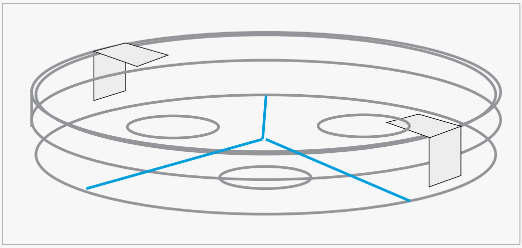
Antiseptics are used to disinfect living tissue – both prophylactically to prevent infection and therapeutically to treat infection. Any given antiseptic is usually more effective against some microbes than others. Its activity may be affected by factors such as dilution, temperature, pH, and the presence of detergent or organic matter.

You will need...

- ✓ Petri dish containing agar covered with a bacterial lawn
- ✓ two named spices
- ✓ 3 small discs of filter paper
- ✓ sticky tape
- ✓ marker pen
- ✓ forceps
- ✓ ethanol

Follow these steps

1. Keeping the lid on the Petri dish, turn the Petri dish upside down. Use the marker pen to draw on the base and divide it into three sections, as shown in the diagram. Label one section ‘control’ and the other two sections with the name of each spice. Turn the dish the right way up.
2. Pick up a filter paper disc with the forceps and dip it into the ethanol. Carefully place the disc on the section of agar labelled ‘control’. Replace the lid.
3. Using the forceps, pick up another filter paper disc and dip it into the ethanol and then the spice.
4. Carefully remove the paper disc and shake off any excess. Place the disc onto the section of agar labelled with the name of the spice. Replace the lid.
5. Repeat step D with the other spice.
6. Tape the lid onto your Petri dishes with two pieces of sticky tape, as shown in the diagram and invert the dish. Write your initials on the base of the dish. Leave it in a warm place (20–25 °C) for two to three days.
7. Look carefully at your dish. Do not open it.



So what happened?

The four spices with the most potent antibacterial effects tested were garlic, onion, allspice and oregano. These four spices inhibited the mast bacterial growth. Many spices with relatively weak antibacterial effects become much more potent when combined; examples are in chilli powder (typically a mixture of red pepper, onion, paprika, garlic, cumin and oregano) and five-spice powder (pepper, cinnamon, anise, fennel and cloves).

What next?

1. Combine spices (as above) and repeat the experiment.
2. Repeat the experiment using different diluted percentages of mouthwash to test its antibacterial properties.
3. Examine plants with other medicinal properties.

How to measure for lung capacity

A simple way to show how much air we can hold

Background

When teaching respiration, we talk about how much alveoli we have and how gaseous exchange occurs. We rarely give students an idea of how much air our lungs take in and breathe out.

You will need...

- ✓ A 5 L bottle of water.
- ✓ Sink half filled with water
- ✓ Straws that bend at the top
- ✓ A volunteer assistant.

Follow these steps

1. Fill the bottle with water to the top and cover with a lid.
2. Invert it into a sink half filled with water.
3. Take off the lid and put the bend of a straw into the water bottle.
4. Breathe normally and breathe out through the straw.

So what happened?

The average lung capacity for the adult human is about 6L of air. However, when we do this, we'll see that with normal breaths, we don't breath out 6L. This is due to when we're not exercising, our bodies don't need as much oxygen as we're not respiring as much.

What next?

1. Use deep breaths instead of normal breaths.
2. Get students to run for a while and repeat when they're breathing heavy.
3. Get students to take one deep breath and then empty their lungs into the bottle to see how much air they can store.

Urban BioKit

Biosphère Urban BioKit (Canada)

Background

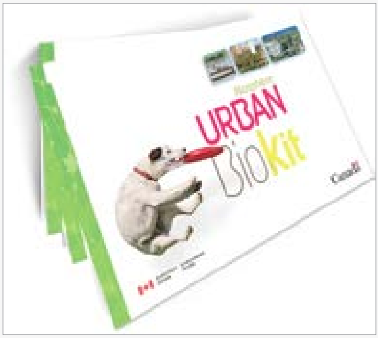
A simple guided methodology to enable students to explore their surroundings and to assess the health of their environment.

You will need...

✓ Hard copy of Biosphère Urban BioKit
✓ Magnifying glass
✓ Binoculars
✓ Camera (mobile phone)
✓ Small mirror
✓ Plastic specimen bags
✓ Clipboard and pencil

Follow these steps

1. Choose a nearby location such as a local park or sports field.
2. Walk towards your destination and as you walk carefully consider all of your surroundings.
3. Whilst en route, complete all of the activities suggested in the BioKit.
4. When you arrive at your destination, continue to observe your surroundings and perform all of the activities and answer the questions suggested in your BioKit.
5. Upon your return to class, discuss your excursion with your classmates and also discuss with your family and friends upon returning home from school.
6. Share the results of your environmental diagnosis with other students in different schools, counties or even countries on the BioKits website.



http://www.ec.gc.ca/biotrousses-biokits/default.asp?lang=En&n=A26BD349-1

So what happened?

By following the BioKit methodology, students will have engaged in many different activities including, recording weather conditions, drawing site maps, looking for evidence of healthy ecosystems such as lichens on trees and rocks, assessing biodiversity and the presence of invasive species, completing a diagnostic checklist, reporting on their site visit and communicating their results to other students via the BioKits website.

What next?

1. Students should be asked to make recommendations about how best to protect their environment. This should help facilitate a discussion of conservation and sustainability amongst students.
2. Students may also use the Nature BioKit to assess and diagnose a more rural location. It would be an interesting extension for students to compare their diagnoses for an urban and rural location.

http://www.ec.gc.ca/biotrousses-biokits/

default.asp?lang=En&n=-3F278ECB-1

How a microscope works

A simple way to show how refraction and curved (Ireland)

Background

Refraction occurs when light passes from one transparent material into another transparent material. When light from an object passes through the interface of two media that is curved, this can cause the image to magnified or diminished.

You will need...

- ✓ Retort stands
- ✓ Green laser pen
- ✓ Dark room, or a room in winter
- ✓ Fresh water sample
- ✓ Plastic syringe.

Follow these steps

1. Place water sample into a plastic syringe.
2. Support it on the retort stand and push a bit of water out so there is a single drop on the top of the syringe.
3. Using another retort stand to support the laser.

So what happened?

Due to the curved shape of the droplet, we see that the light diverges out onto the screen and we get a big area. Depending on the water same we have, we are able to see numerous micro-organisms moving around in the water sample.

What next?

1. Use different water samples to compare the amounts of micro-organisms found in different habitats.
2. Try to sketch the different types of micro-organisms and classify them based on their shapes. (LC Biology)

Biology

DNA model

Background

Teaching Models in Biology

You will need...

- ✓ waste plastic water bottles (3 doz.)
- ✓ 4 different coloured paints, to paint inside of bottles
- ✓ 2 lane dividers from swimming pool (foam)

Follow these steps

1. Make a double helix using foam
2. Colour inside of bottles, some red, blue yellow and green to form the bases
3. Connect bottles according to the DNA code using a glue gun.

So what happened?

A 3D model of DNA was formed.

What next?

1. You could use this idea to form RNA Transcription.

How to find your Blind Spot

Background

The blind spot is the area of the retina without receptors that respond to light. It is the region of the eye where the optic nerve exits to the brain. An image that falls on this area will NOT be seen.

You will need:

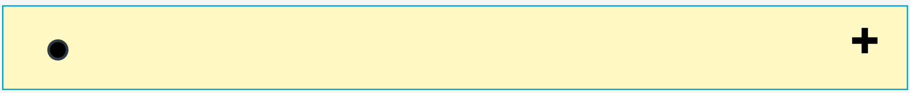
A piece of card, a marker and a ruler

Follow these steps:

1. Cut a piece of card 2.5 cm × 15 cm.
2. Place a small dot on one side and a cross on the other.
3. Hold the card about 40 cm from your face and level with your eyes.
4. Close the right eye and stare at the cross with your left.
5. Slowly bring the card closer to your face until the dot disappears.
6. This is your blind spot as the image of the dot is now focused on this area of your retina.

What Next

These experiments demonstrate a property of light and can be extended to include refraction and used in a cross curricular way in the demonstration of how the eye perceives and processes light.



Electrolysis of water

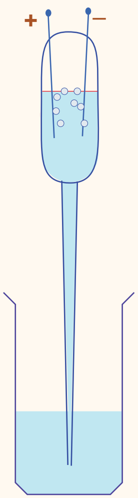
Electrolysis of Water, for less than a tenner! (Poland)

Background

Hoffmann voltammeters are very big, delicate and expensive. Using this alternative set up, we can split up water into its elements with materials that all the students can use. They can compare this experiment to the Hoffmann voltammeter later.

You will need...

- ✓ 9 V battery
- ✓ 2 sewing needles, or steel pins
- ✓ Salt water / acidified water
- ✓ Pasteur pipette
- ✓ Bowel of soapy water
- ✓ Wires and crocodile clips
- ✓ Switch



Follow these steps

1. Fill the bulb of a Pasteur pipette with salt water or acidified water and pierce it with 2 sewing needles. Make sure they are not touching one another.
2. Using the wires and crocodile clip, connect it back to the 9 volt battery and leave the switch open.
3. If you wish to collect the gases, place the other end of the Pasteur pipette into the bowel of soap water.
4. Close the switch after you have produced / collected enough bubbles.
5. Light the bubbles with a safety lighter.... you know you want to!

So what happened?

The electric current passing through salt water / acidified water allows the hydrogen to separate from the oxygen. You don't get to see the ratio of each gas produced unfortunately but you do get a satisfying pop when the hydrogen and oxygen bubbles combust together.

What next?

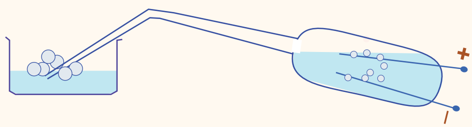
Compare experimental set up with an actual Hoffmann voltammeter to discuss ratio of gases produced and identification of anode and cathode.

Compare what happens to the needles and to the colour of the water if acidified water is used instead of salt water.

Note

The positive electrode (needle) will corrode unless it is made of platinum or other inert material.

Using steel sewing needles Fe^{++} ions will enter the solution at the positive electrode. There will be a corresponding reduction in the amount of oxygen formed. The negative electrode will not be affected.



Coloured Hydrogen

A combination of acid-base reaction and emission spectra (Poland)

Background

When a metal is put into an acid, hydrogen gas is always given out, and a metal hydroxide is produced. When metal atoms are suspended in the gas given off, lighting them excites the atom and the energy is released as light.

You will need...

- ✓ Aluminium foil
- ✓ 0.1 M HCl
- ✓ Copper chloride
- ✓ Conical flask
- ✓ Taper or a safety lighter
- ✓ Fume hood
- ✓ Spatula

Follow these steps

This experiment should be done in the fume hood.

1. Place 2 spatulas of copper chloride into a conical flask.
2. Add in approximately 20 cm^3 of HCl.
3. Tear up a few piece of the aluminium foil and place them into the conical flask.
4. When the gas is produced, hold a lighting taper or a safety lighter over the top of the flask.

So what happened?

This is usually a slow reaction but the presence of the copper chloride has a catalytic effect and speeds up the production of the gas. When the gas is lit on fire, it has a green colour, which is characteristic of copper when returning from an excited state to a ground state.

What next?

Try using difference salts or combinations of different salts to get a variety / mixture of colours.

Reacting sodium with chlorine

Alkali metal (sodium) reaction with a halogen (chlorine) (Hungary)

Background

Group 1 alkali metals react readily with Group 7 halogens (‘octet rule’).

In the reaction, a stream of chlorine gas is directed over a piece of heated sodium in a test tube. The sodium reacts with a bright orange glow to form the white solid, sodium chloride.

Note: The method described here is adapted from the Royal Society of Chemistry (RSC) version. This demonstration was developed by Dr Colin Chambers, formerly of Bolton Grammar School.

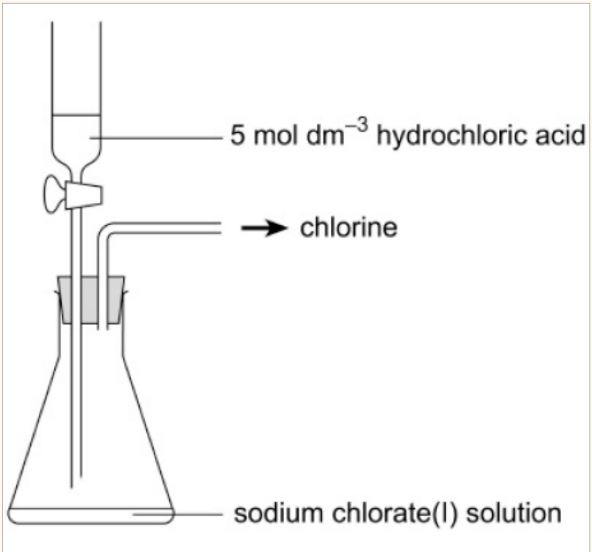


Figure 1 A chlorine generator

You will need...

- ✓ Pyrex™ boiling tube
- ✓ Glass delivery tube with right-angled bend long enough to reach the bottom of the boiling tube
- ✓ A short length of flexible tubing to connect the glass delivery tube to the chlorine source
- ✓ Scalpel or knife to cut the sodium
- ✓ Filter paper to dry the sodium
- ✓ Tweezers
- ✓ 2 stands, each with boss and clamp
- ✓ Bunsen burner
- ✓ Magnetic stirrer

A chlorine generator. This consists of a 500 cm^3 conical flask fitted with a two-holed bung, delivery tube and a tap funnel — see Figure 1.

Chemicals

A small piece of sodium (highly flammable and corrosive) about 4 mm cube.

To prepare chlorine:

50 cm^3 of 14% (w/v) sodium chlorate(I) (sodium hypochlorite) solution (corrosive) and 20 cm^3 5 mol dm^{-3} hydrochloric acid (irritant). These quantities will produce about 1 dm^3 of chlorine. The sodium chlorate(I) solution must be reasonably fresh. Any over 18 months old may well have lost chlorine during storage.

WARNING: Sodium chlorate(I) has the formula NaClO and is only found in solution and never as a solid. Take care not to confuse it with sodium chlorate(V), $NaClO_3$ which is usually available as a solid.

Follow these steps

1. Work in a fume cupboard.
2. Set up the chlorine generator, securing it with a clamp. If a magnetic stirrer is available, place the flask on it and add a magnetic stirrer bar.
3. Place 50 cm^3 of the sodium chlorate solution in the flask and 20 cm^3 of hydro-

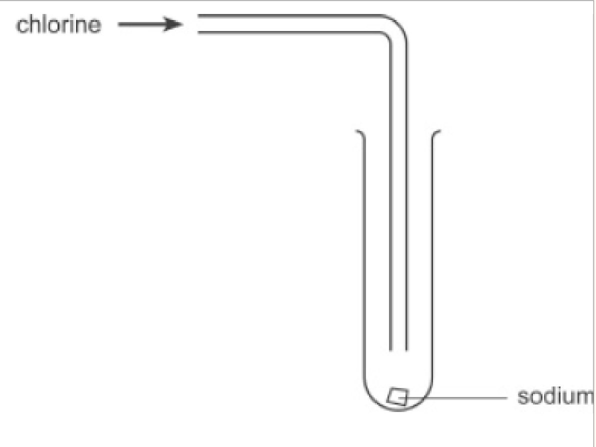


Figure 2 Reacting sodium with chlorine

chloric acid in the dropping funnel. Start the stirrer.

4. Clamp a boiling tube vertically. Cut a piece of sodium about 4 mm × 4 mm x 4 mm.
5. Carefully dry the oil from the sodium. This is important because otherwise a smoky flame will be seen, resulting from the reaction of the oil with chlorine.
6. Place the sodium in the bottom of the boiling tube. Attach the glass delivery tube to the chlorine generator via the flexible tube and hold the end of the delivery tube about 1 cm above the piece of sodium, see Figure 2.
7. Manipulate the tap of the tap funnel to drip hydrochloric acid slowly onto the sodium chlorate(I) solution until air is flushed from the chlorine generator (the pale green colour of chlorine will be seen in the generator) and a steady flow of chlorine onto the sodium is produced.
8. Heat the sodium gently with the Bunsen burner until the sodium starts to react, producing an orange glow and white fumes of solid sodium chloride.
9. A layer of sodium chloride may form on the surface of the sodium and prevent further reaction. If this occurs it may be necessary to remove this by tapping the sodium with the chlorine delivery tube during the reaction to allow the full vigour of the reaction to be demonstrated.
10. Wear eye protection.
11. Work in a fume cupboard
12. The pupils should be at least 3 m from the fume cupboard.

So what happened?

The reactive group 1 alkali metal reacts with the halogen chlorine to produce the salt sodium chloride. The reaction is remarkable for the amount of energy given off in the form of bright orange light. (Most of the energy is released by the formation of the crystals of salt, i.e. from the lattice energy.)

The reaction is:

$2Na(s) + Cl_2(g) = 2NaCl(s)$

What next?

1. This experiment could fit into a topic about the reactions of the alkali metals or of the reactions of halogens.
2. This method will work with other reactive metals, such as calcium, in place of sodium.

Endothermic Cocktail

Street science busking (UK)

Background

In chemical reactions bonds are broken and bonds are formed. Energy changes occur.

A tremendous amount of energy is held in the bonds that hold molecules together. When these bonds are broken, a large amount of energy is released. This also means that it takes a great deal of energy to form bonds.

An endothermic reaction occurs when a greater amount of energy is required to break the existing bonds in the reactants than is released when the new bonds form in the products. In other words, this means an endothermic reaction requires or takes in energy in order for it to proceed. The energy that is required by the reaction to move forward, can be in many forms, but it is typically in the form of heat.

Dissolving salt in water is endothermic, even though a mixture (solution) is formed rather than a new chemical compound. Here, bonds in the molecules (intramolecular bonds) are not broken, bonds between them (intermolecular bonds) are, and an energy exchange is involved where the deficit of energy is taken in from the environment.

This simple experiment demonstrates how energy is removed from the surroundings in the form of heat, to allow the reaction to happen, thus demonstrating an endothermic reaction.

You will need...

- ✓ 25 cm^3 citric acid solution (concentration not important and can be varied)
- ✓ 15 g baking soda
- ✓ a Styrofoam cup
- ✓ thermometer
- ✓ stirring rod

Follow these steps

1. Pour the citric acid solution in a styrofoam coffee cup. Use a thermometer to record the initial temperature.
2. Stir in the baking soda (sodium bicarbonate). Track the change in temperature as a function of time.
3. The reaction is: $H_3C_6H_5O_7(aq) + 3\ NaHCO_3(s) \rightarrow 3\ CO_2(g) + 3\ H_2O(l) + Na_3C_6H_5O_7(aq)$
4. When completed, simply wash the cup out in a sink. No toxic chemicals have been produced.

So what happened?

An endothermic reaction is a reaction that requires energy to proceed. The energy is sourced from the surroundings, in the form of heat.

The intake of energy may be observed as a decrease in temperature in the solution, as the reaction proceeds.

The change in temperature can be measured and recorded throughout, using a thermometer.

Once the reaction is complete, the temperature of the mixture will return to room temperature.

Examples of everyday endothermic reactions

- melting ice cubes
- melting solid salts
- evaporating liquid water
- converting frost to water vapour (melting, boiling, and evaporation in general are endothermic processes)
- cooking an egg
- baking bread

Deflection of a water jet

Coriolis effect with water and a turntable (Italy)

Background

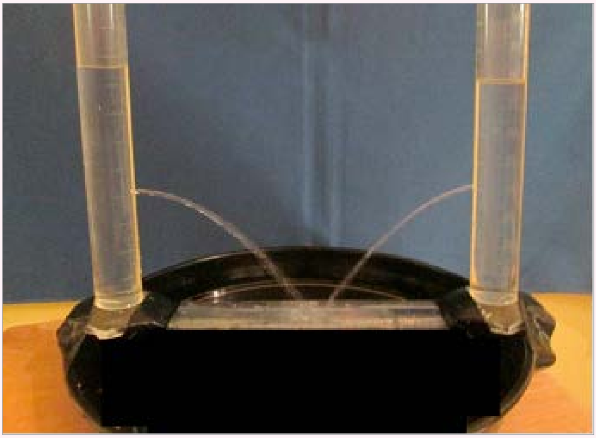
From our study of Geography we know that if the Earth didn't rotate, winds would travel either north or south due to differences in temperature and pressure at different latitudes. But since the Earth does rotate, the Coriolis force deflects these winds to the right in the Northern hemisphere and to the left in the Southern hemisphere.

You will need...

- ✓ A turntable (whether motorised like an vinyl record player, or hand-spun like a cheese board)
- ✓ A circular tray,
- ✓ Two small graduated cylinders
- ✓ glue
- ✓ Two cocktail sticks
- ✓ Water.

Follow these steps

1. Drill a tiny hole at the same height in each of the two graduated cylinders. Plug both holes with cocktail sticks.
2. Fix the graduated cylinders to the tray with glue.
3. Fix the tray to the turntable with glue.



4. Fill both graduated cylinders to the same height with water.
5. Remove both cocktail sticks simultaneously and immediately set the turntable spinning.

So what happened?

The downward pressure within each tower of water causes two jets of water to spurt out as shown and the Coriolis effect is observable as the turntable spins.

What next?

Reset the experiment and spin the table in reverse.

:

Dynamics

Real graphs from real data

(UK)

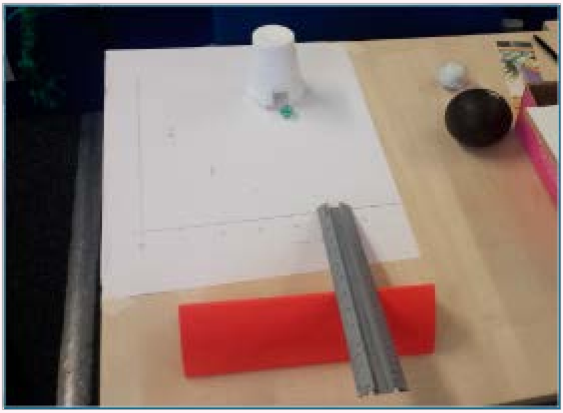
You will need...

(per group)

- ✓ 1 marble / ball bearing
- ✓ 5 plastic cups
- ✓ 1 A3 page
- ✓ 1 ruler
- ✓ 1 piece of paper folded into a triangular prism.

Follow these steps

1. Cut out a lip on the lid of the cups that will allow the ball bearing through.
2. Draw a graph on the A3 paper, with distance on the *y*-axis and cup number on the *x*-axis.
3. Place a cup on the position marked 1 on the *x*-axis.
4. Set up the ruler on the paper prism so that a ball bearing will roll down the top of the ruler into the cup.
5. Release the bearing and mark where the cup stops.
6. Repeat 5 times.
7. Mark the mean stopping distance, and also draw in error bars if you wish.
8. Place a second cup on top of the first and place at position marked 2 on the *x*-axis.
9. Repeat for up to 5 cups.



So what happened?

This gives student the opportunity to understand the identification of variables and the use of graphs in science in a relatively straight-forward investigation. Students can easily determine that as the mass of the cups increase, the distance travelled decreases. This can be used as a discussion point when explaining inverse relationships, or discussed in the context of static and dynamic friction.

What next?

Challenge the students to think of other variables to change and plot along the *x*-axis instead of number of cups. Suggestions could be the angles of the ruler or the mass of the bearings used.

Rolling jars of sugar

(Ireland)

Background:

Heavy and light fall objects at the same rate but do they roll at the same rate down an incline?

You will need...

- ✓ Four identical jars,
- ✓ Sugar,
- ✓ A ramp
- ✓ A meter stick

Follow these steps

1. Fill one jar with sugar. Add sugar to another until it is two-thirds full. Add sugar to another jar until it is one-third full. Leave the fourth jar empty.
2. Incline the ramp as shown. Place the four jars on their side (in a horizontal row) at the top of the ramp.
3. Hold them in a line with a meter stick. Release them to roll at the same instant.

So what happened?

They all rolled down the incline at different rates. Full and empty arrived together, followed by the jar that was two-thirds full, and in last place is the jar that was one-third full.

What next?

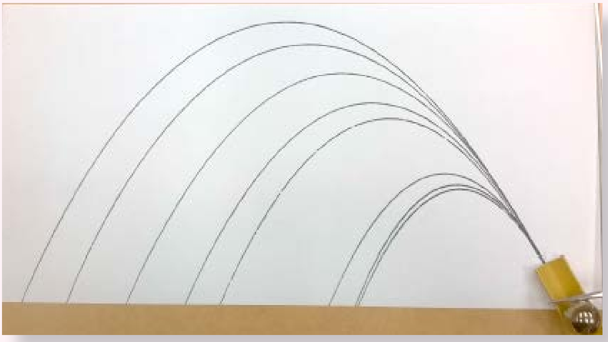
Examine either of the partially filled jars as it rolls and the sugar will be seen to cascade over, causing a braking effect. The effect is greater in the one-third full jar and its inertia is less than the two-thirds full jar. For a combination of these reasons the outcome is as described above.

Painted by light and shade

Physics "painted" by light and shade (Poland)

Background

The traces left by hot metal ball bearings as they travel over thermoactive fax paper may be used to study various topics in Physics and Applied Mathematics, including kinematics and dynamics.



You will need...

- ✓ Thermoactive fax paper
- ✓ Small metal ball bearings
- ✓ Hot plate or soldering pot (200 °C) and metal tongs
- ✓ Wooden wedges
- ✓ Metal prisms and spheres of various shapes
- ✓ Chopping board, sellotape, ruler and protractor

Follow these steps

1. Place a sheet of thermoactive fax paper on a slightly inclined surface.
2. Position a wooden wedge at edge of fax paper that will act as a ramp.
3. Place a metal ball bearing on a pre-heated hot plate (200 °C) for 60 seconds.
4. Transfer heated ball bearing to top of wooden wedge using a metal tongs.
5. Release ball bearing and observe the permanent black trace left on fax paper by moving ball bearing.
6. http://www.scienceon-stage.org.uk/exhibition2015/Poster%20pdfs/157242.pdf

So what happened?

The heated ball bearing leaves a permanent trace on the thermoactive fax paper. The motion of the ball bearing is captured by this trace. By overlaying the trace with a suitable axis, students may analyse the motion for parameters such as displacement, velocity, acceleration, maximum point, etc. Much of the above analyses may be conducted using dynamic mathematics software such as www.geogebra.org Potential energy and kinetic energy may also be considered.

What next?

Students should be asked to consider the following questions:

1. Why does the heated ball bearing cause the fax paper to turn black?
2. What is the generic term used in Mathematics to describe all such curved shapes?
3. What mathematical function may best model the motion of the ball bearing?
4. Students should be asked to investigate the effect, if any, on the motion of the ball bearing of varying the following factors:

- Mass of ball bearing
- Angle of ramp; height of ramp
- Angle of inclination of fax paper attached to chopping board
- Motion of ball bearing after collision with (i) static and (ii) moving objects.

Dynamic mathematics software

GeoGebra and Sketchometry (Commercial)

Background

Dynamic mathematics software can be a useful tool for students in their study of many physical concepts, in particular, topics in mechanics such as displacement-time and velocity-time graphs and simple harmonic motion, etc. Most students will be familiar with GeoGebra from their study of Project Mathematics. Sketchometry is less well known but is also very useful in both a Physics and Mathematics lesson.

You will need...

- ✓ PC, laptop, tablet or smartphone
- ✓ Free software, downloadable from:

  https://www.geogebra.org/

  http://en.sketchometry.org/index.html
- ✓ Dynamics cart, track and ticker tape apparatus

Follow these steps

1. Using the traditional dynamics cart, track and ticker tape apparatus (or air track and photogate or datalogger and motion sensor), students record the displacement of the cart from its starting position after 0, 2, 4, 6, seconds etc. until it comes to rest.
2. Students plot this data using the graphing function in either GeoGebra or Sketchometry.
3. Students analyse the shape of the resultant graph and comment upon the motion of the cart – is the cart:
4. at rest?
5. moving at constant velocity?
6. experiencing a constant acceleration?
7. Experiencing a varying acceleration?
8. Using the slope function in either GeoGebra or Sketchometry, students should be able to mathematically confirm the motion of the cart at various stages during its journey.

So what happened?

The data collected for displacement versus time will depend upon the slope of the track. Upon fitting a line of best fit to these points, a line or curve will be formed. Students should consider the significance of the slope of such lines or the slope of tangents at different points on the curve. Students should link the shape of line or curve with slope data and also appreciate how the line or curve and their corresponding slopes reflects the motion of the cart.

✓ What next?

1. As an extension, students should also collect data for velocity versus time and repeat the above steps for with respect to a velocity-time graph.

Home-made Euler's disc

Euler's disc from computer hard drives (UK)

Background:

Euler's disc is a heavy smooth disc that is made to spin on a smooth flat surface. There is a paradoxical dramatic speed-up in spin rate as the disc loses energy and approaches a stop.

The commercially available toy consists of a heavy, thick chrome-plated steel disk and a rigid, slightly concave, mirrored base. The rigid mirror is used to provide a suitable low-friction surface. The slightly concave surface keeps the spinning disk from "wandering" off.

You will need...

(per group)

✓ Several "hard-drive" discs

✓ strong glue

✓ a large concave mirror.

Follow these steps

1. Glue the hard-drives together while they rest on a spindle to ensure they are perfectly concentric.
2. Place the concave mirror so that it will remain perfectly steady on a horizontal table.
3. Set the disc spinning on the surface of the mirror.
4. Observe.

So what happened?

As the disc begins "spolling" which means spinning and rolling it produces a captivating sonic hum. As the disc spolls around in a circle it is held in place by a balance of the gravitational force pulling the disc down and the force applied by the mirror base which holds the disc up.

What next?

The disc's energy eventually dissipates through friction, vibration and the emission of sound. The noise can be quite dramatic before a sudden silence when all motion ceases.

Measurement of capacitance

Investigating the relationship of common area and distance with capacitance (Czech Republic)

Background

As there is not a lot of investigation traditionally done in this area, these small quick experiments can be used for students to develop an understanding of the factors the affect capacitance in parallel plate capacitors.

You will need...

- ✓ Aluminium Foil.
- ✓ A book (about 300 pages)
- ✓ Multimeter with capacitance measurement
- ✓ Wires with crocodile clips
- ✓ Callipers (digital, if available).

Follow these steps

1. Use a digital callipers to measure the thickness of 50 pages, i.e. from page 1 to page 100. Calculate the thickness of one page.
2. Cut out two piece of aluminium foil and place them on page 1 and page 31 of your book.
3. Record the capacitance between them in nF.
4. Repeat by putting the second foil on page 60, 90, 120, 150, 180, 240 and 300.
5. Draw a graph of "C vs. d" and "C vs. $1/d$".

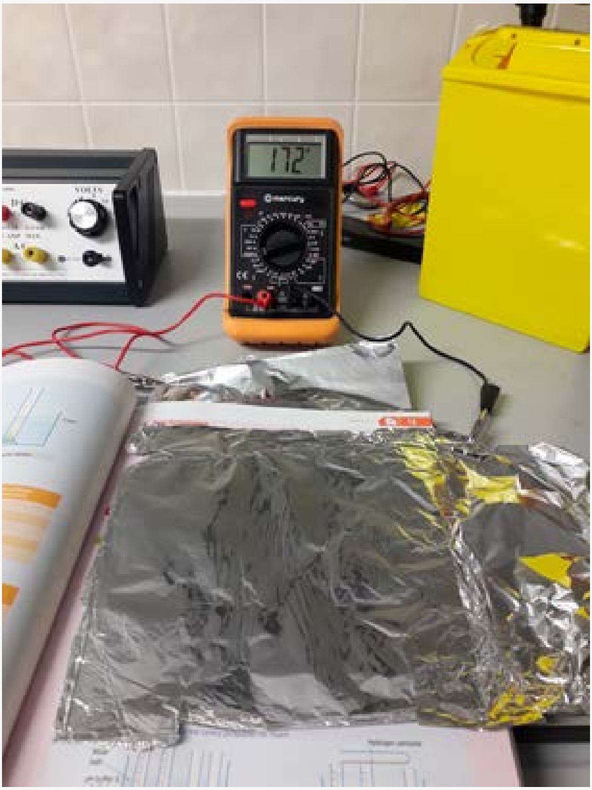
So what happened?

In the first graph we see a asymptotic decrease typical of inverse relationships. For the second graph we get a straight line through the origin.

Using the area of the foil and the slope from the second graph, we can work out the permittivity of the paper.

What next?

1. This whole investigation can be done by recording various areas, while keep distance between pages constant.
2. Using other materials out than books, we can work out the permittivity of many materials.



Let the music flow through you

Using your body as a conductor to connect an mp3 player to an amplifier and speaker

Background

A common misconception students reveal in school is that the human body is an insulator. When they do experiments with light bulbs using their skin, they get a negative result. This experiment shows that humans conduct electricity, though it's a small current because the human body has high electrical resistance. To overcome this, we need to use an amplifier to boost the signal.

You will need...

- ✓ 30 W guitar amplifier
- ✓ a guitar lead
- ✓ an audio lead (coaxial cable with 3.5 mm jack plugs at each end)
- ✓ MP3 player or other audio source
- ✓ 2 crocodile leads.

Follow these steps

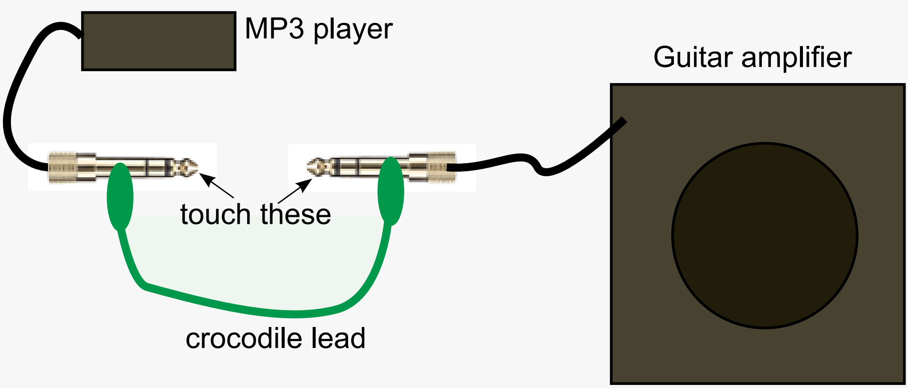
1. Plug one end of the audio lead into the earphone socket of the MP3 player. Plug the guitar lead into the amplifier.
2. Using the crocodile leads, connect the ground of the audio lead to the ground of the guitar lead.
3. Turn on the music and the amplifier.
4. Touch the tip of your fingers off the tips of both the audio lead and the guitar lead. This should complete the circuit.

So what happened?

As the ground and tips of the wires are electrically insulated, they don't form a closed circuit. When you touch the tops of the live, you allow the electricity to flow through you completing the circuit and thus, you can hear the music.

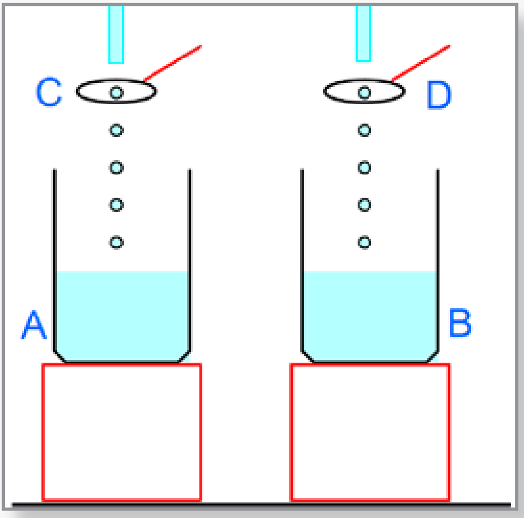
What next?

1. How many people can you make it work with?
2. Does it work better or work with parallel networks of people?



Making sparks

The Kelvin water-powered high voltage generator (Romania)



Background

This high voltage generator was invented by Lord Kelvin in 1867. The key to its operation is the conductivity of water. An electric charge near a conductor (such as water) attracts opposite charges to the side nearest the charge and repels similar charges.

You will need...

- ✓ 2 metal cans on insulated blocks (A & B)
- ✓ 2 wire rings with insulated handles (C & D)
- ✓ 2 sources of drops (e.g. a container with two taps)
- ✓ 3 leads with crocodile clips
- ✓ 1 neon bulb
- ✓ a suitable stand

Follow these steps

1. Set up the apparatus as shown. Connect A to D with one crocodile lead. Connect B to C with the other crocodile lead.
2. Allow the water to flow. The water should form a continuous stream (or be confined to a tube) as far as the two insulated wire rings, **but not beyond them.**
3. Connect the third lead to A and bring the other end near B, but not touching it. After a while sparks may be seen to jump across the gap.
4. Hold one terminal of the neon bulb and bring the other terminal near one of the cans. It should be seen to flash every time there is a discharge.

So what happened?

The cans become oppositely charged to high potential (> 10,000 V). The polarity is unpredictable.

As the drops fall to the cans some may be slightly charged. Let us say that A becomes slightly positively charged. Because D is connected to A, it too becomes positively charged. This induces a negative charge on the water stream at D and so the drops emerging from there bring a negative charge to B, and also to C. This induces positive charge on the water coming through C. The effect rapidly escalates and large opposite charges are built up on the cans.

What next?

1. Explore the effect of bringing a charged rod near one of the water streams at the start.
2. Try wire rings of different size.
3. Arrange the neon bulb to almost bridge the gap between the cans and record the rate of flashing. Find the position of the wire rings that gives the greatest flash rate.

Exploring Lenz’s law

Physical experiments with beverage cans (Czech Republic)

Background

The aim is to show the effect of Lenz’s law.

Lenz’s law: When magnetic flux changes the induced emf opposes the cause producing it.

You will need...

- ✓ Aluminium can,
- ✓ Three strong neodymium magnets
- ✓ Pencil
- ✓ Blu Tack.

Follow these steps

1. Cut off the top of the can.
2. Sharpen a pencil and position it so that it stands vertically on a table with the help of blue-tack (sharp tip upwards).
3. Balance the can on the tip of the pencil.
4. Move the three neodymium magnets quickly in a circle of similar circumference to the can and just above it.

So what happened?

While an Aluminium drinks can is not magnetic, a small electric current called an eddy current can be induced to flow in it by a magnet moving nearby.

The induced current then gives rise to a magnetic field. The interaction of the two magnetic fields gives rise to rotation

What next?

1. Reverse the direction of the circular motion of the magnets.
2. See if the can may be made to move by any other means.

Measure *g* using eddy currents

The effect of eddy currents produced by a falling magnet (UK)

Background

Magnets can generate forces when brought close to a metal even when the metal does not appear to be 'magnetic'.

When magnets are dropped through plastic and copper pipes there is a startling difference in the eddy currents made. A home-made piece of equipment (plastic water pipe with hand-wounds coils at every 5 cm) is used to measure these eddy currents.

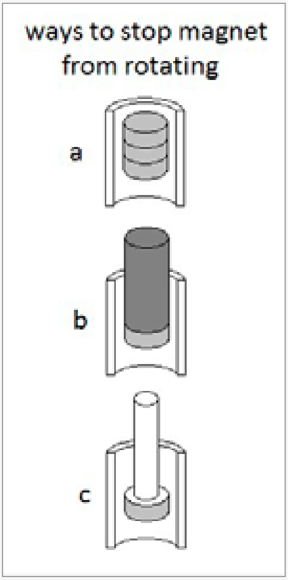
The electrical signal can be recorded by the microphone input of a computer and displayed on the screen. Simple mathematics of the eddy current pulses can be used to measure the acceleration due to gravity.

You will need...

- ✓ Straight copper pipe at least 30 cm long
- ✓ Circular neodymium (rare earth) magnet that will fit comfortably inside pipe
- ✓ Straight plastic pipe for comparison

Follow these steps

1. Drop magnet down plastic pipe and observe.
2. Drop magnet down copper pipe and notice the difference



3. The small electrical signal can be recorded by the microphone input of a computer and displayed on the screen.
4. Simple mathematics of the eddy current pulses can be used to measure the acceleration due to gravity.

So what happened?

A neodymium magnet will fall much slower though a copper pipe than a plastic pipe because as the magnet falls, it creates electric currents in the copper pipe.

These currents are called eddy currents because they circulate like eddies in water.

As they move with the magnet they also create a magnetic field around them.

Lenz's law states that the magnetic field created will oppose the original magnetic field.

These two magnetic fields oppose each other and so the magnet, being repelled, will fall in slow motion.

Uses:

To slow something down, such as brake, often used on trains and roller coasters.

Material separator, metals from non-metals in trash.

Identification of metals, to detect counterfeit coins.

To detect cracks in metals.

What next?

1. Try using more magnets stacked together to create a more obvious effect.
2. Check out relevant websites:

Colourful atomic model

Modelling spectral emission in Bohr models using 'Skittles'

You will need...

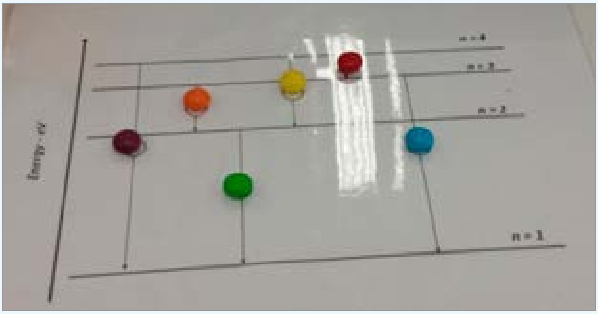
✓ Skittles
✓ Energy level graph

Follow these steps

1. Print out an energy level diagram (sample below).
2. Give students one diagram and skittles of the following colours – blue, green, red, orange, yellow and violet. These represent the photons.
3. Challenge the students to place the right coloured photons on the energy level drops and justify their layout.

So what happened?

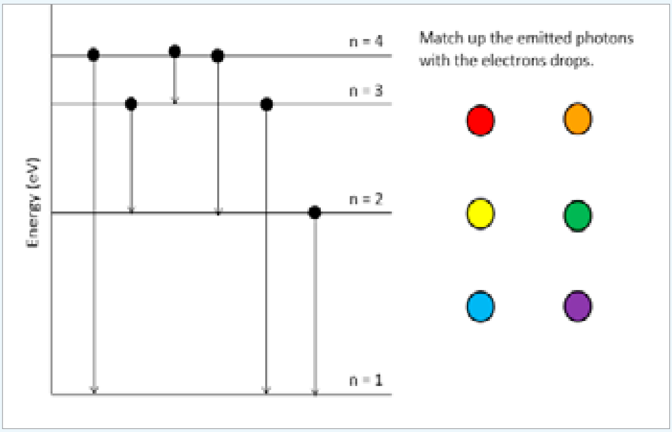
If we consider the visible light section of the electro-magnetic spectrum, the red is the weakest energy photon, while violet is the strongest.



Therefore, students can arrange the electrons from lowest to highest energy in terms of their colours. This allows them to layout the electrons correctly, as the biggest energy jump requires the most energy (n = 4 to n = 1), and the lowest energy is required for the smallest jump (n = 4 to n = 3)

What next?

With a good quality printer, various shades of the colours could be printed with energy level diagrams of different size jumps. Students could arrange them in the same manner and this provides an opportunity for discussion of the unique line spectra emitted by different elements.



Eye spy

A simple model to show how the eye works (Ireland)

Background

Explaining how the eye works usually refers to using diagrams. One such demonstration / model that can be used to show the eye is a bi – lens system to focus images onto a screen.

You will need...

- ✓ Candle / Torch
- ✓ A couple of lenses of various focal lengths.
- ✓ Screen.
- ✓ 2 Lens Holders.

Follow these steps

1. Set up apparatus with two lenses with short focal lengths.
2. The screen represents our retina, the middle lens represents our variable lens, the other lens represents the cornea and the torch represent any object.
3. Move the torch back and forth until you find a position where the image is focused.
4. Move the object back and observe what happens to the image.
5. Ask students how does our eye manage to focus images that are far away.
6. When suggestion of using a different lens is said, change the middle lens, highlighting the a bigger focal length is needed.
7. Use to idea to model the expansion and contraction of the lens as the distance from the object to the eye changes.

So what happened?

Our internal lens is variable, in that, it can change focal length to focus images that are far away. The further an object it, the longer the focal length needs to be. Otherwise the image focuses in front of the retina and the image becomes blurry, which can also be shown using the set up.

What next?

1. Remove the other lens to simulate how our eyes react under water.
2. Breath onto the middle lens to simulate the effect of a cataract in the eye.

Pixels and Colour 1

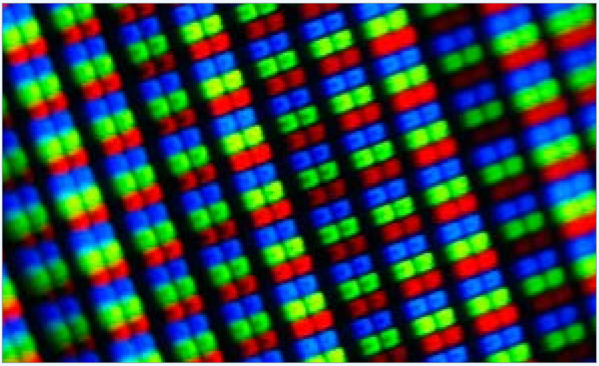
(UK)

You will need...

- ✓ A phone that displays images in colour
- ✓ A microscope.

Follow these steps

1. Get students to put a picture on their phone from their photogallery.
2. Place the phone under a microscope.
3. Observe.



So what happened?

The students will see an array for different colours of red, green and blue. These primary colours can be mixed to give cyan, yellow, magenta and white. Our phones use the information stored to display each pixel at certain intensities. As they are so close together and there is a high number of them, we see a clear image. The closer and small these pixels can be made, the higher quality images we can see.

What next?

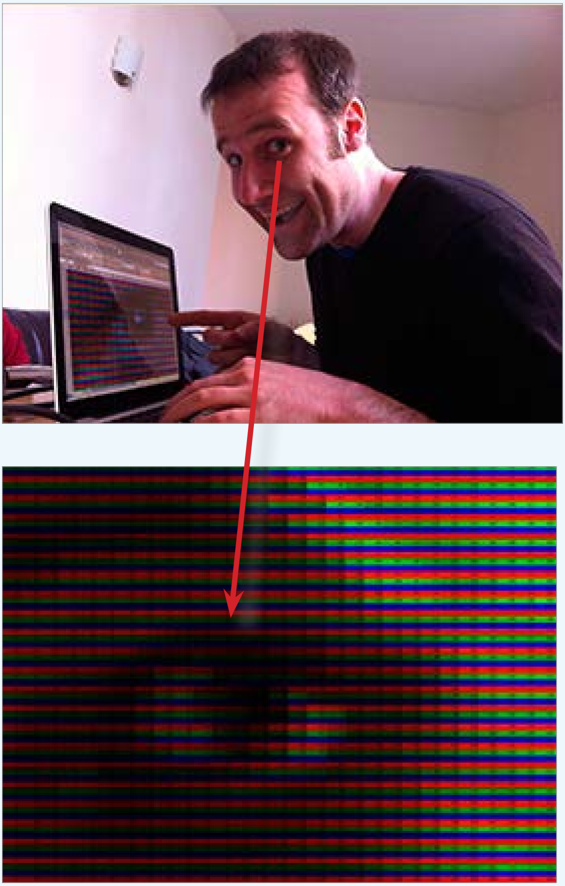
Get students to move their images around under the microscope. This will demonstrate for them how the intensity of each pixel changes when they combine to give different colours in the image.

Pixels and Colour 2

Colour mixing (UK)

You will need...

✓ Internet access
✓ A digital photograph.



Follow these steps

1. Go to http://www.think-maths.co.uk/spreadsheet
2. Upload the photo and download the converted excel file.
3. Open the file in Excel.
4. Zoom out.

So what happened?

The cells in Excel file are coloured in the same formatted as an RGB display (RGB: Red-Green-Blue). The numbers indicate the intensity of each colour shown. Intensities range from 0 to 255.

When you zoom out of the image, the cells become small and close together, similar to the pixels on a phone. This allows us to see the image that was uploaded.

What next?

Showing students how changing cell values changes the colour can lead to a discussion on the processes involved in digital photo editing.

The eye as an optical system

The eye as an optical system (Denmark)

Background

The human eye is able to form clear images of objects at various distances from the eye. The cornea and elastic lens are responsible for refracting light and bringing it to a focus on the retina. The elastic lens changes shape in order to clearly focus light from objects at different distances in front of eye on the retina – this is referred to as ‘accommodation’.

You will need...

- ✓ Convex and concave lenses of various focal lengths
- ✓ Glass sphere filled with water
- ✓ Laser (or other light source, for example, a candle)
- ✓ White card
- ✓ Ruler and Blu-Tak

Follow these steps

1. Fill a glass sphere with water – this is analogous to the vitreous humour.
2. Position a sheet of white card against the back of the glass sphere – this is analogous to the retina.
3. Position the first convex lens 3 cm in front of the glass sphere – this is analogous to the cornea.
4. Dim the lights in the laboratory and place a laser in front of this first lens.
5. Turn on laser and adjust the position of white card until a sharp image is formed on same.
6. Now return the card to its original position, i.e. in contact with back of glass sphere.
7. Position a second lens (either convex or concave of different focal lengths) somewhere between the first convex lens and the front of the glass sphere until a sharp image is formed on card in its original position – the second lens is analogous to the elastic lens in the eye and the sharp image formed on card is analogous to clear image being formed on the retina.

So what happened?

The rays of light converge on the back of the glass sphere filled with water and an image is formed on the card. By looking in from the side, it should be possible to see the laser light changing direction upon passing though lens, i.e. refraction, and travelling through water in glass sphere.

What next?

Students should be asked to investigate the effect, if any, of varying the following factors:

1. Position of laser; position of first convex lens
2. Focal length of first convex lens
3. Diameter of glass sphere filled with water
4. Placing a perpendicular glass block between laser and first convex lens; changing the angle of this glass block with respect to laser
5. The colour of the laser.

Can you light a candle with a piece of glass?

Background:

Simple explanation

Reflection: light is bounced back from a surface

Advanced explanation

Reflection is the change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated.

You will need:

✓ a lighted candle
✓ an unlit candle
✓ a piece of glass

Follow these steps:

1. Arrange the candles about 20 cm apart as shown in the picture.
2. Light the candle nearest to you.
3. Insert the piece of glass halfway between the candles and perpendicular to the line between the tops of the candles.
4. When the reflection of the flame of first candle coincides with the wick of the second candle, both candles appear to be lighting.

Absorbance of diapers

Absorption capacity of diapers (Belgium)

Background

Students are asked to investigate the material present in diapers that is responsible for the absorption of water. This activity may be used as a means of introducing students to inquiry-based learning (IBL) methodologies.

You will need

- ✓ Diapers
- ✓ Reference materials including cloth, cotton wool, swim diapers, etc.
- ✓ Beakers
- ✓ Water and syringes
- ✓ Scissors and mass balance

Follow these steps

1. Ask students why the majority of today's parents and guardians use disposable diapers rather than the re-usable cloth diapers that were widely used in the past.
2. This question and subsequent discussion should be 'buffered' to arrive at the likely prediction that "disposable diapers absorb water better than cloth diapers". The teacher should facilitate students to frame this prediction as a testable hypothesis.
3. Students design a method to test their hypothesis paying particular attention to independent variables, dependent variables, controlled (fixed) variables and a suitable control.
4. Students conduct their investigation and gather necessary data.
5. Students analyse data.
6. Students evaluate original hypothesis in light of analysis of their own data.

So what happened?

The various materials will have absorbed water to different degrees. In particular, the diaper will have absorbed more water than either cloth or cotton wool of same dimensions and/or mass.

What next?

1. Students should be asked to examine the composition of a diaper and note the different materials used in each layer, specifically the bead-like sodium polyacrylate. Students should collect a sample of each material used in the manufacture of the diaper and design another investigation to determine which of these materials is responsible for absorbing most water.
2. Students should research other commercial uses of sodium polyacrylate.
3. Students should consider the environmental impact of the disposable diaper industry.

Students should consider the following questions:

- What other considerations need to be taken into account in diaper design?
- Would you expect normal diapers or swim diapers to be more or less absorbent?
- Urine is not simply water; it is an acidic solution of urea and salts. Will the acidic nature of urine need to be considered in diaper design?

Bulletproof ice

How to teach material Science using Pykrete (UK)

Background

Pykrete was a material proposed by Geoffrey Pyke during World War II.

It was in response to a demand for tough materials.

You will need

✓ Water
✓ Saw-dust
✓ A plastic container
✓ A freezer

Follow these steps

1. The ideal mixture seems to be 14% saw-dust (or wood pulp) and 86% water. This must be well mixed to ensure that it doesn't separate as it freezes.
1. Place the mixture in a freezer over-night and remove the mould the next day.

So what happened?

The various materials will have absorbed water to different degrees. In particular, the diaper will have absorbed more water than either cloth or cotton wool of same dimensions and/or mass.

What next?

Pupils can devise various tests of their own to see how tough the material is.

Possibilities include:

- Dropping from various heights until it smashes.
- Compressing with a G-clamp until it cracks…. counting how many twists
- Spike test: Pace a large nail with its tip on the ice. Using a suitable pipe as a guide, drop various quantities of 100 gram slotted masses through the pipe and record the depth of penetration of the nail each time.

Will it overflow?

How our eyes interpret volume (UK / Poland)

Background

This experiment is a nice way to show the relationship of a radius of a cone, its height and its volume.

You will need...

- ✓ 2 identical cocktail glasses
- ✓ Water

Follow these steps

1. Fill one glass with water and empty water from one into the other, so they are equal height, in the prep room.
2. Ask the students to predict whether the glass with overflow, be full or be under full.

So what happened?

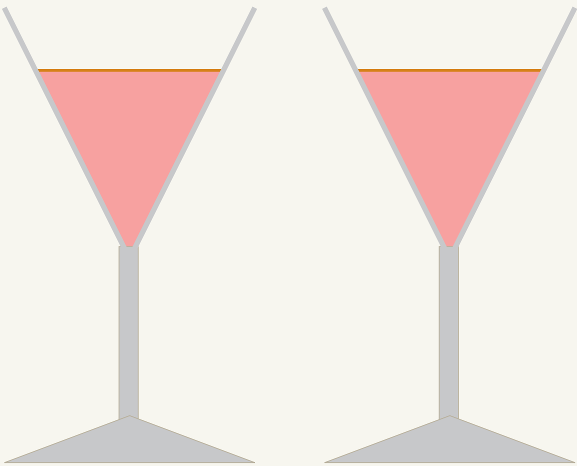
Due to the diverging nature of the shape, the volume of the water that the glass can contain increases as the height increases. Initially, there is little space and so the height increases rapidly but as the water gets higher, there is more space for the water to occupy. This is a good way to show the logarithmic growth.

What next?

1. Get students to work out the ratio of the heights mathematically using the volume formulae and similar triangle rules to show the ratio between the heights is given as:

$$\frac{h_1}{h_2} = \sqrt[3]{2}$$

2. A similar way to show how we perceive volume in different shapes is to get multiple containers that hold the same amount of liquid and fill them up, asking students to rank them in terms of how much water they contain.



Learning by Doing in Mathematics

Background

'Learning by doing in mathematics' promotes the collaborative and experimental way of learning. Using specific shapes/objects, learners make connections between knowledge and experience by solving puzzle activities. The use of the simple 2D equilateral shape like a triangle, or a square, to build 3D polyhedrons, encourages teachers and students to think differently about the learning of mathematics.

You will need...

✓ 1 metre wooden/plastic poles

✓ Plastic tubes 10–15 cm lengths (joined together in twos or threes by a nut and bolt, to allow construction in a number of planes).

Follow these steps

1. Using the wooden poles and plastic tubes, students explore constructing 2D and 3D shapes like triangles, squares, rectangles and tetrahedron, cube, octahedron and more.
2. Students can identify the number of faces, vertices and edges for each shape and record this in a table (see below).
3. Using Euler's formula students can learn about Platonic solids and homeomorphic objects
4. A vertex is a corner. An edge joins one vertex with another. A face is an individual surface.

Euler's Formula

For many solid shapes the number of faces plus the number of vertices minus the number of edges always equals 2.

This can be written:
$F + V - E = 2$

A cube has 6 faces, 8 vertices, and 12 edges:

$6 + 8 - 12 = 2$

Try to construct other polyhedrons and apply Euler's formula and see what you find;

So what happened?

Exploring shapes and objects by making them, shows patterns and connects real observable mathematics with theoretical mathematical formulae such as Euler's formula.

Students get the opportunity to discover:

- 2D and 3D shapes, objects, polygons, polyhedrons
- Euler's formula: $F + V - E = 2$
- Platonic solids
- The 5 platonic solids
- Euler's characteristics
- Homeomorphic objects (Platonic solids and sphere, doughnut and coffee cup)

A platonic solid is one of five regular solids (a tetrahedron, cube, octahedron, dodecahedron, or icosahedron). They are special because every face is a regular polygon of the same size and shape. Example: each face of the cube is a square.

What next?

Check out the following references for more about 'Learning by doing mathematics':

Polyhedra, Learning by Building: Design and Use of a Math-Ed. Tool by Simon Morgan Rice University School Mathematics Project Rice University, email: smorgan@math.rice.edu

https://www.mathsisfun.com/geometry/eulers-formula.html

Name		Faces	Vertices	Edges	F+V-E
Tetrahedron		4	4	6	2
Cube		6	8	12	2
Octahedron		8	6	12	2
Dodecahedron		12	20	30	2
Icosahedron		20	12	30	2

Under Pressure

Showing the relatioship between force, area and pressure (Ireland)

Background

This is a simple way to show the relationship between force, area and pressure.

You will need...

✓ A block of wood with nails in it.

✓ A balloon.

Follow these steps

1. Blow up the balloon.
2. Ask students how it will react if one nail is pushed into it.
3. Burst balloon.
4. Ask students to predict how a second balloon will react if the block of nails is used, since there are now more points.
5. Burst the second balloon.

So what happened?

As there is more area on the surface on the nails, more force is needed to burst the balloon. We assume that the pressure to burst the balloon is constant and thus we can easily show the affect of increasing surface area and pressure.

What next?

1. Relate pressure to diving, the ‘bends’, etc.
2. Crushing a can using atmospheric pressure.

The world of fountains

Make a fountain in a bottle (Poland)

Background

The operation of these fountains seems at first to go against the laws of hydrostatic pressure. On closer examination they demonstrate those laws very well.

You will need...

- ✓ 4 2-litre clear plastic bottles with caps
- ✓ About 2 m of rigid plastic tubing (ca. 6 mm in diameter)
- ✓ Drill and 6 mm bits
- ✓ Glue gun

Follow these steps

Fountain 1

1. Cut two lengths of tubing (e.g. 40 cm and 20 cm)
2. Drill two holes in the cap of the bottle and seal the tubes in place as shown in the diagram
3. Cut one bottle across the middle. Use the bottom part for container A. (Keep the top part for Fountain 2.)
4. Fill container A. Half fill bottle B and then screw on the cap. Invert B as shown.

Fountain 2

(more complicated)

1. Cut three lengths of tubing (55 cm, 36 cm and 32 cm)
2. Stick a bottle cap onto the bottom of bottle B with hot glue.
3. Drill two 6 mm holes through the cap (and the bottle).
4. Stick two other bottle caps together using hot glue (back to back). Drill two 6 mm holes through them. Screw this tightly onto bottle B.
5. Insert the three tubes as shown and seal them in place with a small amount of hot glue. (This step is not easily reversed.)
6. Screw the top half of a bottle onto the base of B.
7. Fill bottle C with water and screw it in place. Invert the assembly and wait for the water to flow for C to B.
8. Turn the assembly upright (as in the diagram) and pour some water into A. Observe the fountain in A.

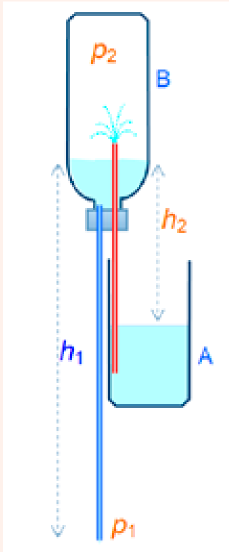
So what happened?

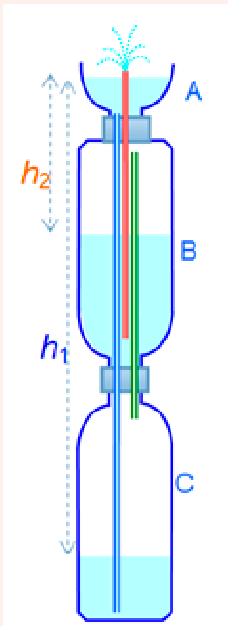
Fountain 1

The pressure p_1 is atmospheric. The pressure p_2 is less than p_1 by the hydrostatic pressure due to $h_1 - h_2$.

Fountain 2

Water initially poured into A goes directly into C. This compresses the air in C and in B. The excess pressure eventually forces water from B into A and forms a small fountain.





Lift a can with your breath

Bernoulli effect with beverage can in a mug (Czech Republic)

Background

Bernoulli described an effect that bears his name when he wrote his book Hydrodynamica in 1738.

In his study of fluids in motion he observed that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure. In this example, the fluid is air and when it moves rapidly over the top of the can, the downward pressure decreases and so uplift occurs.

You will need...

✓ Aluminium can

✓ A mug

Follow these steps

1. Empty the can. Place it inside the mug.
2. Hold the mug in front of your mouth. Blow a lungfull of air horizontally at the rim of the mug (as if trying to extinguish a candle)

So what happened?

The can will rise up and may in fact come out of the mug completely and follow a parabolic trajectory to the floor.

What next?

Replace the can in the mug and blow again, but this time try to catch the mug before it lands. This will test your speed of reaction and dexterity.

Air-driven paddle wheel

Physical experiments with beverage cans – Air pressure (Czech Republic)

Background

Boyle's law tells us that if the volume of a gas is reduced, the pressure of the gas increases.

You will need...

- ✓ Two aluminium cans (one slender enough to fit inside the other)
- ✓ A straw,
- ✓ A coat-hanger,
- ✓ Paper and scissors.

Follow these steps

1. Cut and remove the top of the wide can. Cut and remove the bottom of the slender can.
2. Make a simple paddle wheel using paper and a scissors, with a straw as an axle.
3. Cut and bend a wire coat-hanger to provide a frame for the paddle wheel to spin.
4. Fix the frame to the top of the slender can. Make a small hole in the upper surface of the slender can where the red spot appears in the photograph.
5. Half-fill the wide can with water.
6. Move the slender one up and down.

So what happened?

The paddle wheel will be observed to rotate because compression of the air (above the water) causes an increase in pressure in the air. Some air is then forced out through the hole, which causes the paddle wheel to rotate.

What next?

Investigate how the speed of the paddle wheel is affected by the rate of change of the air-pressure inside the cans.

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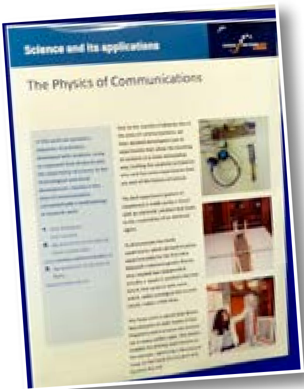
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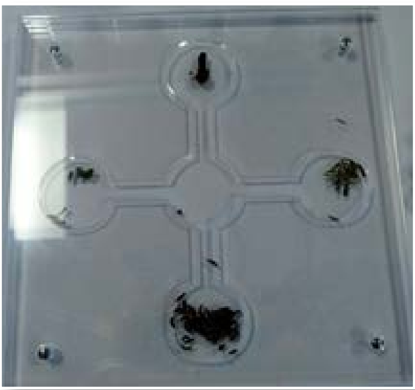

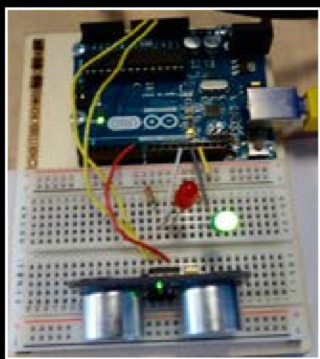

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