SCIENCE on Stage 2019

Demonstrations and teaching ideas

selected by the Irish team

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Science on Stage 2019
Demonstrations and teaching
Ideas selected by the Irish team
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Science and everyday life cannot and should not be separated.

Rosalind Franklin

Biology is the study of the complex things in the Universe.
Physics is the study of the simple ones.

Richard Dawkins

I like to learn. That's an art and a science.

Katherine Johnson

If I have seen further than others, it is by standing
upon the shoulders of giants.

Isaac Newton

Disclaimer

The National Steering Committee for Science on Stage Ireland 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. SOS (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 SOS. 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.

www.scienceonstage.ie/

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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 Estoril Congress Centre in Cascais, Portugal on the 31 October to 3 November 2019. Under the motto “Skills for the Future” 450 primary and secondary school teachers from 30 countries shared experiments and teaching ideas for science, technology and mathematics education at stands, in workshop and on stage over four days in Cascais.

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 on-stage 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 Institute of Physics in Ireland. Science on Stage Ireland gratefully acknowledges funding support received from the Science Foundation Ireland 2019 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 2019 contributors: Declan Cathcart, Máire Duffy, Rory Geoghegan, David Keenahan, Seán Kelleher, Sinead Kelly, Aoife McDonnell, Eilish McLoughlin, Thomas McMahon, Paul Nugent and Jane Shimizu. 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 2019 Science on Stage festival 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 SOS2019 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/SOS booklets, please visit: www.scienceonstage.ie/

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

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

SOS2019 Team and Contributors

A team of nine delegates represented Ireland at the 2019 European Science Teaching Festival “Skills for the Future” held in Estoril Congress Centre in Cascais Portugal. The team consisted of:

- Eilish McLoughlin, School of Physical Sciences & CASTeL, Dublin City University – Team Lead;
- Paul Nugent, Santa Sabina and IOPI teacher network coordinator – SonS Board Member;
- Declan Cathcart, Temple Carrig School, Wicklow;
- Máire Duffy, Clonkeen College, Blackrock, Dublin;
- Seán Kelleher, Coláiste Choilm Swords;
- Sinead Kelly, St. Olivers Community College, Drogheda;
- Aoife McDonnell, PDST Technology in Education;
- Thomas McMahon, Firhouse Community College, Dublin;
- Jane Shimizu, Scoil Chaitríona Junior, Galway.

At the festival Paul Nugent, co-Chair of Science on Stage in Ireland, was re-elected to the executive board of Science on Stage Europe.

Irish Science on Stage team in Cascais in October 2019.

Left to right: Eilish McLoughlin, Declan Cathcart, Aoife McDonnell, Máire Duffy, Thomas McMahon, Seán Kelleher, Jane Shimizu, Sinéad Kelly and Paul Nugent.

The survival game

(Ireland and Denmark)

Background

This is a classroom-based game with a storyline that builds on the previous activity. A series of cards bring student groups through a sequence of environmental changes that affect the population of organisms in which there are several different coloured varieties. Students observe the effect of different environmental pressures on the population over a few generations. The colour of organisms is seen to influence their ability to survive and reproduce, passing on their traits (colour) to their offspring.

You will need:

- ✓ The story cards as shown.
- ✓ Different Coloured counters

Follow these steps:

1. Students work in groups of four.
2. Each student is assigned a different colour counter.
3. The story begins with a population containing four different coloured variants of the same species.
4. Students take turns to read out the cards.
5. The population is adjusted according to the instructions on the cards.

So what happened?

The relative numbers of different coloured variants changes over generations. Different environmental pressures result cause changes in the population. Possessing a particular colour is a selective advantage in some circumstances, but in another environment is a disadvantage. Biotic and abiotic factors can be identified by students.

What next?

The sequence of the cards can be rearranged to investigate if the population changes are different. Dice can be introduced and the story can be adapted as a game in which each student represents a particular coloured variant of the species, and a dice roll can introduce the element of chance into the survival of that particular variant.

There is plenty of food, so your population survives and reproduces. Add 5.
There's lots of food and hiding places for the green and blue, but the red ones can't hide and get eaten.
When food is plentiful again the remainder mate and produce 5 offspring some white and some yellow.
It's winter and 5 of your population die.
It is a particularly hot summer, blue and green are poor temperature regulators; white and yellow, which reflect heat, are much more likely to survive.

The bright yellow of some of your offspring attracts predators. All but two of them get eaten.
There is plenty of food when spring arrives, so another 10 offspring are born. There is a variety of colours.
There is plenty of food when spring arrives, so another 10 offspring are born. There is a variety of colours.
The bright red colour attracts mosquitoes carrying a deadly disease. They all die.
There is lots of food, and all reproduce 2 offspring, but the whites are better at finding water and hiding from predators so they produce 5 offspring.

Biology

Beaky feeding frenzy

(Ireland and Denmark)

Background:

This game activity involves students choosing a 'beak' type (forceps, clothes pegs, bulldog clips, spatulas etc.) and being timed to see how many food items they can collect from a pool of mixed food (beans, rice, rubber bands etc.). The food types can then be changed or restricted to see which beak type is best adapted to the available food. The activity illustrates adaptation.

You will need:

For each group:

- ✓ As beaks: fine forceps, clothes pegs,
- ✓ tongs, bulldog clips,
- ✓ As food types: dried beans, rice,
- ✓ dried pasta, elastic bands.
- ✓ Cups or beakers
- ✓ Stopwatches

Follow these steps:

1. Students work in groups of four. Each student chooses a beak type (forceps, clothes peg etc.)
2. Each student is given 30 seconds to collect as many food items as possible by putting them singly into the cup (the bird's 'stomach'), using only the beak they chose.
3. The data is recorded in a suitable table and repeated for different food types. Averages are calculated and displayed on a bar chart.
4. The process is repeated using an equal mixture of different food items.

So what happened?

If food items are not replaced between each student's turn, a food shortage scenario can be developed, in which any bird that doesn't collect a minimum number of food items dies off.

Surviving birds can also reproduce. Offspring with the same beak can then join the group of feeding birds and take a turn. Beaks that are suitable for collecting more than one type of food may have an advantage over a beak that can very efficiently collect only one food type.

What next?

- Data from each group can be compiled and displayed on a digital spreadsheet and bar chart using Excel or similar. Differences between groups in terms of beak success could be explored – certain individuals may have learned how to use their beak in a different way to collect a food type it didn't initially feed on. Some beaks could be used as hooks or scoops as well as pincers.
- There are some other versions of this activity on the internet, and there is plenty of scope for extending this activity, perhaps by creating a storyboard or a game.

Water Pollution with Nail Polish

(UK and Italy)

Background

A joint project, named 'Beyond Water', between a primary school and secondary school.

The project focus was not to explain water but use water to provoke students' interests in all the scientific laws they connect.

Here we will use the visual effect of drops of nail polish on water, to imagine the effect of a larger scale oil spillage/pollution of water and its possible effect on habitats and species.

You will need:

- ✓ A sheet of black card cut into rectangular pieces
- ✓ Bottle of clear nail varnish (other nail varnishes will work but will leave a colour stain on the card)
- ✓ Water in a shallow dish

Follow these steps:

1. Fill the shallow bowl with water.
2. Cut off a large piece of the black card.
3. Place card in water and submerge, holding card down at edges with finger tips.
4. Add 1 drop of nail polish to the water.
5. Observe the colours that appear and the depth of the colours in the water.
6. Slowly lift the black card out of the water (here the coloured part of the water will move).
7. Aim to catch the coloured area of the water onto the black card.
8. Set aside the card to dry.

So what happened?

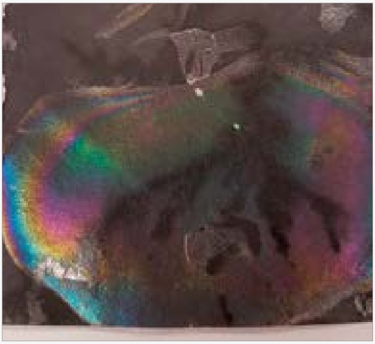
The nail polish disperses across the surface of the water. Light is reflected from the film of nail polish floating on the water. It will be a spectrum of colours, as seen in the images. The colourful interference pattern is seen when light is reflected from the top and bottom boundaries of the nail polish. Similar to an oil film on water.

You may also notice that the colours on the black paper change when you tilt the paper back and forth. This happens because light hits the paper at different angles as you tilt it.

What next?

The result you see on the card is only the effect of one drop of nail polish. What would the effect be on a larger scale? Discuss pollution of waters, how the nail polish being present in the water may affect the habitats and species that are present.

Extension: Repeat the above steps and use 2 drops of nail polish, then 3 drops etc. This could also be repeated throughout the class with each group of students adding different amount of drops of nail polish and the colour difference can be observed and discussed.



Biology

Game of clones

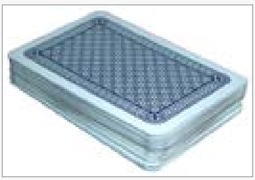
(Ireland and Denmark)

Background:

This is a role-play activity in which student act as bacterial cells. Student are dealt a set of five playing cards, and the ratio of red cards to black cards determines their ability to survive doses of antibiotic. During reproduction, a six-sided die is rolled by students to introduce mutation events (changing the number of red or black cards). The effect of antibiotic treatment on the population was observed and recorded – results showed the increase in antibiotic resistance of the bacteria over several generations.

You will need:

✓ 2 packs of playing cards
✓ Dice



Follow these steps:

1. Ten students (bacteria cells) are given five cards each at random from one pack of cards and stand together in an area of the classroom.
2. This first generation of 'bacteria' are then 'treated with an antibiotic'.
   a) Students with three or more red cards are more able to survive. They stay in the group.
   b) Students with less than three red cards are killed off by the antibiotic. These students join the rest of the class again.
3. The surviving bacteria are able to reproduce and their 'offspring' (new students added to the group) have the same genes (colour cards) as their 'parents'. However, before joining the population, each new individual can role a single die before they receive their 'genes'.

   a) If they role a 5 or a 6, they will receive one more red card to replace one of their black 'genes' (cards).
   b) If they role a 1 or a 2, they will receive a black 'gene' instead of a red 'gene' they would receive. These changes in genes are mutation events.
4. The next generation of individuals are again treated with an antibiotic and the process is repeated for as many generations as time allows, or until the antibiotic has no effect on the population any more.

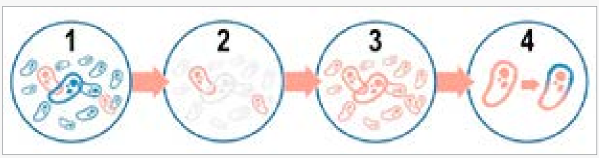
Note: it might be more 'realistic' if every individual rolls the die (the chance of acquiring a mutation) and not just new individuals, but it is quicker if only new students roll the die.

So what happened?

Over a few generations, the antibiotic becomes less effective as the relative number of antibiotic resistant bacteria increases.

What next?

If the antibiotic treatment becomes ineffective, the concentration of antibiotic can be increased, so that only those 'bacteria' with four or more red cards survive. The storyboard can also include bacterial cells transferring resistance genes (by conjugation) to other bacteria in the population.



Hunting jelly beans

(Ireland and Denmark)

Background

An outdoor role-play predator-prey game activity was carried out as a model of adaptation. A student "predator" captures as many coloured jellybean "prey" as they can in 10 seconds from a 3m x 3m grassy area. Students recorded the numbers of each colour and group data was collated back in the classroom. The data was analysed, and inferences were drawn. Student ideas and conclusions were elicited through questioning.

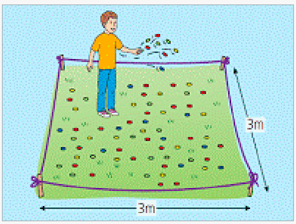
You will need:

✓ 40 coloured jellybeans
✓ Stopwatch
✓ Pen and paper

Follow these steps:

Students work in groups of five. One student will be the predator, and four others are each assigned a different colour jellybean ('prey'). One of the four can also be timekeeper, another can be data recorder.

1. Pace out a roughly 3 m x 3 m square area (the hunting area) on the grass.
2. The 'prey' students each take 10 jellybeans, a different colour for each student. One student gets green, another blue etc.
3. The prey students stand at the four corners of the area, and while the predator turns her back on the area, the jellybeans are thrown randomly within the hunting area.
4. The timekeeper starts the clock (10 or 20 seconds depending on the length of the grass) and the predator gathers as many jellybean prey as she can in that time.
5. The number of each colour jellybean captured by the predator is recorded in a suitable table.
6. The hunt is repeated a few times and the capture frequency is recorded each time.



	Green	Brown	White	Orange
Hunt 1	1	1	3.33	3
Hunt 2	0.75	0.75	4	3.25
Hunt 3	0.67	1	0.67	2
Mean capture frequency	0.65	0.91	2.66	2.75

So what happened?

- Averages are calculated for each colour jellybean as a 'capture frequency' (i.e. numbers caught by the predators).
- Each group can present their results in a suitable chart.
- Groups can also combine their data in a whole class table or results displayed on the classroom board.
- Combined data can be presented as a chart and can be compared to the group charts.
- Survival probabilities could be calculated

What next?

- Why are there survival differences within the jellybean population?
- Which prey are better adapted to survive the predator?
- What would happen to this population of jellybeans over a long time?
- Explain how changes in the population occur.

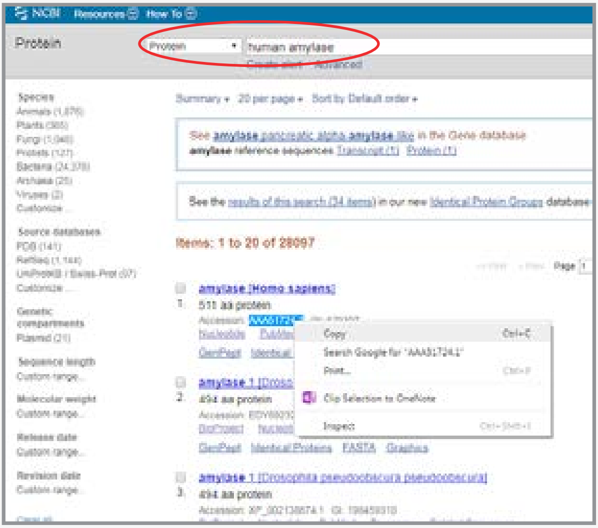
Biology

My cousin is a fruit fly

(Ireland and Denmark)

Background:

Student were introduced to the online protein and DNA sequence tools GenBank and Blast, and shown how to use these tools to search for amino acid sequences, and carry out multiple sequence alignments. By aligning the sequences from a diverse range of organisms (mammals, insects, fungi, bacteria etc), students were able to show their percentage similarity as an indicator of their evolutionary relatedness. This led to the introduction of the concept of the phylogenetic tree, and the idea of a universal common ancestor.



You will need:

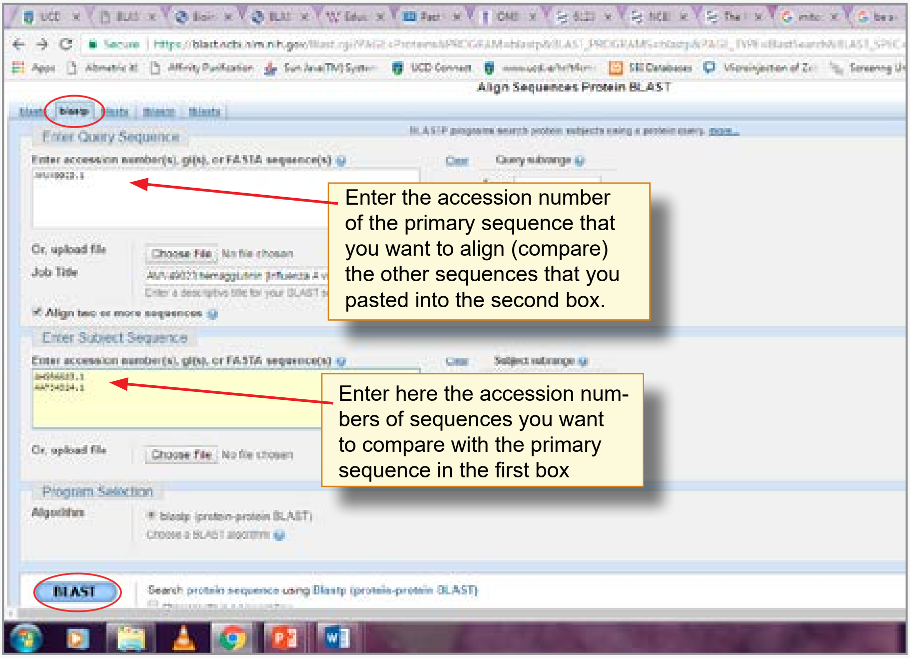
✓ Tablets or PC's with internet access

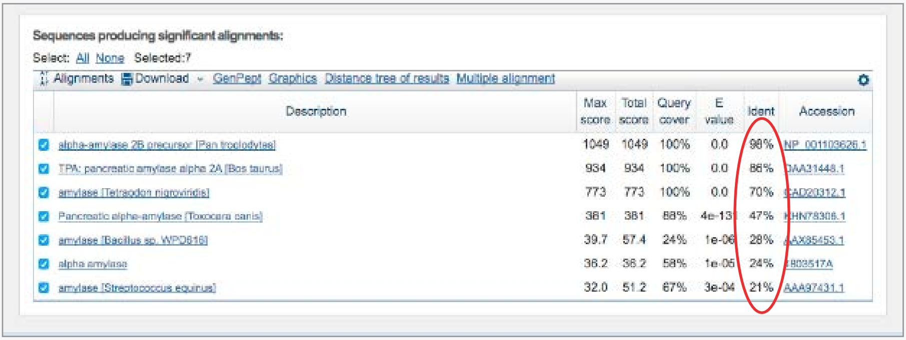
Follow these steps:

1. Go to the **NCBI GenBank** website and select "**Protein**"
   Search for a protein that is common across the living world. Amylase is a protein familiar to most students. Cytochrome C is also quite ubiquitous, and makes a good "molecular chronometer" (steady mutation rate, good for constructing phylogenetic trees).
2. Copy the database **accession number** of the amino acid sequence for the human protein.
3. Open a new browser window and go to the BLAST sequence alignment tool website.
4. Paste the accession number from Genbank into the BLAST tool. Click on "Align two or more sequences"
5. Return to Genbank and find the accession numbers of the protein as found in other species.
6. Paste those accession numbers into BLAST, using return to separate each one after pasting.
7. Click the big blue "BLAST" button to align the multiple sequences.

So what happened?

BLAST results show the percentage similarity between the sequence of the molecule (e.g. amylase) from humans and that of other species. Sequence alignments can also be viewed in the results.





Sequences producing significant alignments:

Select: All None Selected:7

Alignments Download GenPept Graphics Distance tree of results Multiple alignment

Description	Max score	Total score	Query cover	E value	Ident	Accession
alpha-amylase 2B precursor [Pan troglodytes]	1049	1049	100%	0.0	98%	NP_001103626.1
TPA: pancreatic amylase alpha 2A [Bos taurus]	934	934	100%	0.0	86%	DAA31448.1
amylase [Tetraodon nigroviridis]	773	773	100%	0.0	70%	CAD20312.1
Pancreatic alpha-amylase [Toxocara canis]	381	381	88%	4e-131	47%	KHN78306.1
amylase [Bacillus sp. WPD616]	39.7	57.4	24%	1e-06	28%	AAX85453.1
alpha amylase	36.2	36.2	58%	1e-05	24%	1803517A
amylase [Streptococcus equinus]	32.0	51.2	67%	3e-04	21%	AAA97431.1

Biology

They’ve got some neck

(Ireland and Denmark)

Background:

Students were asked to arrange a series of statements which could explain the evolution of the long neck of the giraffe. They are asked to arrange them in the order they think makes most sense. Students work in groups, allowing the teacher to observe and listen to the arguments and discussion between students, and any arguments or misconceptions that arise. The ‘correct’ sequence is open to question, and debate should be encouraged. The activity aims to model natural selection.

You will need:

✓ Laminated cards and a laminated timeline as pictured below.

Follow these steps:

1. Students can work in groups of between 2 and 4, or it can be a task for individuals.
2. Each group is given a set of cards and a timeline arrow.
3. Students must place the cards in the order they think makes most sense.

So what happened?

The sequence of statements can be arranged so that they describe an example of evolution by means of natural selection or “survival of the fittest”. In some cases, statements can be swapped around and still offer a sensible explanation of the evolutionary process.

What next?

- This activity can be used to introduce the historical ideas about evolution, and how the Lamarckian view of evolution is different from Darwin’s Theory of Evolution by means of Natural Selection.
- There are other similar activities that can be found, and more detail can be added with more cards.
- A similar activity can be easily put together using different traits e.g. beak shape of finches or colour of peppered moth.

Giraffes with longer necks are able to reach food higher up.	Offspring are born with long necks.	Giraffes have a variety of neck sizes due to genetic variation.	Food close to the ground becomes scarce.	Longer necked giraffes survive	Longer necked giraffes reproduce and pass on their genes.

past → **present**

From mouth to toilet

(Netherlands and Germany)

Background:

Model the process by which large insoluble molecules of food are broken down into smaller soluble molecules through the digestive system with this hands-on activity.

You will need:

✓ Bowl, scissors, potato masher, a sealable plastic bag, water/orange juice, tights, tissue, towels, food items (banana/biscuits/bread/yogurt) and a bin bag.

Follow these steps:

1. Prepare the demonstration area by putting newspaper down.
2. Place the food items into a bowl and gently crush with a potato masher to mimic the chewing action of our teeth.
3. Pour the crushed food into a sealable plastic bag and mimic the churning action of our stomach walls breaking down food.
4. Place the plastic bag containing the food over a tray.
5. Cut one corner of the plastic bag and squeeze the food contents into the open leg of the tights. The tights represent the small intestine.
6. Squeeze the food through the tights and collect the liquid that sweeps through the tights in the tray below. The liquid that that ends up on the tray represents the nutrients that are absorbed by the body.
7. Cut the tights at the end and pass the solid food content (waste) through the opening and onto a tray containing tissue.
8. Dry the solid food with the tissue to represent the function of the large intestine.
9. Pass the dried solid food content into a bin bag to represent the function of the rectum.
10. Cut the black bin bag at the bottom and push the solid food content through.

So what happened?

At different stations, students simulate the digestive system processes together in a comprehensible inclusive setting that involves multiple senses: seeing, touching, and feeling.

What next?

In order to make models simple enough to communicate ideas some accuracy may be lost. Students should evaluate the digestive system model to identify the strengths and limitations of the model.

Biology

Left and right dominance

(Switzerland)

Background

The majority of humans are right-handed. Many are also right-sided in general (that is, they prefer to use their right eye, right foot and right ear if forced to make a choice between the two). The reasons for this are not fully understood, but it is thought that because the left cerebral hemisphere of the brain controls the right side of the body, the right body side is generally stronger. It is suggested that the left cerebral hemisphere is dominant over the right in most humans because in 90-92% of all humans, the left hemisphere is the language hemisphere.

You will need...

- ✓ A volunteer
- ✓ A notepad to record your findings

Follow these steps

1. Test to see which hand you use to scratch your back.
2. Fold your hands (praying)! Which thumb is on top?
3. Bring one hand down to the other to make a clapping sound. Which hand comes from above?
4. Test to see which eye you use to wink.
5. If you clasp your hand behind your back with one hand on the other, which hand is the clasping one?
6. Which ear do you use with your mobile phone? Which hand do you put behind an ear in order to hear more clearly?
7. Using your index finger, count to the number three on the other hand. Which index finger do you use?
8. Tilt your head sideways to your shoulder. Which shoulder does your head touch?
9. Cross your arms. Which forearm is on top?
10. Fix a small distant object with both eyes. With your stretched arm make a circle between your finger and thumb and enclose the distant object with this circle. Close one eye and then close the other one instead. Which eye was open when the object was circled correctly? This is the dominant eye.

So what happened?

Could you determine whether you are right-handed, left-handed or have crossed dominance?

What next?

Try using right and left handed scissors and other tools. This will give you an understanding of the difficulties of being left-handed in a world dominated by right-handed people!

Image: https://en.wikipedia.org/wiki/Hand

Mirror illusion

(Switzerland)

Background

A mirror can be used to give the illusion that our hands are not behaving as they should.

You will need:

- ✓ A free standing mirror
- ✓ paintbrush
- ✓ partner

Follow these steps:

1. Place the mirror on a table with the reflective surface facing to the right
2. Place your left hand to the left side of the mirror (it is hidden by the mirror)
3. The right hand is placed to the right side of the mirror in an exact imitation of the position of the left hand
4. Move both hands slowly in the same way (e.g. parallel lifting, form a fist etc.) for a few minutes
5. Stop the movement with your left hand while continuing to move your right hand
6. Try changing the "roles" of the hands: the left hand moves, the right one remains still.

So what happened?

You can see how the "left hand" (actually the mirror image of the right hand) moves, but you can't feel it. Describe your perceptions.

Our brains can't deal properly with such contradictions.

What next?

Repeat the investigation, but this time your partner touches your right hand (the hand behind the mirror) with a paintbrush. You can see how the "left hand" in the mirror is touched, but you can't feel it (with the real left hand), giving the impression that the left hand is numb.

It’s a green world! (Part 1)

— The air that I breathe

(Germany)

Background

This is a series of photosynthesis experiments suitable for both junior and senior secondary level students. Using simple techniques, students demonstrate that during photosynthesis, plants

- consume carbon dioxide,
- require light and chlorophyll
- produce starch and oxygen.

You will need

- ✓ 2 empty clean 0.5 l bottles/ glasses (e.g. milk, yoghurt) with screw cap,
- ✓ ten large fresh leaves (beech, hornbeam, cherry, etc.),
- ✓ straws,
- ✓ lime water,
- ✓ tablespoon

Follow these steps:

1. Students work in groups of two.
2. One of the bottles is filled with the leaves.
3. The same person then exhales several times into both bottles with a straw for two minutes.
4. Both bottles are closed and placed in the sun for half an hour (the more time available, the better).
5. Then four tablespoons of lime water are added to both bottles. The bottles are closed as quickly as possible and shaken vigorously.

So what happened?

The lime water in the bottle with the leaves is clearer than the lime water in the bottle without leaves. This is because plants use carbon dioxide during photosynthesis.

The result depends very much on the exhalation technique; care must be taken to keep the residual opening of the bottle as small as possible, keeping the bottle upright since carbon dioxide is heavier than air. It is advisable to cap the bottles after exhaling into them.

It's a green world! (Part 2)

— The ivy lift

(Germany)

You will need

✓ Baking soda,
✓ washing-up liquid,
✓ ivy leaves,
✓ office hole punch,
✓ three small beakers,
✓ 500 ml water,
✓ 20ml plastic disposable syringes.

Follow these steps:

1. Dissolve a pinch of baking powder in 500 ml of water and add two drops of washing-up liquid.
2. Use an office punch to punch twenty leaflets discs out of **green ivy leaves**. Five of the ivy leaf discs are placed in beaker 1 without further treatment.
3. The remaining ivy plates are placed in a disposable plastic syringe without a needle. The syringe is half-filled with the baking powder solution.
4. The open end of the syringe is closed with the thumb and **the plunger is pulled out** almost completely for about 10 seconds. Then lift the thumb and repeat the procedure again.
5. The leaf discs are distributed between beakers 2 and 3.
6. All three glasses are half filled with the remaining baking powder solution.
7. Beaker 1 and beaker 2 are placed in the sun, the beaker 3 is placed in a closed cabinet.

So what happened?

The ivy plates in glass 1 will swim at the top of the water level, in beaker 2 and 3 the leaf discs are at the bottom of the class. Because of the light, the discs in beaker 2 go up after a few minutes. The leaf discs without light (beaker 3) will stay at the bottom.

It is worthwhile to discuss the experimental setup and to have the pupils explain the purpose of the method steps indicated in bold (see above).

Baking powder (carbon dioxide source); washing-up liquid (facilitates the penetration of water into the ivy plates); office punch (produces plates of the same size), green (only chlorophyll-containing plant parts carry out photosynthesis); ivy (relatively hard leaf, can be easily punched); plunger (produces a negative pressure which draws the gas out of the plates so that water can penetrate and the discs therefore sink downwards).

What next?

The experiment can be varied and extended in many ways. The necessity of chlorophyll can be demonstrated using variegated ivy leaves. The influence of temperature (different water temperatures in the glass), the influence of pH, light intensity, amount of carbon dioxide (baking powder), the difference between light and shadow leaves of ivy, the wavelength of light (coloured cups that fit over the glass) can be demonstrated by simply measuring the time it takes for all the leaf discs to reach the water surface.

Biology

It's a green world! (Part 3)

— Teatime

(Germany)

You will need

- ✓ 20 large leaves (hazel, hornbeam, etc.) freshly picked,
- ✓ white bowls,
- ✓ Lugol's solution,
- ✓ drip pipette,
- ✓ kettle,
- ✓ tea strainer/tea glass

Follow these steps:

1. The leaves are dried in the oven for two hours (circulating air/40°C), crumbled and then boiled as tea. Allow to cool.
2. 5 ml of tea are pipetted into a white bowl and three drops of Lugol's solution are added to one bowl.

So what happened?

This results in a clear black coloration of the liquid as proof of the starch.

What next?

Glucose test sticks can also be used to detect glucose in tea. As a variation one can additionally compare the starch content or the glucose content between leaves that are exposed to light, and those that are kept in the dark (for approx. 5 days).

The dried leaves can also be used to produce a crude chlorophyll solution that can be used to produce good chromatograms.

If the leaves are dissolved in methylated spirits, you can use is for demonstrating fluorescence using a hand-held UV-lamp or UV torch (it also works with a LED torch or a mobile phone light).

It's a green world! (Part 4)

On the trail of Joseph Priestley

(Germany)

You will need

- ✓ one or two large pots (at least 5 litres) with glass lid,
- ✓ two tea lights,
- ✓ 1 stick lighter,
- ✓ stop watch/mobile phone,
- ✓ 1 geranium or another green pot plant.

Follow these steps:

1. First a tea light is placed in a pot. This is closed with the glass lid and placed in the sun for two hours.
2. Then the tea light is lit, the lid closed and the time stopped until the flame goes out.
3. The experiment is repeated with the pot plant or carried out in parallel.

So what happened?

The bigger the pot, the longer the tea-light will burn in the pot with the plants, than in the pot without. Since the plant also takes up a certain volume in the pot, this should be determined (e.g. by measuring the litres).

The easiest way to calculate the oxygen production is based on the fact that within the European Union the tea lights are standardized in relation to the oxygen consumption, i.e. a normal tea light consumes 1.4 ml of oxygen per second.

Summary of the four photosynthesis experiments

At the end of the experimental series it is worth spending time going through the results and conclusions of the investigations again.

Experiment 1 (leaves and lime-water in a bottle) shows that plants need carbon dioxide, which they absorb from the air.

Experiment 2 (floating ivy discs) shows that plants produce a gas under the influence of light and in the presence of chlorophyll.

Experiment 3 (testing leaves for starch) shows that the leaves contain starch and glucose.

Experiment 4 (tea-light in a pot) shows that the gas is oxygen.

Enzyme action with Lego

Teaching enzyme action through a simulation game

(Netherlands)

Background

Using everyday material to simulate biological processes. Embodies simulations (ESs) are teaching and learning activities in which students simulate or enact a specific process in their own interpersonal space using tangible materials and or body actions. The simulated process is usually invisible to the naked eye and it usually takes place at a microscopic scale.

You will need:

- ✓ a mixture of Lego bricks
- ✓ 3 different coloured bricks to represent the enzymes
- ✓ a marker to label the bricks
- ✓ smaller bricks for the substrates
- ✓ 3 long thin connector bricks to hold substrate together (Image 1)

Thin connectors

Follow these steps:

1. Take 3 different coloured bricks and label each lipase, protease, amylase.

Enzymes

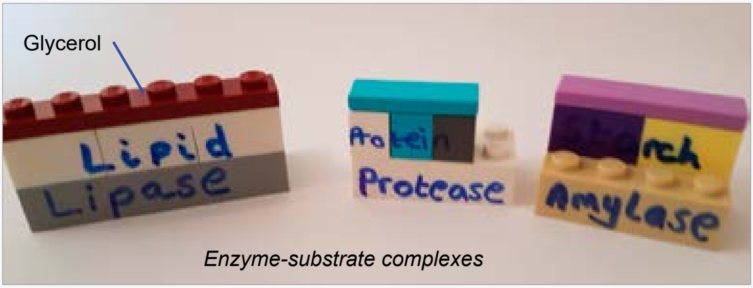
2. Take the other different bricks and label lipids, protein and starch.
   Be careful not to use all the same coloured brick for the enzyme and its matching substrate.
3. The bricks for lipids will work best as 3 small bricks as when broken down or disconnected they will represent 3 fatty acids and a glycerol.

Substrates

4. The bricks for the protein will work best as 4 small bricks as when broken down or disconnected they will represent small singular amino acids, as seen in image 3 & 4

Products

5. The bricks for the starch will work best as 2 small bricks as when broken down or disconnected they will represent maltose, a disaccharide, as in image 3 & 4.
6. Ask students to match the correct enzyme with the matching substrate & connect them together, as in image 5.
7. Then ask students to disconnect the bricks of the substrate to make products as in image 6.



Enzyme-substrate complexes

So what happened?

Students match the correct enzyme with its substrate. When the enzyme and substrate are connected students can visually see the enzyme-substrate complex. They then show the action of the enzyme by breaking up the substrate into products. The top of the enzyme brick is the active site and the active site theory can be discussed. The enzyme acting on the food part / substrate is a chemical reaction. The reaction is digestion where food is broken down into smaller parts. This reaction is the metabolic reaction and an example of a catabolic reaction where large molecules are broken down into smaller molecules.

What next?

- Other enzyme examples could be added. These enzymes can be in a pile and students must place them under headings such as mouth, stomach or pancreas etc. They then must understand where these enzymes are found, what substrate they act on and what products are produced.
- Bring in discussions explaining mechanical and chemical digestion.

Image 1. Examples of thin connectors

Image 2. Enzymes

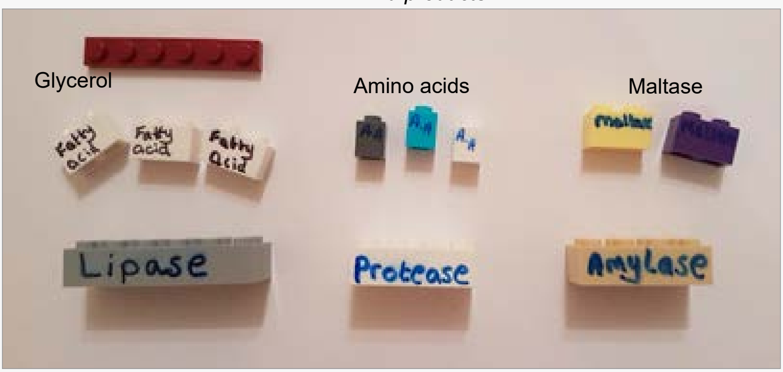
Image 3. Substrates

Image 4 Products

Image 5. Enzyme-substrate complexes

Image 6. End products

End products



Genetics and Lego

Teaching genetics through a simulation game

(Netherlands)

Background

Teaching genetics taught through a simulation game.

Using everyday material to simulate biological processes. Embodies simulations (ESs) are teaching and learning activities in which students simulate or enact a specific process in their own interpersonal space using tangible materials and or body actions. The simulated process is usually invisible to the naked eye and it usually takes place at a microscopic scale.

You will need:

- ✓ 2 empty non see-through bags / non see-through containers
- ✓ A mix of 24 bricks of different colours but same shape and length.
- ✓ Random mutations: 2 different coloured bricks not already used but the same shape and length

Follow these steps:

1. Use template in image 1.
2. Put 6 sets of 2 bricks together under A and 6 sets of 2 under B as in image 2
3. Ask students to separate each set but leave bricks in their 2 piles as in image 3
4. A has 12 bricks, B has 12 bricks
5. Label one bag A/mother and the other B/father
6. Place mix of 12 bricks into bag A for mother
7. Place mix of 12 bricks into bag B for father
8. Ask student to randomly collect a brick from bag A and then bag B
9. Connect both bricks together, & place in box for zygote
10. Repeat step 8 5 more times from bag A and bag B. Collect a total of 6 sets of bricks.
11. Discuss your results; colour of sets of bricks; the bricks left in the bags and other possibilities.

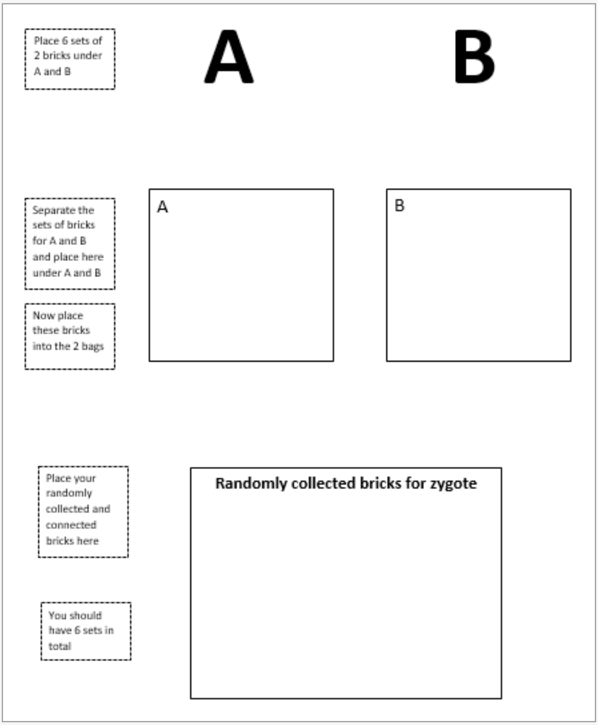


Image 1

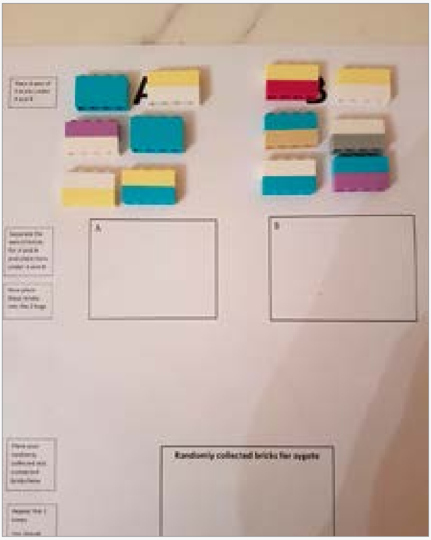


Image 2

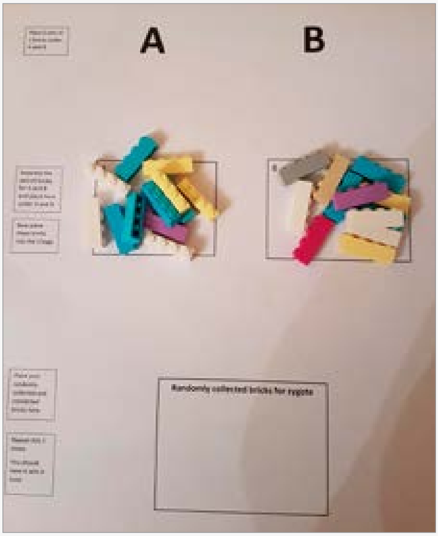


Image 3

Part 2.

12. Separate the zygote bricks and place back into bags
13. Remove a random brick from bag A and remove a brick from bag B
14. Replace 1 brick with a different colour brick representing a random mutation to bag A
15. Replace the other brick with the 2nd brick representing a random mutation to bag B
16. Now repeat steps 8-11
17. What are the results, did any mutations occur?

So what happened?

The activity demonstrates Mendel's law of segregation at step 3 and the law of independent assortment at step 8.

Repeating the selection of bricks with a random mutation added to the bags, demonstrates the possibilities of inheriting a genetic disorder.

- ✓ The bags represent the parent's chromosomes.
- ✓ The coloured bricks within the bags are the possible alleles/genes and possibility of a random mutation.
- ✓ The randomly chosen bricks at the end are a representation of the genes passed on to the zygote.

Image 4

There are 6 sets of bricks / chromosomes for each parent. The parent passes on 6 single chromosomes to form the zygote. The zygote then has their own 6 sets of chromosomes.

What next?

Bricks for the male could be represented as a long and short chromosome, XY, by changing the length of the brick used.

The Strength of a Seed Project

(Germany)

Background

Background: This is activity is adapted from the project ‘How tomatoes conquer biology lessons’. Planting seeds with a class at the start of a term, caring for them, watching them grow and develop. Opportunities then arise for leaving certificate biology revision while watching the seeds grow and develop. Pin point questions to be asked to lead to revision topics being covered. Topics such as; seed formation, seed dispersal, germination, photosynthesis, reproduction in plants, cell division, nutrition in plants, zones of differentiation, plant responses and the characteristics of life.

You will need

- ✓ Soil / compost
- ✓ Small trowel
- ✓ Radish seeds x 20
- ✓ Propagator (optional)
- ✓ If not using a propagator then a seed tray
- ✓ Windowsill or lamp
- ✓ Water

Follow these steps:

1. ¾ fill the seed pot with soil
2. Plant 2 radish seeds into each pot at a depth of a finger nail
3. Lightly cover over with soil
4. Sprinkle with water

5. Place lid of propagator on top if using
6. Place on windowsill
7. Monitor over class times
8. Ask the students each class as to what is happening, what they can observe.
9. Use trigger questions as a guide.

So what happened?

The radish seeds will start to sprout around 3 days. The days before this is happening questions can be discussed; how did the seed form, how may it have been dispersed, what is germination, what are the conditions needed.

As the radish sprouts and grows the process will make it more realistic for the students and the depth of questions can grow.

What nest?

- Seed project can be used for revision in leaving cert biology or as a junior science project.
- A student report can be written on the growth of radish seeds. Keywords can be given that have to be used. This will summarise a large part of the plant biology course.

The Strength of a Seed Project — worksheet

Trigger questions for 'The strength of a seed project' for leaving certificate biology

1. Not all questions need to be asked, this is just a guide.
2. Show the students the seeds; ask how the seed was formed & what precisely gave rise to the seed?
3. How could the seeds be dispersed in their habitats?
4. What conditions are needed for seeds to germination?
5. What is the seed coat called?
6. When the seed is germinating what does the radicle and plumule give rise to?
7. After germination & growth into a young plant what chemical process does the young plant now carry out?
8. Where does this process of photosynthesis occur in the plant & what are the materials needed?
9. What plant tissue is responsible for the transport of the water, minerals and food?
10. Write out both the word and chemical equations for photosynthesis.
11. Now that the plant is growing what adverse conditions within the habitat could affect the growth of the plant?

Questions for more depth:

12. Growth occurs in the plant, explain the type of cell division that is happening. In what zone does this division take place and or name the tissue that is involved. Name the other 3 zones. Sketch a labelled diagram of the zones of differentiation.
13. As the plant is growing list the plant growth responses involved. Explain each one.
14. List the characteristics of life that are evident during the growth from a seed to a plant.

Biology

Urban trees as climate messengers

(Austria)

Background

The urban climate is characterised by higher air temperature and lower relative humidity, then in rural areas. This phenomenon is called the “urban heat island effect”. In the picture below you can see several causes:

Due to the ongoing climate change, this effect will be reinforced. In order to have healthy and efficient urban trees in the future, scientists want to find out more about how trees react and which tree species are particularly resistant.

You will need:

✓ Data logger

✓ wireless temperature and humidity sensors

Follow these steps:

1. To detect how high the mitigation effect is, we installed Beacons
2. (Bluetooth readable temperature and humidity sensors/loggers)
3. in self-made radiation shields inside and outside the tree crown.
4. With the microclimate measurements in combination with the phenological

Left: Beacon (Comapy: BlueMaestro UK)

Rigth: radiation shield made out of plant pots.

monitoring, we will answer the following research questions:

• How does the urban climate affect urban trees?

• How do urban trees affect the urban climate?

• What does this mean for the trees’ future and for our future?

Phenology

“Phenology” describes the life phases of plants and observes when those recur throughout the seasons. The phenological monitoring on the one hand should show the influence of the urban climate on the trees and also determine the length of the vegetation period.

Spring monitoring

You watch 10 end buds in the upper part of the crown. Ideally, they are facing south. Each end bud is assigned a stage of development and receives the corresponding score (0-2).

The individual values have to be entered in the Web-App or noted down in the admission sheet and summed up at the end. This procedure should be carried out all 3 days. As soon as all 10 end buds have been rated “2”, giving a total of 20, phenological monitoring is completed in spring.

Autumn monitoring

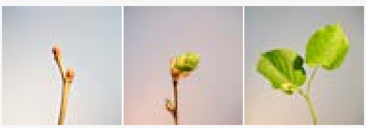
For the autumn monitoring the observer, categorise the whole tree in to 4 categories. This will be repeated weekly.

0 completely green

1 starts colouring and/or losing the first leaves

2 50% coloured and/or 50% lost leaves

3 completely coloured or any leaves,



Urban trees are more than just GREEN!

(Austria)

Background

Imagine buying a delicious ice cream on a hot summer day and looking for a cool place to enjoy it. Would you rather sit on a bench in the sun, under a parasol or under a big tree? Which place do you choose? Why did you choose this place?

On the one hand, the tree cools by throwing its shadow on us, but that is what the parasol also can do. Apparently the tree does something else ... something we can‘t see!

You will need:

- ✓ An area with a variety of trees (woodland, local park).
- ✓ Clear plastic bags.
- ✓ String.

Follow these steps:

A: Cooling by evaporation

The evaporation of the trees leaves easily can be visualized.

1. Find a branch with leaves in the sun.
2. Put a plastic bag over it
3. Tie it with a piece of string as airtight as possible
4. Observe changes over time.

B: Do all leaves evaporate the same amount of water?

1. Look for 3 trees of different species that have leaves of different shapes and sizes. Put plastic bags over the branches as before and watch which bag fogs the fastest!

So what happened?

Various factors affect the rate of transpiration, including the number of stomata, the presence of a cuticle etc. These factors vary from species to species.

What next?

The amount of water collected in the bags could be measured using a micropipette, and the data presented in the form of a chart or graph. The rate of transpiration could also be investigated by measuring the volume of collected water over time.

Name	Description of the leaves	Ranking

Biology

Gene hunting game (Part 1)

Walking along chromosomes

(Italy)

Background

Groups of students (4-5) have been instructed to produce information sheets on human genes ("gene cards"). In order to do this, they have been introduced to the online DNA and protein databases containing all the relevant info about genes, the function of the corresponding protein, diseases associated mutations and their frequency in the population.

Each group has accessed https://en.wikipedia.org/wiki/Human_genome, chosen a chromosome and identified the genes of interest in the gene list.

You will need:

✓ Tablets or PC's with internet access.

✓ Form to be filled with all the relevant information:

- Gene symbol and name https://www.genenames.org/, https://ghr.nlm.nih.gov/gene
- Gene location https://www.genecards.org/
- Protein name, structure and function https://www.uniprot.org/ https://www.rcsb.org/
- Gene expression and protein subcellular localization https://www.genecards.org/
- Mutations https://www.omim.org/
- Associated pathology https://www.orpha.net/consor/cgi-bin/index.php?lng=EN
- Incidence of the disease in population https://www.malacards.org/
- Available therapies https://www.ncbi.nlm.nih.gov/books/

Follow these steps:

Fill in the form finding the relevant information in the given databases

So what happened?

In the end, each group will be able to fill out one or more gene cards collected in a dedicated website

What next?

- See the Gene Hunting game Walking along the chromosomes part 2

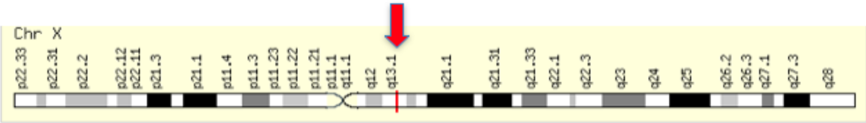
If you have any comments or suggestions please email: cusmibio@unimi.it

PHENOTYPE NAME: Severe combined immunodeficiency

Italian version

SYMBOL AND GENE NAME: IL2RG: interleukin 2 receptor subunit gamma

GENE LOCATION: chromosome X position q 13.1

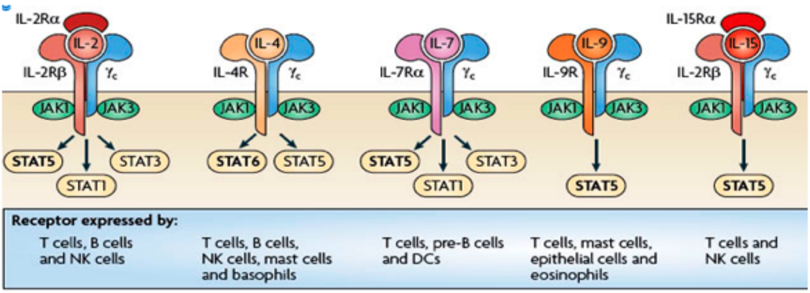


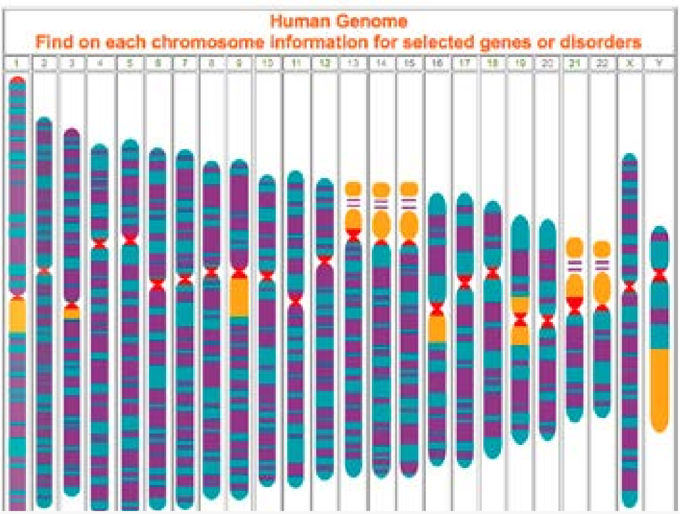
PROTEIN NAME AND FUNCTION:

Protein name: Cytokine receptor common subunit gamma
Length: 369 aminoacid
Molecular weight: 42287 Da
Uniprot access: P31785

Description and function:

The protein encoded by IL2RG gene is an important signaling component of many interleukin receptors, including those of interleukin -2, -4, -7, -9,- 15 and 21 and is thus referred to as the common gamma chain (in blue in the picture). These receptors are expressed in cells of the immune system.





Gene hunting game (Part 2)

Walking along chromosomes

(Italy)

Background

This is a game activity in which students are involved in a gene hunting using QR code and playing cards.

You will need:

- ✓ Tablet or mobile for reading QR code;
- ✓ playing cards,
- ✓ posters

Follow these steps:

1. Find and print chromosomes posters (e.g. using web.ornl.gov/sci/techresources/Human_Genome/posters/chromosome/)
2. Generate QR code for each gene cards (e.g. using www.the-qrcode-generator.com/)
3. Paste QR code in the right position on chromosome poster
4. Print "playing cards" with picture get by each gene card.

Students will be divided into teams with post-its of different colours (the blue team, the pink team etc.). Each team must search for genes on the posters using QR code and associate the gene to the correct playing card. In this way, genes are "captured" by teams by sticking their team post-its onto the chromosome and the gene cards. At the end of the hunting activity, teams can be asked to summarise for the rest of the class, what they learned about the gene they found (name, location, function, mutation etc.).

So what happened?

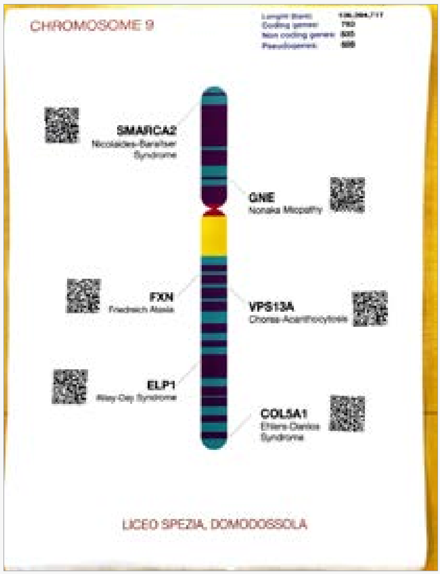
The winner is the team who capture more gene and answer in the correct way to questions about gene

What next?

See the **Walking along the chromosomes 1**

- You can play "Gene hunting" using all the material published on www.cusmibio.unimi.it/genoma; the only thing you have to do is to create QR code for each gene card.
- If you have any comments or suggestions please email: cusmibio@unimi.it

Sample playing cards



The importance of water

Raising the awareness of a water footprint.

(Ireland)

Background

Students wanted to raise awareness of a water footprint and how we can contribute to the conservation of water and make our resources more sustainable. Students researched the water footprint value of different foods and materials. This then led to a second project to encourage others to may an impact by making small changes. A water footprint measures the amount of water used to produce each of the goods and services we use.

You will need:

- ✓ Access to the internet
- ✓ Ideas from the students on items or materials that they would like to research to estimate the amount of water used to produce.
- ✓ Students will need an understanding of what conservation and sustainability of natural resources mean.

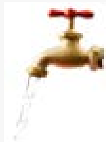
Follow these steps:

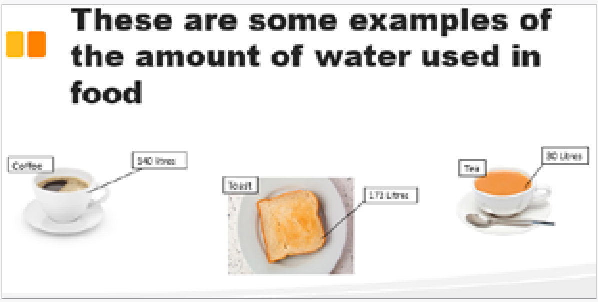
1. Students work under a theme of 'Water' or 'Importance of Water'
2. Research the importance of water and its value
3. Research what a 'water footprint' is.
4. Research the water footprint of items of interest
5. Choose a way to present findings for example as a computer presentation, a poster or a fact file.
6. Possible links to the community can be made; invite speakers in from local groups to discuss 'Water' or make links with a local primary school undertaking the 'Green flag'.
7. Design leaflets on how to 'Make an Impact' and save water.

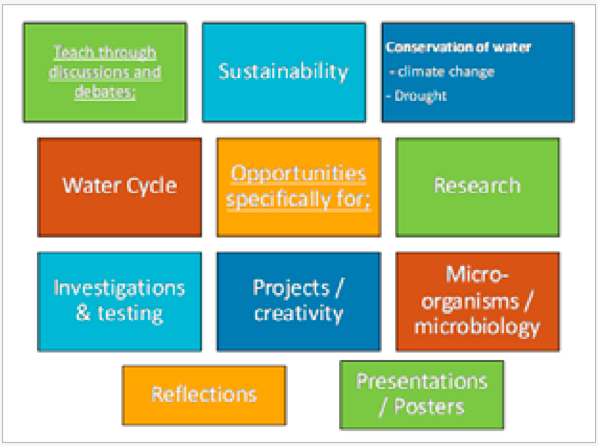
What next?

Use the theme of water to explore areas within the junior cycle science course or for a project. Use the table below as a guide.

Every water droplet saved counts







Combustion in a jar

(Bulgaria)

Background:

Combustion is the scientific word for burning. In a combustion reaction a substance reacts with oxygen from the air to produce carbon dioxide and water. Heat and light energy is also given off.

You will need:

✓ Jar (or glass)
✓ Water
✓ Food colouring
✓ Plate with sides/container
✓ Candle
✓ Matches

Follow these steps:

1. Add 3-4 drops of food colouring to water.
2. Pour the coloured water onto a plate that has sides/container.
3. Place a candle in the centre of the plate.
4. Light the candle.
5. Wait until the candle is burning brightly.
6. Turn the jar over the burning candle.
7. Record your observations.

So what happened?

As the candle burns it heats the air inside the jar. It consumes some of the oxygen and produces a somewhat smaller volume of carbon dioxide. Some of the hot gases bubble out of the jar. Eventually the flame goes out and the air inside the jar begins to cool and contract. This causes a drop in pressure inside the jar. The outside atmospheric pressure then forces water into the jar until the pressure is equalised.

The candle also used oxygen in the combustion reaction to produce carbon dioxide and water vapour. The water vapour can be seen on the inner walls of the jar.

What next?

- Repeat the experiment with two candles (one small and one tall) in the same jar. Which candle goes out first and why?
- Carbon dioxide is produced in the reaction between vinegar and baking soda. Using the gas carbon dioxide, extinguish a candle flame.



Have fun with bubbles

Chemistry and physics combined

(UK & Italy)

Background

This is based on a joint project named 'Beyond Water' between a primary and secondary school.

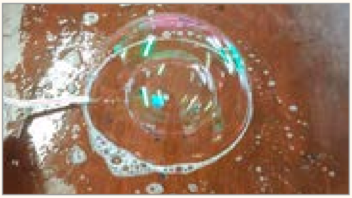
The project focus was not to explain water but use water to provoke students' interests in all the relevant scientific laws. Here we will use water to teach the students about light and measurement.

You will need:

- ✓ a small empty bottle e.g. 500 ml
- ✓ 15 ml of detergent
- ✓ 15 g of brown sugar
- ✓ tap water
- ✓ drinking straws
- ✓ a cloth to clean table

Follow these steps:

1. Add 15 g of brown sugar into bottle.
2. Add 15 ml of detergent to bottle.
3. Fill the bottle will tap water and shake.
4. Allow it to stand for at least 20 minutes before using.
5. On a the classroom table top surface, pour a small amount of mixture onto your hand and spread onto the table. Apply more if needed.
6. Using the straw blow bubbles on the table.
7. Have fun blowing the bubbles, then ask students to put bubbles inside bubbles. See who can blow the largest bubble. What happens the shape of a bubble when more than one bubble is placed around it.



Questions to ask students:

1. What is helping your bubble last longer?
2. What is reflected off the surface of the bubbles?
3. What can they see?
4. What is this band of colours called and how does it occur? What natural phenomenon can we link it to?
5. Leaving some measuring tools on the tables ask: how to find the diameter of the bubble. Let them work it out

So what happened?

The addition of brown sugar to the solution helps the bubbles last longer. The water in bubbles evaporates quickly, and hence are more fragile. The sugar slows down this evaporation, making the bubbles last longer.

We see a spectrum of colours in the surface of the bubbles.

Why?

Light is reflected from both the thin outer and inner surface of the bubble. When an incoming ray of light strikes the outer surface of a bubble, part of the light ray is reflected immediately, while the other part is transmitted into the bubble film.

The colours seen on a rainbow, came from differential refraction, but the colours you can see here on the bubble come from **interference** of the light reflecting off the inner and outer surfaces of the thin bubble film.

Students were asked to get the diameter of the bubble. They simply burst the bubble and using a ruler measure the diameter of the ring of mixture left on the table. But this is a great way to have them discuss the most appropriate tools to use.

What next?

- Students can add glycerine to the solution, making the solution even stronger.
- Compare different types of washing up liquids as some liquids have glyercol added to them.

Chemistry

Getting to know the elements of your smartphone

(Portugal)

Background

The project title 'Periodic Table of the Smartphone'.

Today all students have a smartphone but what substances and mixtures are they made up of? Let students explore the elements of their phone while they understand more about the importance of the periodic table and the information it gives us. A researched based activity.

You will need:

- ✓ Teachers' can use a copy of information is image 1 a copy of 'Elements of a Smartphone'. This information sheet can be found at www.compoundchem.com
- ✓ Students use a template as in image 2 to carry guide them with their research.

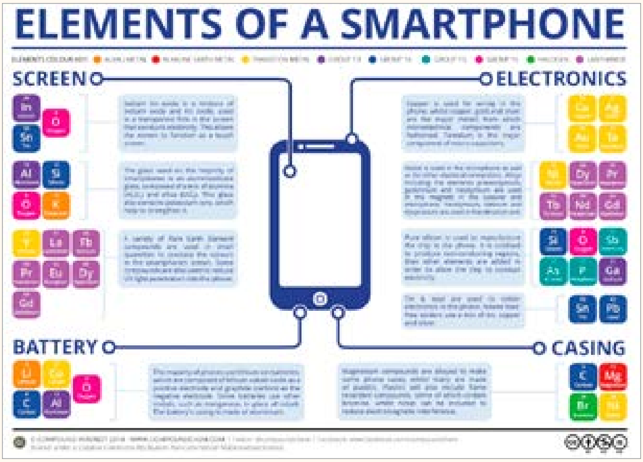
So what happened?

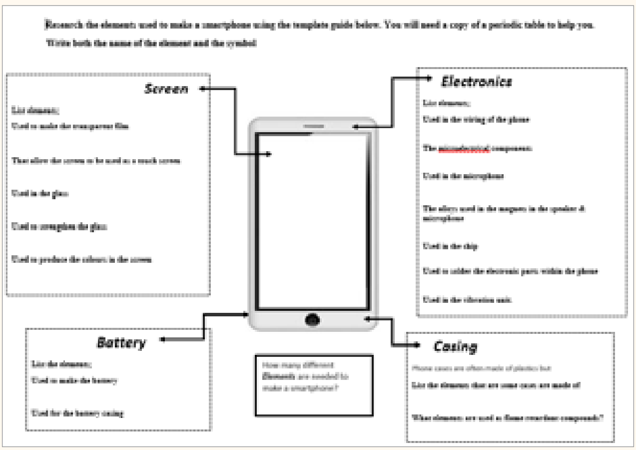
By carrying out the research activity students should become more aware of the elements on the periodic table and what they can be used for. The activity will develop student discussions on the range of elements that are needed to make a smartphone and how valuable they are.

What next?

Students can extend on this by;

- Research the sustainability of the elements used.
- The varying quantities of the elements used and the effects of using & depleting these resources.
- The strategies phone companies are or can put in place to make their phones more sustainable.





Research the elements used to make a smartphone using the template guide below. You will need a copy of a periodic table to help you.

Screen

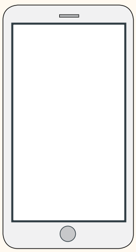
List elements;

- used to make the transparent film
- that allow the screen to be used as a touch screen
- used in the glass
- used to strengthen the glass
- used to produce the colours in the screen.

Electronics

List elements;

- used in the wiring of the phone
- the microelectrical components
- used in the microphone
- or alloys used in the magnets in the speaker & microphone
- used in the chips (integrated circuits)
- used to solder the electronic parts within the phone
- used in the vibration unit.



Battery

List elements;

- used to make the battery
- used for the battery casing.

Case

Phone cases are often made of plastics but

- list the elements that some cases are made of
- which elements are used as flame retardant compounds?

How many different Elements are needed to make a smartphone?

General

Boiling point of water

(Ireland)

Background

Gas syringes are typically used to demonstrate that as pressure is reduced (or volume increased) the boiling point of water changes. However these are expensive and can break easily. This model allows students to experience the pressure-boiling point relationship for themselves, using inexpensive equipment

You will need:

✓ Large rubber stopper
✓ A Philips head screwdriver
✓ 50 cm^3 plastic syringe
✓ Jug of warm water
✓ Oven gloves
✓ Kettle

Follow these steps:

1. Use a Philips head screwdriver to make a hole in an inverted large rubber stopper. Make sure the hole is large enough and deep enough to fit the tip of a 50 cm^3 syringe.
2. Heat some water to about 50°C and pour it into the jug.
3. Allow each student or group to fill their syringe one-third full of the warm water.
4. Invert the syringe and eliminate the air above the water level.

5. The syringe tip needs to be securely inserted in the hole in the stopper.
6. Using oven gloves, a student can hold the barrel of the syringe securely and then pull the syringe piston.
7. This can be repeated several time with the same water sample.

So what happened?

As the volume within the syringe increases, the internal pressure drops. This causes the boiling point of water to decrease also. Not only is steam produced but bubbling can be seen throughout the water.

When the piston is lowered the boiling stops.

What next?

- This explains why cooking food by boiling at higher altitudes may not be safe
- Also the reverse principle can be used to explain why pressure cookers are so effective at cooking food

Osmotic pressure

(Ireland)

Background:

This model demonstrates osmotic pressure across a semipermeable barrier, using water and Golden Syrup

You will need:

- ✓ Golden Syrup (or a honey of the same consistency)
- ✓ 35 mm film cannister
- ✓ Small rubber stopper with a hole
- ✓ 5 cm of glass tubing
- ✓ Craft knife
- ✓ Felt-tip marker
- ✓ 250 cm^3 beaker
- ✓ Cling film
- ✓ Scissors
- ✓ Water

Follow these steps:

1. Turn the film cannister upside down and draw the outline of the narrow end of the rubber stopper, onto the bottom of the cannister.
2. Using the craft knife cut out this disc carefully.
3. Working at a slow pace, cut out the central disc of the cannister cap, but leave the lock-ring in place.
4. Place the cling film over the end of the cannister, secured by the lock ring of the cap. Trim off an excess with a scissors.
5. Carefully fill the cannister form the opposite end, with golden syrup, to within 5mm of the stopper end.
6. Put the stopper, with glass tube, in place, and sit the cannister into a beaker of water to half its depth.
7. Within 2 minutes the syrup will be seen to rise in the glass tube.

So what happened?

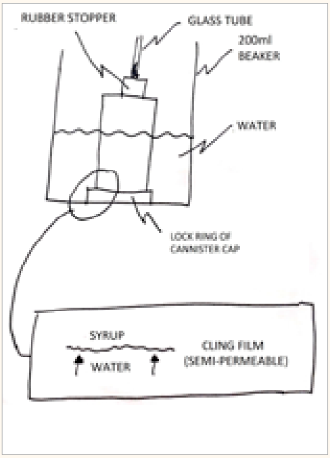
Water has no sugar, while Golden Syrup has a high sugar content. This means that there is a concentration gradient across the cling film barrier. This creates osmotic pressure causing the water to move into the film cannister.

Water passes through the semi-permeable barrier of cling film into the cannister increasing the total liquid volume. The larger molecules in the Golden Syrup cannot pass through the barrier. The increasing total volume causes the Golden Syrup to rise up the glass tube. If there was not a glass tube the internal pressure would stretch or burst the cling film.

This simple model shows how root tips and cellular membranes work as selective/semi-permeable barriers

What next?

The model could be used to explore the factors affecting osmosis, by varying the contents of either or both the cannister or beaker, or their concentrations. Additionally, the permeability of a variety of thin laminas could be tested.



Chemistry

New properties from superficial changes 1 – mechanical properties

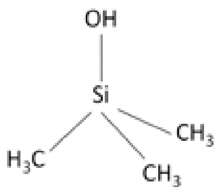
(Spain)

Background:

Properties of so-called magical, kinetic sands compared with common sand are explored by performing simple experiments. The chemical composition of the sand does not vary, but by changing the chemical that the sand is coated with, it is possible to change its properties in a superficial way.

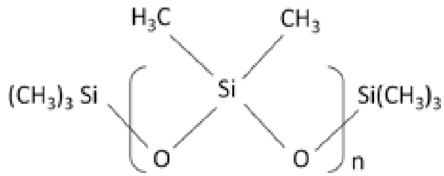
Various types of sand can be created for testing, using DIY instructions, details of which, including other areas of extension can be found here bit.ly/SonS2019

MAGIC SAND: The hair like molecules of trimethylhydroxysilane, repel water molecules. Submerged in water this creates a layer of air bubbles around the sand allowing water to run off the sand without wetting it. Magic sand was developed originally to use in oil spill clean-ups. It is known as Nano Sand outside of its use as a toy.



Trimethylhydroxysilane – magic sand

KINETIC SAND: Developed as a commercial sand moulding product, polydimethylsiloxane (PMDS) is the chemical coating that gives kinetic sand its superficial properties.



Poly(dimethylsiloxane) – kinetic sand

PDMS is a silicon-based organic polymer, known for its flow properties. The longer the polymer chain (the larger the n number), the greater its elasticity. PDMS is also present in shampoos (as dimethicone makes hair shiny and slippery), food (antifoaming agent), caulking, lubricants and heat-resistant tiles. Its food safety number is E900, and trace amounts can be found in fast food nuggets, as its antifoaming ability prevents oil spatter in cooking. It is also found in chips, milkshakes and smoothies.

You will need:

- ✓ Dry sand
- ✓ Magic sand (or dry sand mixed with Scotchguard)
- ✓ Kinetic sand (or dry sand mixed with shaving foam)
- ✓ Water
- ✓ Four plastic plates (or large clock glasses)
- ✓ Knife

Follow these steps:

1. Place roughly the same amount of dry sand onto two of the plastic plates.
2. Repeat for one plate each of magic sand and kinetic sand.
3. Add water to one plate of dry sand until soaked.
4. With your fingertips pinch the sand in each dish to test whether it holds its form when released.
5. Then test each sand sample by cutting a line through each.

So what happened?

The elasticity or stickiness of the sands increases in the order dry sand, wet sand, magic sand, kinetic sand. The why of this is best demonstrated using a microscope camera, as hair like strands will be seen in increasing amounts. These binding strands occur because of the trimethylhydroxysilane and polydimethylsiloxane.

What next?

- Dimethicone (a form of PDMS used in shampoo and skin moisturisers), or bees-wax spray can be used to form alternative water repellent sands, for comparison.
- Nature employs a number of hydrophilic compounds in a wide variety of situations: forest fires cause the rapid decomposition of organic material forming organic acids that coat soils, causing water to run off these soils rather than soak into them. As some plants require the intense heat of fires to cause germination, perhaps the prevention of water logging allows these plants to grow.

Chemistry

New properties from superficial changes 2 – wetness

(Spain)

Background:

Properties of so-called magical, kinetic sands compared with common sand are explored by performing simple experiments. The chemical composition of the sand does not vary, but by changing the chemical that the sand is coated with, it is possible to change its properties in a superficial way.

Various types of sand can be created for testing, using DIY instructions, details of which, including other areas of extension can be found here bit.ly/SonS2019

MAGIC SAND: The hair like molecules of trimethylhydroxysilane, repel water molecules. Submerged in water this creates a layer of air bubbles around the sand allowing water to run off the sand without wetting it. Magic sand was developed originally to use in oil spill clean-ups.

KINETIC SAND: Developed as a commercial sand moulding product, polydimethylsiloxane (PMDS) is the chemical coating that gives kinetic sand its superficial properties.

Both these sands are hydrophobic, and can be used to introduce and explore the polarities of various liquids, consolidating student understanding of solubility, when related to the charges on various substances.

You will need:

- ✓ Dry sand
- ✓ Magic sand (or dry sand mixed with Scotchguard)
- ✓ Kinetic sand (or dry sand mixed with shaving foam)
- ✓ Three plastic plates (or large clock glasses)
- ✓ Five Pasteur pipettes
- ✓ Teaspoon
- ✓ Permanent marker
- ✓ Water
- ✓ Acetone
- ✓ Petrol (petroleum spirit)
- ✓ Detergent (washing-up liquid)
- ✓ Engine oil

Follow these steps:

1. Section a plastic plate into five segments
2. Label each segment by writing the name of the test liquids on the plate rim, (fig 1).
3. Repeat for two more plastic plates.
4. Place a roughly equal amount of dry sand in each segment of one of the plates (approximately 1 teaspoon).
5. Repeat for magic sand and kinetic sand.
6. Using a Pasteur pipette place 2 – 3 drops of water onto the dry sand, magic sand and kinetic sand.
7. Repeat for acetone, petrol, detergent and engine oil.
8. Record the soakage/ non-soakage in a results table, (Fig 2).

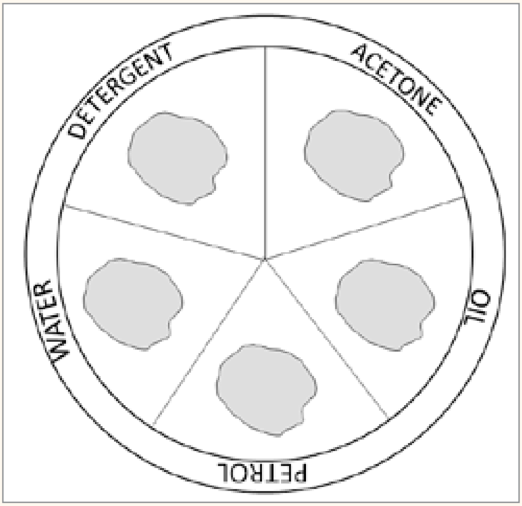
So what happened?

Soakage implies attraction between polar substances, and in non-polar substances a lack of repulsion. Non-soakage implies repulsion due to polar/non-polar interaction, or substances of the same polarity repelling each other. A simple analogy is the interaction of water and oil.

What next?

- Scientists try to recreate this in a number of contexts, in order to waterproof materials exposed to moisture. Waterproof coatings on shoes and clothing often use the water repellent effects of various natural waxes and oils, as well as synthesised chemicals. Modern car waxes and paints work similarly. High rise buildings, where it is unsafe for window cleaners to operate use water repellent coatings on glass, which cause water to run off. Running down from the top of a building this water effectively cleans the glass.

- Dimethicone (a form of PDMS used in shampoo and skin moisturisers), or beeswax spray can be used to form alternative water repellent sands, for comparison.
- Other hydrophobic substances found in the lab that might be tested are: ethanol, hexane, heptane, soap solution, various cooking oils.
- Student might also extend the waterproofing to textiles, perhaps examining "breathability" e.g. Gore-Tex.



TEST LIQUIDS	DRY SAND	MAGIC SAND	KINETIC SAND
water	soaks	repelled	repelled
acetone	soaks	soaks	soaks
petrol	soaks	soaks	soaks
detergent	sits on surface	sits on surface, rolls off	some soakage
engine oil	some run off, some soakage	soaks quickly	sits on surface

Polypocket Chemistry 1

– acidity

(Bulgaria)

Background:

This low-cost chemistry kit is designed to be glass free, using easily and cheaply obtained components, and micro amounts of reagents. Contained in a small cardboard box, it is portable and easy to store, (Fig 1 & 2).

Designed to optimise student learning, workplace for each small group of students is minimal and takes up the space of an A4 sheet of paper. All experiments are carried out by the means of pipetting, so it is possible to conduct lessons in a non-specialist room, with some simple precautions.

Reagent solutions are 0.1M in concentration, and are stored in 10ml screw-top plastic containers. As are any solids, and the indicator papers. The PVC polypockets are hydrophobic, so the dilute water-based solutions used can be easily wiped with minimal amounts of tissue paper. The disposable Pasteur pipettes being similarly hydrophobic, they do not necessarily need to be rinsed by students between uses. It may however be simpler to provide enough pipettes for each reagents' use.

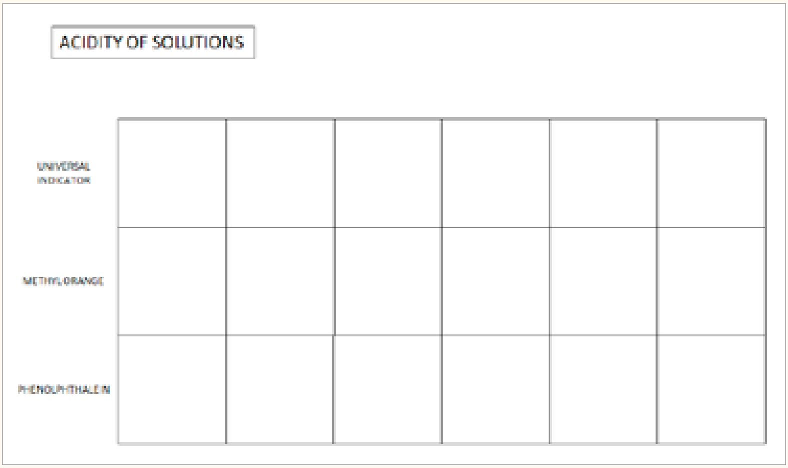
The full details of how to assemble the kit, and prepare the reagents, and other polypocket activities can be found via this link bit.ly/SonS2019

This example focuses on testing and comparing the acidity of various substances (Fig 3)

You will need,

(per small group):

- ✓ Universal indicator (red cabbage juice indicator paper)
- ✓ Sodium hydroxide (0.1M)
- ✓ Sodium hydrogen carbonate (0.1M)
- ✓ Sodium carbonate (0.1M)
- ✓ Hydrochloric acid (0.1M)
- ✓ Vinegar
- ✓ Phenolphthalein indicator



- ✓ Methyl orange indicator
- ✓ Seven disposable Pasteur pipettes
- ✓ Polypocket insert for acidity

Follow these steps:

1. Break up some universal indicator strips in approximately 1cm lengths, placing one in each of the squares in the top row of the table.
2. For both methyl orange and phenolphthalein, place 1-2 drops of solution in each of the corresponding squares, in the table.
3. For the first column, pace one drop of sodium hydroxide on the indicator paper, the methyl orange and the phenolphthalein.
4. Repeat this process for sodium hydrogen carbonate, sodium carbonate, vinegar and hydrochloric acid
5. Remember not to place any reagent on the fourth column so this can act as a reference, sitting between the base and acid solutions.

So what happened?

The colour range allows you to engage students with how different indicators work.

Universal indicators work across a wide range of pH, as they are usually a combination of a number of indicators. In red cabbage there are several pH sensitive chemicals called anthocyanins, allowing it to work as a universal indicator.

Methyl orange works in pH 3.1 – 4.4 range, so only changes colour when pH drops into this range, (orange to red), and shows no colour change for bases.

Phenolphthalein works in the 8.2 – 10.0 range, changing colour when pH rises to this range (colourless to red). This also highlights that an indicator colour change to red is not just an acid indicator, simply that most indicators that students use have this colour change)

What next?

- Its possible to test a wider range of substances, perhaps pooling observations from one or more groups, who have examined different sets of reagents.
- As a home assignment student could be given some cabbage indicator strips and a single Pasteur pipette, to test substances at home. A ceramic saucer and some tissue, as well as frequent rinsing between test liquids would be advisable, in this situation.

Polypocket Chemistry 2

– hydrochloric acid

(Bulgaria)

Background:

Continuing with the low-cost chemistry This example focuses on testing and comparing the reactions of hydrochloric acid

The full details of how to assemble the kit, and prepare the reagents, and other poly-pocket activities can be found via this link bit.ly/SonS2019

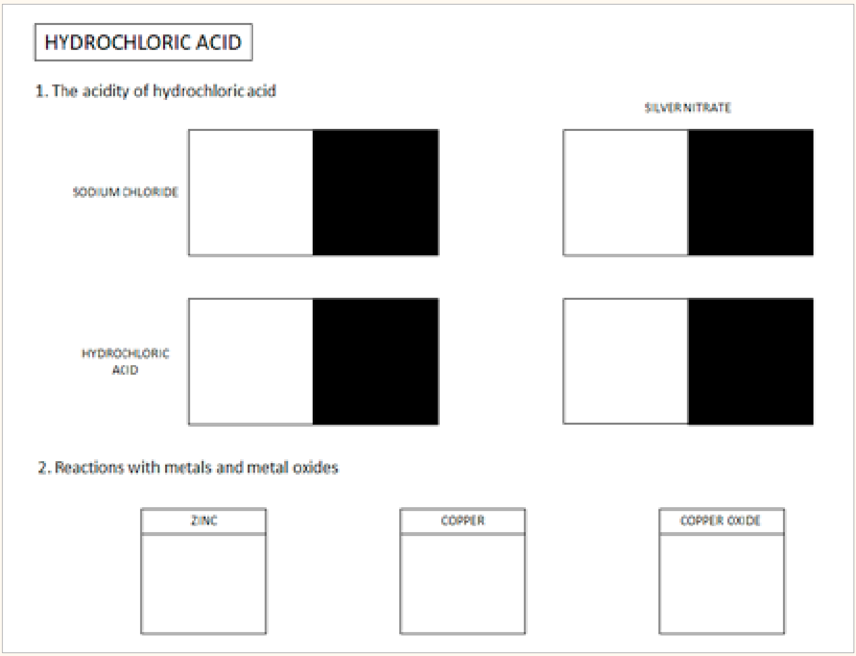
You will need,

(per small group):

- ✓ Universal indicator (red cabbage juice indicator paper)
- ✓ Sodium chloride (0.1M)
- ✓ Silver nitrate (0.1M)
- ✓ Hydrochloric acid (0.1M)
- ✓ Copper strip
- ✓ Copper oxide (powder)
- ✓ Zinc granule
- ✓ One wooden splint
- ✓ Three disposable Pasteur pipettes
- ✓ Polypocket insert for hydrochloric acid

Follow these steps:

1. Split a strip of red cabbage universal indicator into two and place on the black indicator square, (Fig 1).
2. Place 1 – 2 drops of sodium chloride and hydrochloric acid in their respective white squares.
3. Place 1 – 2 drops of silver nitrate on a black test square for both sodium chloride and hydrochloric acid.
4. Slide both pieces of indicator paper into their reagents and note any colour change.



5. Add a drop of reagent to their corresponding silver nitrate drops. A white precipitate forms in each case.
6. Add 1 – 2 drops of hydrochloric acid to each of zinc granule, copper stirp and copper oxide powder. Note any changes.

So what happened?

The pH testing of two chlorine containing compounds demonstrates that chlorine does not determine acidity

Students know that hydrogen chloride is acidic, so may conclude that hydrogen determines acidity. Scientists created the pH scale based on this idea which has been refined with further research since.

Both compounds react in the same way with silver nitrate, so chlorine is the common reactive element (chlorine displaces the nitrate ion).

Chlorine is a strong reagent used in many industrial processes and in synthesising other chemicals.

The concept of displacement can be introduced here

The metal reactions show that one metal is resistant to a strong acid, while another reacts evolving a gas (bubbling)

Will all metals react in similar ways? How do we know this?

Opportunity for students to design a follow-up experiment

The oxygen in copper oxide is displaced by the chlorine forming copper chloride, and causing a colour change from black to blue. The reaction is also not as rapid as with zinc (not all chemical reactions are fast, due to a range of factors)

What next?

- Extension into the reactivity series of metals
- Looking at the factors that affect the speed of a reaction (concentration, warmed solutions)
- Testing other acids in a similar way.

Chemistry

Diffusion using plant life

(Czech Republic)

Background

This is part of an early years project ('Life of Plants') in which the pupils learn how plants work!

You will need:

✓ a test tube or glass graduated cylinder.
✓ UV torch
✓ water to fill graduated cylinder
✓ grated Horse Chestnut bark

Follow these steps:

1. Grate the outside of chestnut bark.
2. Fill the test tube with water.
3. Sprinkle a small handful of bark over the top of the water.
4. Turn the lights off in the room.
5. Using the UV torch shine the torch through the water in the test tube.
6. You should see the bark as fluorescence blue speckles diffusing through the water.
7. Sprinkle some more bark over the top to watch again and see the movement of the bark through the cylinder.

So what happened?

Patterns of diffusion through the water will be seen from the bark and when the UV torch is shone on the water these patterns can be seen.

The horse chestnut bark has a chemical called **aesculin** which is found in its leaves, seeds and bark. It is soluble in water and fluoresces blue.

What next?

- Use bark from other trees and compare.
- Investigate whether different water temperatures will affect the blue fluorescence.
- Research why aesculin dissolves in water and fluoresces blue in UV light.

Piezoelectric sparker

(Ireland)

Background

The piezoelectric sparker is a rewired BBQ lighter connected to a film cannister, in which there is a single drop of methanol is combusted to demonstrate the activation energy (E_{act}) of an exothermic reaction.

The demonstration and construction instructions are courtesy of Mr. John Daly and can be found at the link: bit.ly/SonS2019

You will need:

- ✓ Piezoelectric sparker (adapted BBQ lighter – see link)
- ✓ Pasteur pipette
- ✓ Methanol
- ✓ Timer
- ✓ Ear protectors

Follow these steps:

1. Open the film canister lid, and Show the students the end of the flex, and that the sparker is working.
2. Set a timer for 30 seconds (timing varies from person to person, as our body heat is individual, so you will need to practice this).
3. Before demonstrating explain to students that a loud noise will happen and demonstrate how they can cover their ears with their hands (sound exceeds 85 dB).
4. Students should be a minimum of 3 m from the sparker.
5. Place the ear defenders on your head.
6. Using the Pasteur pipette add only one drop of methanol to the film cannister. Start the timer simultaneously.
7. Close the cannister lid, and wrap the palm of your hand around it, for 30 seconds.
8. Give students a countdown during the last 5 seconds.
9. Point the sparker at a target/blank wall.
10. Just before ignition unwrap you hand form the cannister and hold the flex 3cm from the cannister lid.
11. Ignite!

So what happened?

The warmth of your hand caused the methanol to vapourise and mix with the air contained in the cannister. The small amount of energy provided by the spark from the piezoelectric trigger allows rapid combustion (explosion) of the fuel air mix.

The combustion depends not just on the vaporisation of methanol but the relative pressures of the methanol vapour and of air. This is why the timing for vaporistion is variable, as the amount of heat radiated from a persons palm is individual.

Also too much methanol may not vaporise sufficiently for combustion.

So what happened?

In addition to demonstrating E_{act} of methanol it is possible

- to examine the chemical equation for methanol combustion
- to use the sparker as a simplified model of an internal petrol combustion engine (LC Chemistry)
- to highlight the power of a natural gas leak explosion in a home if a single drop can cause the effect students witness.

Dynamics and Statics

Cloud in a bottle

(Ireland)

Background

This model demonstrates a physical change (change of state) through the formation of a cloud inside a sealed bottle. No new substances are formed but squeezing and releasing the bottle causes a cloud to form and dissipate, replicating in a simple way, an aspect of our weather

You will need….

- ✓ 2 litre soft drinks bottle
- ✓ 20 cm³ of tap water
- ✓ Small beaker
- ✓ One match

Follow these steps:

1. Place approximately 20 cm³ of tap water into the bottle, seal and shake vigorously for 1 minute.
2. Empty the bottle of water and reseal.
3. Light a match (or small piece of taper) and allow to burn for half of its length, and then extinguish.
4. Open the bottle and place the extinguished match inside while still emitting some smoke.
5. Seal immediately. Squeeze repeatedly until a cloud appears.

So what happened?

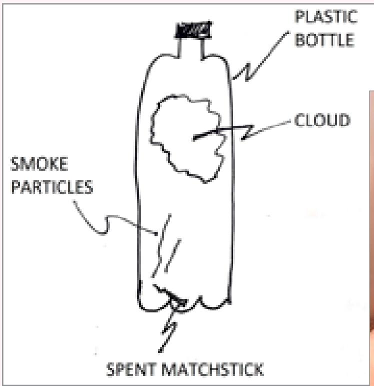
Shaking the water in the sealed bottle creates a vapour with the bottle. When the smoking match is placed in the bottle, this adds smoke particles to the internal atmosphere.

Squeezing increases the internal pressure, causing a heat increase, maintain the water as vapour. Releasing the bottle reduces the pressure and temperature, water droplets form. These cooled droplets attach to smoke particles forming a cloud (nucleation).

The more squeezing that happens the more persistent the cloud will be inside the bottle.

What next?

- This demonstration can be related to the weather effects of pressure at JC Science and JC Geography (barometric pressure)
- On a careers thread it can also be used to hep explain why meteorologists are required to have physics degrees as a great many weather phenomena have a heat or pressure aspect.
- If pressure changes were created by a bicycle pump with a pressure gauge, this could be extended into an investigation of vapour pressures and cloud density/cloud cover and fogs.



Float an aluminium boat on gas!

(Belgium)

Background

Sulfur Hexafluoride (SF6) is a colourless, odourless inert gas. The gas is more dense than air. Sulfur Hexafluoride (SF6) is normally used in the demonstration to float an aluminium boat on gas, however, Sulfur Hexafluoride is expensive and difficult to get. Air Duster PRF 4-44 Green is a cheaper alternative containing tetrafluoropropene which is also more dense than air.

You will need:

- ✓ Non-flammable Air Duster PRF 4-44 Green (Contains tetrafluoro-propene)
- ✓ Thin aluminium foil
- ✓ Fish tank/large plastic tub

Follow these steps:

1. Set up the experiment in a well ventilated area and away from draughts.
2. Create a boat using thin aluminium foil. Fold up the sides and smooth the corners of the boat.
3. Spray the Air Duster PRF 4-44 Green into a large transparent container.
4. Place the aluminium foil boat into the large container containing the Air Duster PRF 4-44 Green spray.
5. Observe what happens.

So what happened?

The aluminium boat floats on the colourless gas. It is worth noting that an object will float if the gravitational (downward) force is less than the buoyancy (upward) force. In this case, the Air Duster PRF 4-44 Green gas sinks to the bottom of the container as is more dense than air.

What next?

- Fill a small beaker with the gas at the bottom of the large container. Pour the gas from the small beaker into the aluminium boat. Will the boat sink or stay afloat?
- Remove the aluminium boat and blow bubbles over the large container containing the dense gas. Notice what happens.

Dynamics and Statics

Balancing bird

(Georgia)

Background

All objects have a balancing point, called the centre of gravity. The lower you make the centre of gravity the more stable the object is.

By finding the centre of gravity, you can make a toy that can easily balance.

You will need

- ✓ A bird made from papier mâché,
- ✓ skewers,
- ✓ elastic bands,
- ✓ pipe cleaners,
- ✓ feathers,
- ✓ sticky tack,
- ✓ wooden/plastic base or flower arranging foam

Follow these steps

1. Make a bird from papier mâché, complete with tail feathers, a pipe cleaner balance and goggle eyes.
2. Stick two upright skewers parallel to each other onto a wooden/plastic base or into flower arranging foam.
3. Use elastic bands to connect another skewer onto the two upright skewers.
4. Balance the bird on this skewer by curling the pipe cleaners.

So what happened?

Your bird will now be able to perch on the skewer without falling over.

What next?

Try making a cardboard balancing clown, a balancing acrobat made from a pipe-cleaner & play dough, or a bird that can balance with wings outstretched.

Centre of gravity

(Georgia)

Background

The centre of gravity of an object is the point at which weight is evenly dispersed and all sides are in balance. A person's centre of gravity can change as he/she takes on different positions, but in many other objects it's a fixed location.

You will need

- ✓ A 30 cm ruler,
- ✓ triangular pivot made from lollipop sticks,
- ✓ elastic bands,
- ✓ sticky tack,
- ✓ small cups,
- ✓ different objects

Follow these steps

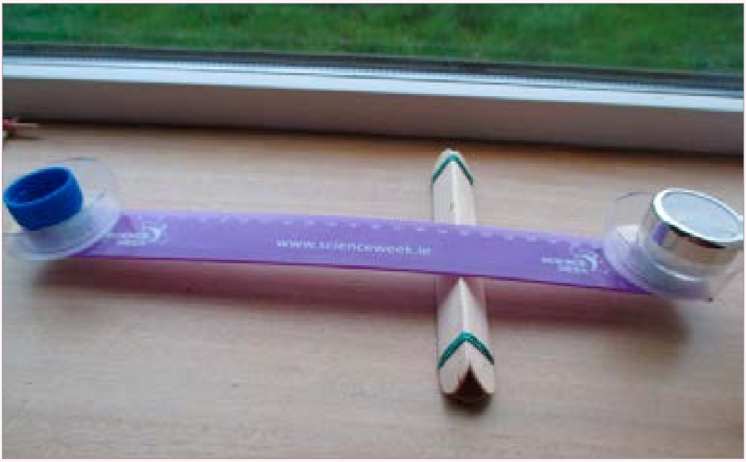
1. Use two elastic bands to join three lollipop sticks together to make a triangular pivot.
2. Use sticky tack to stick a small cup to each end of the ruler.
3. Balance the ruler on the lollipop pivot.
4. Add toys or weights to each cup.
5. Slide the ruler along the lollipop pivot until the ruler balances. You have found the point of gravity for these weights.
6. Record the weight of the objects and the position of the pivot under the ruler.

So what happened?

As you slide the ruler along the pivot you will reach a point where the centre of gravity is reached. This can be recorded.

What next?

Repeat the investigation, but this time keep the ruler balanced with the pivot directly underneath the mid-point of the ruler. Now instead of moving the ruler, move one cup along the ruler towards the pivot in order to find the centre of gravity. Record your findings.



Dynamics and Statics

Elastic catapult

(Poland)

Background

Energy is stored in the elastic band which is pulled around other elastics and through the neck of the bottle. As the elastic band is pulled, muscle energy is stored. When re-leased the elastic band jumps forward propelling the ball outwards.

You will need:

- ✓ Empty plastic bottle
- ✓ Elastic bands
- ✓ Knife or scissors
- ✓ Small ball

Follow these steps:

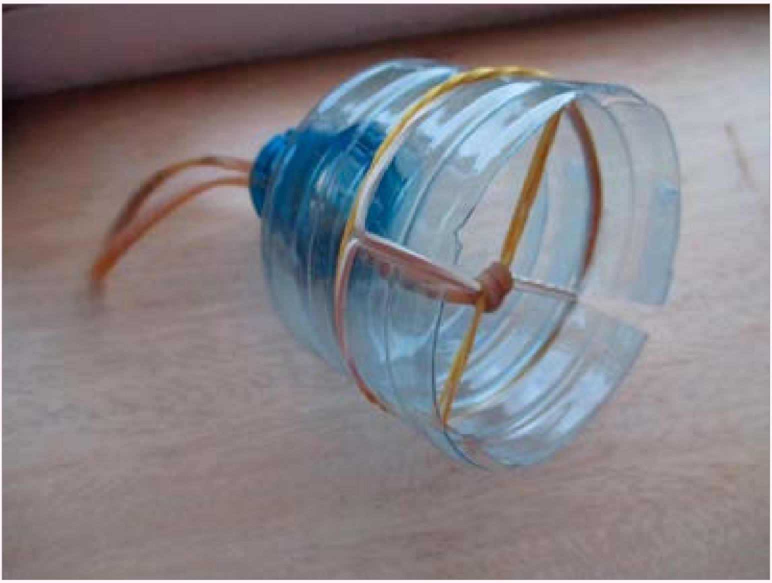
1. Cut the end off a plastic bottle.
2. Cut 4 notches in the cut end of the plastic bottle.
3. Thread two elastic bands through these notches, making semi-circular shapes.
4. Knot another elastic band around the place in which the elastic bands meet.
5. Push the other end of this elastic band through the neck of the bottle.
6. Pull.

So what happened?

As the elastic band is pulled back through the neck of the bottle and then released, the ball is forced out of the cut end of the bottle.

What next?

Try making different types of elastic catapults using different materials. Does the length of the elastic band or the thickness of the elastic band make any difference to how far the ball flies? Does the stretch of the elastic band make any difference to how far the ball flies?



Boats: 1. Elastic paddle boat

(Czech Republic)

Background

Energy is stored in the rubber band which is attached to the paddle wheel. As the paddle wheel is wound, the attached rubber band also winds, storing muscle energy. When released the rubber band unwinds, in turn causing the paddle wheel to rotate and the boat to move.

You will need:

✓ Lollipop sticks
✓ Elastic band
✓ Hot glue gun
✓ Sharp knife
✓ Small saw

Follow these steps:

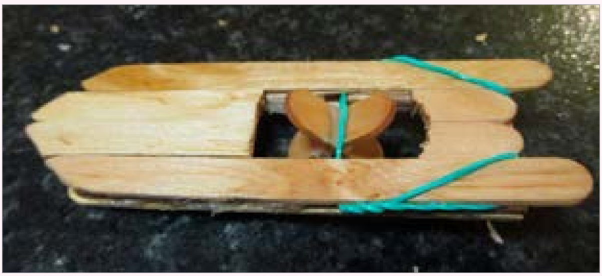
1. Using lollipop sticks and a hot glue gun construct a boat as shown above (the first picture shows the boat from above, the second shows the underside of the boat).
2. To make the paddle: Use another lollipop stick. Cut off two small identical pieces.
3. Round both ends of each of the two pieces.
4. Use a small saw to cut a notch halfway along each piece, cutting down past halfway in each stick.
5. Click these two pieces together to make a paddle.
6. Wind the elastic band through the paddle and over each end of the back of the boat.
7. Wind the paddle backwards, put the boat in water and release.

So what happened?

The boat will speed forwards in the water.

What next?

Try making other elastic band boats, changing the type of material the boat is made from, the material used to make the paddles and different sized elastic bands.



Boats: 2. Water powered boat

(Czech Republic)

Background

Water is poured into the cup. This water empties through the straw, pushing the boat forward.

You will need

✓ Small cup
✓ Straw
✓ Cork
✓ Hot glue gun

Follow these steps

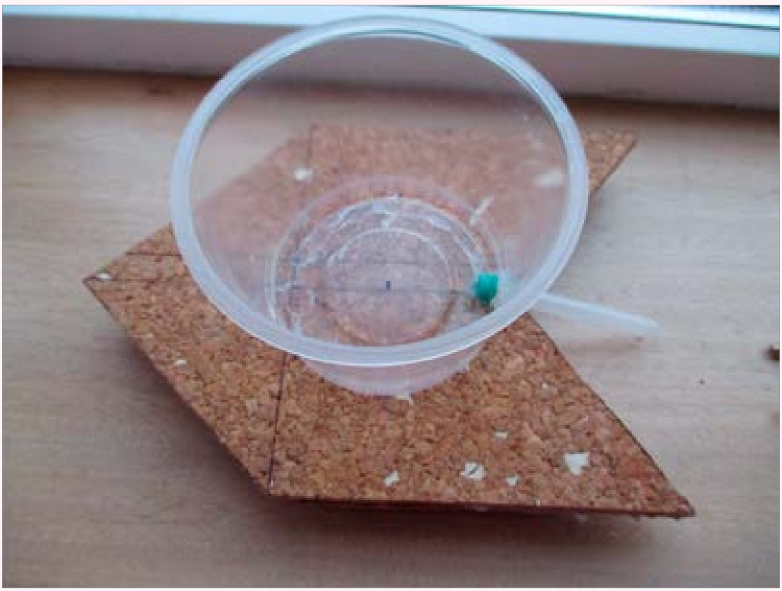
1. Make a boat shape from layers of cork.
2. Make sure this boat floats.
3. Make a small hole in the bottom of the cup.
4. Push a straw through the hole in the cup. Use the hot glue gun to seal any spaces between the straw and the cup.
5. Glue the cup to the cork with a hot glue gun.
6. Float the boat on the water.
7. Add water to the cup.

So what happened?

As the water empties from the cup the boat will speed forward in the water.

What next?

Try making different shaped boats or boats from different materials that work on this principle.



Boats: 3. Simple steam boat

(Ireland)

Background

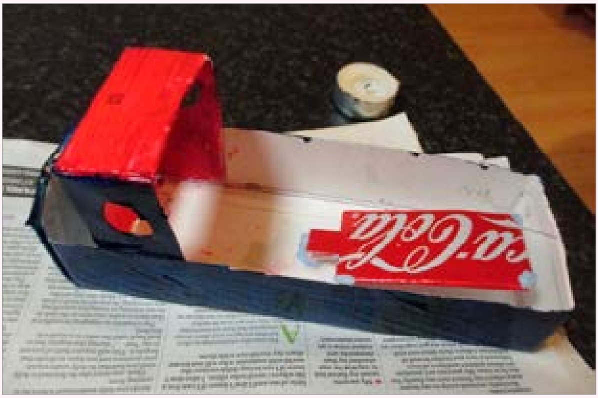
A lit candle will heat up a boiler of water creating a brief burst of steam that is expelled through the pipes in the rear of the boat. The force of the expanding gas (steam) pushes the boat forward.

You will need:

- ✓ Milk carton
- ✓ Stapler
- ✓ Sticky tack
- ✓ Tea light and matches
- ✓ Syringe
- ✓ Straws
- ✓ Empty soda can
- ✓ Sharp knife

Follow these steps:

1. To make the boat cut the milk carton in half lengthwise.
2. Cut a piece of the remaining carton to make a cabin for the boat.
3. Staple the cabin onto the boat.
4. Halfway along the boat make a small hole to allow two straws to pass through.
5. Cut the soda can so that you have a piece of metal 18cm by 6cm.
6. Fold this in half.
7. Cut a 1cm piece off three of the sides (not the folded side) of one of the folded sides.
8. Use sticky tack to glue the three 1cm sides as you fold these over the smaller half of metal. This becomes the boiler for the boat.
9. Roll the two straws in sticky tack and insert these into the boiler you have just made.
10. Insert the boiler into water and blow through the straws to ensure that the boiler is airtight and no air is escaping.
11. Push the straws through the hole in the boat and seal this hole with more sticky tack.
12. Use a syringe to fill one straw with water. Continue to fill water in one straw until water pours from the other straw.
13. Float the boat on the water.
14. Light a tea light under the boiler.



So what happened?

As the water in the boiler heats, steam will be expelled through the pipes in the rear of the boat. The force of the expanding gas will cause the boat to speed forward in the water.

What next?

Try making different shaped boats or boats from different materials that work on this principle.

Dynamics and Statics

Boats: 4 Steam boat

(Czech Republic)

Background

A lit candle will heat up water in the pipes, creating a brief burst of steam that is expelled through the pipes in the rear of the boat. The force of the expanding gas (steam) pushes the boat forward.

You will need:

- ✓ Sardine can
- ✓ Copper piping
- ✓ Metal piping, hacksaw, drill
- ✓ Syringe
- ✓ Hot glue gun
- ✓ Tea light and matches

Follow these steps:

1. Shape the copper wire around a metal pipe into a coil.
2. Use a drill to drill two holes in bottom of the sardine can, right at the back.
3. Push the ends of the coil through the holes.
4. Seal the holes with glue from the hot glue gun.
5. Use a syringe to fill one end of the pipe with water. Continue to fill this pipe with water until water pours from the other end of the pipe.
6. Float the boat on the water.
7. Light a tea light under the metal coil.

So what happened?

As the water in the metal coil heats, steam will be expelled through the pipes in the rear of the boat. The force of the expanding gas will cause the boat will speed forward in the water.

What next?

Try making different shaped boats or boats from different materials that work on this principle.

Rotating cup

(Poland)

Background:

Energy is stored in the elastic band which is wound by the skewer at the top. As the skewer is wound, the attached elastic band also winds, storing muscle energy. When released the elastic band unwinds, in turn causing the strings and beads to spin outwards.

You will need:

- ✓ Two skewers
- ✓ Plastic cup
- ✓ Plastic shot cup
- ✓ Elastic bands
- ✓ String & scissors
- ✓ Beads
- ✓ Drill

Follow these steps:

1. Drill a hole in the middle of the bottom of the cup.
2. Drill a hole in the middle of the bottom of the plastic shot glass.
3. Stick the shot glass to the cup.
4. Drill two small holes 2/3 way up the cup, opposite each other.
5. Thread an elastic band through the two cups, then through a bead, catching it on a skewer.
6. Bring the other end of the elastic band into the large cup and catch it onto another skewer.
7. Thread this skewer through the two holes in the cup.
8. Make 16 holes around the rim of the cup.
9. Cut equal lengths of string.
10. Thread these lengths of string through the holes around the rim of the cup and knot the ends.
11. Knot a bead onto the end of each string.
12. Wind the skewer at the top of the cups.
13. While holding the skewer at the top of the cup allow the elastic band to unwind.

So what happened?

As the skewer is wound, the attached rubber band also winds. When released the rubber band unwinds, in turn causing the string and beads to spin outwards.

What next?

Try varying the position of the holes in the cup, the weights on the ends of the string and the lengths of string. Note the differences.

Dynamics and Statics

Projectiles: 1. Mouse projectile

(Ireland)

Background:

Air in a plastic milk bottle can be propelled upwards when the bottle is squashed. A mouse projectile can then be launched upwards into the air.

You will need:

- ✓ plastic milk bottle
- ✓ card
- ✓ sticky tape
- ✓ scissors
- ✓ paper and pens

Follow these steps:

1. From a circle or semi-circle make the cone shaped body of the mouse.
2. Add ears, nose, tail and a face.
3. Sit your mouse on the top of the empty plastic milk bottle.
4. Count down and then squeeze or 'clap' the milk bottle with your arms extended. (This will ensure that your face is away from the rocket mouse when it is propelled upwards.)

So what happened?

When the air from the squeezed bottle is propelled upwards so too is the mouse projectile.

What next?

Try repeating this exercise several times varying the size of the mouse, the size of the bottle and the force of the push. How will each of these changes affect the height the mouse rises? Can you direct the mouse to hit a target? What can you do to make the mouse travel further or faster? What is the heaviest mouse you can launch? Try adding measured quantities of modelling clay inside the mouse's nose cone and make a graph of weight and height/distance travelled.

Projectiles: 2. Straw projectile

(Ireland)

Background

Air in a straw can be used to propel a paper projectile.

You will need:

✓ a sheet of paper
✓ a straw
✓ scissors
✓ pencil (of approximately the same diameter as the straw)
✓ sticky tape
✓ measuring tape

Follow these steps:

1. Starting at one end of the pencil, hold the paper at an angle of approximately to 45˚ the pencil.
2. Roll the paper strip around the pencil fairly tightly until you get to the other end.
3. Tape the tube at the outside of each end and at the middle of the projectile.
4. Cut off both ends of the tube.
5. Fold the upper end firmly and tape it.
6. Design the projectile's nose and fins. (For the nose: draw and cut out a circle, then remove a segment from the circle. Overlap the straight edges and tape down. Alternatively draw and cut out a rocket shape. Stick this to the tube you have made.)

So what happened?

Launch the projectile be inserting the straw in the open end and blow.

What next?

Try repeating this exercise several times varying fins and the tip of the projectile. How will each of these changes affect the height the projectile rises? Try adding measured quantities of modelling clay inside the nose of the projectile and make a graph of weight and height/distance travelled.

http://www.sfi.ie/site-files/primary-science/media/pdfs/col/dpsm_paper_rocket.pdf

Dynamics and Statics

Projectiles: 3. Air projectile

(Ireland)

Background

Compressed air can be used to propel a paper projectile.

You will need

- ✓ sheets of card
- ✓ scissors
- ✓ sticky tape
- ✓ bicycle pump
- ✓ measuring tape
- ✓ homemade launcher (https://www.instructables.com/id/Launcher-for-Air-Rockets-and-Corks-Using-a-Garden-/)

Follow these steps

1. Roll a rectangular sheet of A4 card around a PVC pipe of equal diameter to the pipe on the end of the launcher. Make this into a cylinder.
2. Cut a circle into two semi-circles and use one of these semi-circles to make the nose cone of the projectile.
3. Make triangular fins for the projectile.
4. Decide on the angle of launch.
5. Use a bicycle pump and closed valve to build up pressure in the launcher.
6. Open the valve.

So what happened?

The projectile is launched.

What next?

Try repeating this exercise several times varying fins and the tip of the projectile. How will each of these changes affect the height/distance travelled? Try adding measured quantities of modelling clay inside the nose of the projectile and make a graph of weight and height/distance travelled. Measure different angles of launch and make a graph of different angles of launch with height/distance travelled. For other ideas on air projectile launchers, check out workshops from @IoPITeachers.

Projectiles: 4. Toilet roll projectile

(Ireland)

Background:

A stretched elastic band can launch a toilet roll projectile.

You will need:

- ✓ toilet rolls and card
- ✓ sticky tape and glue
- ✓ chopsticks or skewers
- ✓ elastic bands

Follow these steps:

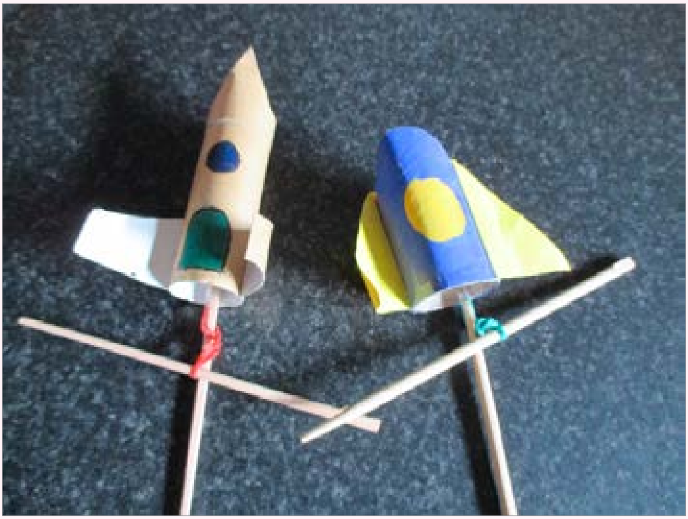
1. Cut a piece off a toilet roll to make a rocket shape.
2. Use another toilet roll or card to make fins and a nose for the projectile.
3. Knot an elastic band around the middle of a chopstick. Keep this chopstick horizontal.
4. Use sticky tape to stick the other end of the elastic band to the tip of the other chopstick.
5. Push the end of the chopstick with sticky tape vertically into the toilet roll projectile.
6. Pull the horizontal chopstick downwards away from the projectile, then let go.

So what happened?

The horizontal chopstick will be pulled upwards and the projectile will be launched.

What next?

Try repeating this exercise several times with different sized elastic bands. Will different sized elastics affect the height/distance travelled?



Projectiles: 5. Foam projectile

(Ireland)

Background:

A stretched elastic band can launch a foam projectile.

You will need:

- ✓ foam pipe insulation
- ✓ strong elastic bands
- ✓ duct tape
- ✓ cardboard or Styrofoam food tray (for fins)
- ✓ scissors
- ✓ long tape measure
- ✓ metre stick
- ✓ copied clinometer

Follow these steps:

Front of Projectile

1. Cut a 12cm length of duct tape down the middle to make two pieces. Place one piece over the other and stick to shiny side, to make the tape stronger.
2. Place a single strand of an elastic band across the top of the foam tube. Tape the elastic band down to the tube, using the double strength duct tape at right angles to the elastic band. Press the tape down to the sides of the tube.
3. Reinforce this tape with another length of tape wrapped around the top end of the side of the tube.

Fins end of Projectile

1. Cut three or four fins from cardboard (or Styrofoam food tray). A suggested way is as follows:
2. Cut a square, draw a diagonal and cut along the diagonal (forming 2 isosceles triangles). Then cut half-way down the height of one triangle and half-way up the other. Nest the fins together, and place them in the slits.
3. Close off the slits with another piece of duct tape wrapped around the foam tube.

Launching the Projectile

1. Loop the elastic band over the end of the metre stick. Pull on the fins end of the projectile, holding it below the fins, as you point it up into the air.
2. Now let the projectile go.

So what happened?

The projectile will be launched.

What next?

- Try repeating this exercise several times with projectiles made of different lengths or with different sized elastic bands or different sized/shaped fins. Will these differences affect the height/distance travelled?
- Discuss the forces involved in the launching (potential/kinetic energy, force of gravity). Measure the distance the projectile travels.
- Use a clinometer to launch the projectiles at different angles. Make a chart showing the affect of different angles on the height/distance travelled.

http://www.sfi.ie/site-files/primary-science/media/pdfs/col/DPSM_Class_Activity_Foam_Rocket_Web.pdf

Archimedes yacht

(Ireland)

Background

What happens when a small boat on a finely balanced trough of water travels from one end of the trough to the other?

A small boat is floated in a trough made from a cut away two litre plastic drinks bottle. The trough is filled to a depth of about two centimeters with coloured water (for extra visibility). The bottle trough is placed on a wooden frame for stability, consisting of a flat base and two half metre wood slats to hold the bottle in position. This is then placed over the edge of a raised block so that it "just" balances.

Follow these steps:

1. Show that the trough is critically balanced and will topple if even a small weight is added to the timber beyond the fulcrum.
2. Then the small boat is gently placed in the water above the supported end of the critically balanced trough. The trough and boat will not tip over.
3. Gently move the boat so that it sails to the unsupported end of the trough

So what happened?

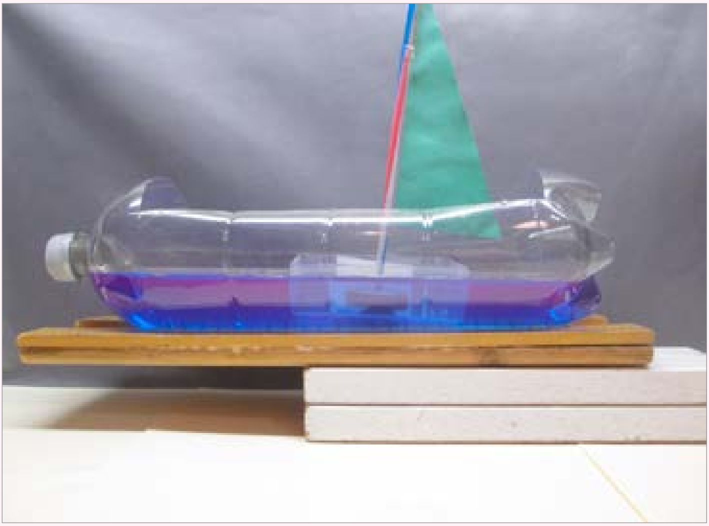
The trough remained in a horizontal plane. The boat did not cause it to topple. The explanation lies in Archimedes principle that a body immersed in water displaces its own weight of water which is evenly distributed throughout the length of the trough preserving the state of balance.

What next?

You could explore what happens when the boat has a small hole in it and takes on water gradually

(a) at the supported end,

(b) at the unsupported end.



Dynamics and Statics

Angular Momentum with a frying pan

(Ireland)

Background

It is recommended that a table-tennis bat is used instead of a frying pan for reasons of health and safety.

If a pancake is flipped and lands back in the frying pan it may not reveal any unusual science.

However if a table tennis bat (red on one side and black on the other) is used in lieu of a frying pan and a CD is used in lieu of the pancake then an interesting feature of angular momentum may be revealed.

You will need...

✓ a table-tennis bat
✓ a CD
✓ a book
✓ A toy mobile phone (or similar flat rectangular object.

Follow these steps

1. With the CD flat on the surface of the table tennis bat, flip the CD so that it lands on the bat (reverse side of CD uppermost).
2. Remove the CD.
3. Now flip the bat on its own. When caught by the handle the black-side of the bat will be uppermost (if originally the red side had been up).

So what happened?

Clearly the bat performed a half rotation around an axis other than the one about which it was flipped, and additional to that rotation. This is strange behaviour indeed. Perhaps when students study "moments of inertia" and the "perpendicular axes theorem" in Dynamics at a later stage in their careers they will better appreciate why this event has occurred. The principle of Conservation of angular momentum requires the unanticipated twist.

What next?

- Show that similar behaviour occurs when ordinary flat rectangular objects like a book are flipped.
- It is worth choosing a book which has a different colour on its front and back covers. Encourage observers to note whether any writing is upside-down or not, and whether the spine of the book is to the left or right. The height of the toss may need to be different than worked for the table-tennis bat. Be sure to flip about the shorter axis.

Rolling Coke cans

(Ireland)

When a coke can rolls in a hollow it oscillates like a pendulum but is the period of oscillation affected if the can is shaken vigorously in advance?

Background

A simple pendulum may oscillate for a few minutes before coming to rest.

A coke can rolling in a hollow as shown in the photograph may come to rest in half a minute.

If the can is then shaken vigorously and allowed to roll in the same hollow, will it roll for longer, the same time as before, or for a shorter time?

Follow these steps:

1. Appoint a timekeeper and a second person to count the number of oscillations before the Coke can comes to rest.
2. Ensure both trials take place under the same conditions.
3. Record results for comparison purposes.

So what happened?

The can which was shaken vigorously rolled for only half the time of the unshaken can.

Also, the number of oscillations completed was approximately half in the second case (shaken can) as occurred in the first case (unshaken can).

Explanations involve the variation in viscosity due to changed distribution of the dissolved gas in the coke. Since the container is "factory-sealed" there is negligible change in pressure inside it.

What next?

Repeat the experiment with clear plastic containers of Coke to observe (if possible) any change in liquid characteristics.

Dynamics and Statics

g by freefall

(Ireland)

Background:

The acceleration due to gravity may be calculated using a sensitive release mechanism and accurate timing.

When objects fall, they accelerate towards the ground. If released from rest, then there is zero initial velocity. Hence the acceleration can be determined by accurate measurement of the distance fallen and the time spent falling. These results may be substituted in the formula

$$s = u\,t + \tfrac{1}{2}\,a\,t^2$$

You will need:

- ✓ Acoustic stopwatch app from PhyPhox or similar
- ✓ 2 screwdrivers
- ✓ A neodymium magnet
- ✓ A screw
- ✓ A steel ball

Follow these steps:

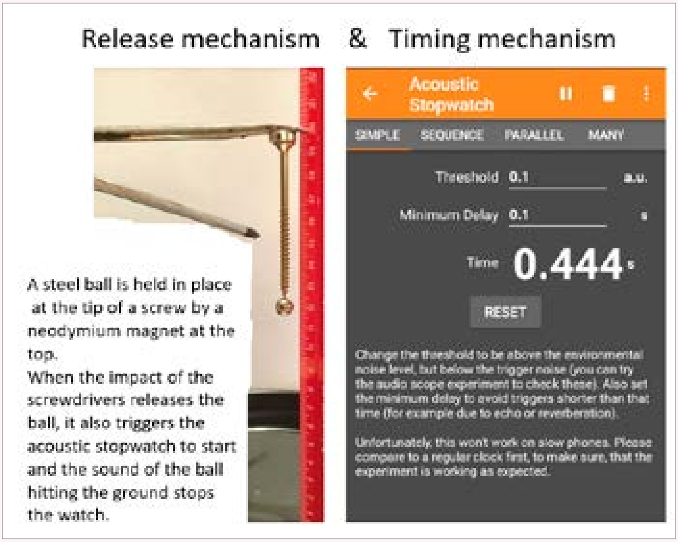
1. Download the “acoustic stopwatch” APP on your phone from PhyPhox. Set the initial conditions as displayed in the photograph. Prime the stopwatch to record.
2. Set up the release mechanism as shown in the photograph.
3. Hold the apparatus so that the ball is a meter above the floor.

So what happened?

When the lower screwdriver struck upwards against the other screw-diver, it simultaneously started the watch and released the ball to fall. When it struck the floor the noise of the impact stopped the watch and the time interval was displayed as shown. When the distance and time measurements were inserted in the formula and processed, the acceleration due to gravity was calculated

What next?

- Repeat the process several times and find an average value.
- Repeat the process for several different heights



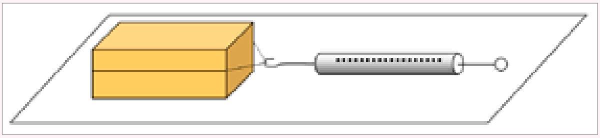
Exploring forces and friction

Is the result what you expected?

(Ireland)

Question

Does the frictional force depend on the area of contact?



You will need...

- ✓ Force meter (0 − 5 N)
- ✓ thread
- ✓ a table or other flat surface
- ✓ a rectangular block. The three dimensions of the block should be **different** so that the frictional force between it and the table can be measured for different orientations of the block.

Follow these steps

1. First find the weight of the block in newtons (*W*)
2. Tie a loop of thread around the block so that it can be pulled by the force meter. Place the block on a table or other level surface.
3. Attach the force meter and gently increase the pull until the block begins to move. **Try to keep it moving slowly but at a steady speed.** Note the reading on the force meter (*F*). This is the **kinetic (or sliding) friction** force.
4. Repeat the pull and note the maximum force before the block moves. This is the **static friction force**. This is generally greater than the kinetic friction force.
5. Repeat steps 2 & 3 but with the block standing on sides with different areas of contact.
6. What do the results indicate?

If the three surfaces have the same finish, then the frictional forces will be **independent of the area of contact**. Why then do racing cars have wide wheels?

The ratio ***F/W*** is called the **coefficient of friction for the pair of substances involved**.

Teacher Notes

Friction opposes the **relative** motion of surfaces that are in contact.

It is **a property of the two surfaces** involved that opposes slippage, e.g. the tyre of a skidding car on an asphalt road (kinetic friction) or the tyre of a car parked on a slope (static friction).

(Note: rolling resistance is quite a different matter.)

Approximate coefficients of friction (μ) for some pairs of substances

Approximate coefficients of friction (*μ*) for some pairs of substances			
		Static	*Sliding*
Rubber	Glass	2.0+	
Glass	Glass	0.9	0.4
Asphalt (dry)	Rubber	0.9	0.7
Asphalt (wet)	Rubber	0.8	0.3 – 0.5
Steel	Steel	0.7	0.6
Wood	Wood	0.3 – 0.5	0.2
Metal	Wood	0.2 – 0.6	
Nylon	Nylon	0.2	
Graphite	Graphite	0.1	
Ice	Ice	0.1	0.03
Synovial joints		0.01	0.003

Dynamics and Statics

Titanic Model

(Ireland)

Background

The R.M.S. Titanic sank as water from one compartment over spilled into another as the compartment walls were not high enough, and the iceberg it had struck cut through several compartments laterally.

In this model coloured water can be added to the "compartments" to show that for a ship to sink a large number of compartments (pill bottles) need to be filled with water. A ship can list or be down at the bow/stern but still float quite well.

The overall density of the entire ship must change enough before sinking can happen i.e. the number of particles in a fixed space (volume) increases.

This answers student questions about why metal ships float but a density cube of steel will sink, using a particle theory approach. This reinforces the classical particle theory concepts and approaches density in a non-mathematical manner.

You will need….

- ✓ Felt-tip marker
- ✓ Scissors/cutting pliers
- ✓ Sheet of acrylic plastic cut into the outline of a ship
- ✓ Plastic pill bottles
- ✓ Glue
- ✓ Transparent plastic box
- ✓ Water
- ✓ Food colouring (cake colouring paste)
- ✓ Plastic jug (2 L)

Follow these steps:

1. Draw the outline of a ship's keel onto the plastic sheet
2. Place the pill bottles so that they fill the shape completely with as few gaps as possible between each bottle. Readjust the keel shape as needed.
3. Glue the pill bottles in position and allow to set. It may be useful to place a flat, heavy object (a thick books) on top of the bottles to prevent sliding while the glue sets.
4. After setting is may be necessary to add some additional glue to ensure that pill bottles at the edges are secure.
5. Three-quarters fill a transparent plastic box with tap water (ocean).
6. To a 2 L jug of water add some food die. Cake fondant colouring pastes are best, as the colours are vibrant and can be clearly seen at a distance.
7. Before placing the Titanic Model into the "ocean", ask your students if the pill bottle "compartments" air empty.
8. Place the model into the ocean and ask students to predict what will happen as you add the coloured water to the compartments.
9. You will be able to demonstrate that the model tilts at various angles, and can sit quite low in the ocean, before sinking.
10. In this modelling it is possible to get the Titanic to "turn turtle", rotate and invert along its long axis, which then dumps coloured water into the ocean.

11. While filling the compartments it is useful to give a commentary on how the R.M.S. Titanic actually sank:

The iceberg cut through several compartments at once (front to back)

The compartment walls were not high enough, so as each compartment filled, water over-topped into the next compartment

In this way the compartments filled more quickly than they should have, and the weight of so much water caused the ship to break into two halves

The sister ship of Titanic, Olympic was retrofitted to correct this, and since then compartmentalisation has been an important ship design factor.

Compartments with water-tight doors allowed many battle-damaged ships in WW1 and WW2 to make if to harbour without sinking.

12. It is useful to repeat the "sinking" several times in each demonstration to ensure all students get the chance to see what happens.
13. Prompt questions about how the air particles in the compartments were displaced by water particles, and how the number of particles in the fixed space has increased are important at this point.

So what happened?

Adding water to the compartments increases density because the number of particles within each compartment, and the overall "ship" increased. Combined with the mass of the plastic the overall density of the ship was more that the water in which it sat, so it then sank.

Relating this back to real life, steel-hulled ships are not solid blocks of metal: they have large air pockets, so their overall density is lower than the density of water.

What next?

- This can be linked to the operation of submarines which take in ballast (water) to increase density and dive, or expel the water (using compressed air)
- Ships which have adjustable ballast tanks of water, to increase stability when sailing, especially if cargo holds are empty.
- It is possible to link this model with iceberg density, at the point were the model has largely sunk – its density is close to that of water, so is mostly sunk but has a small amount above the water line (as with icebergs)
- A live demonstration, with teacher commentary, helps students understand density through particle theory without becoming confused by also trying to apply the density formula, but a video clip linked to a student worksheet, can be useful as a consolidation or extension exercise for homework

This demonstration is the first of three consecutive demonstrations; see Relative Floatation 1 and Relative Floatation 2.

Dynamics and Statics

Relative Floatation 1

(Ireland)

Background

Building on concepts established by the Titanic Model demonstration, this demonstration emphasises that the floatation of an object depends on its density i.e. the number of particles in a fixed space.

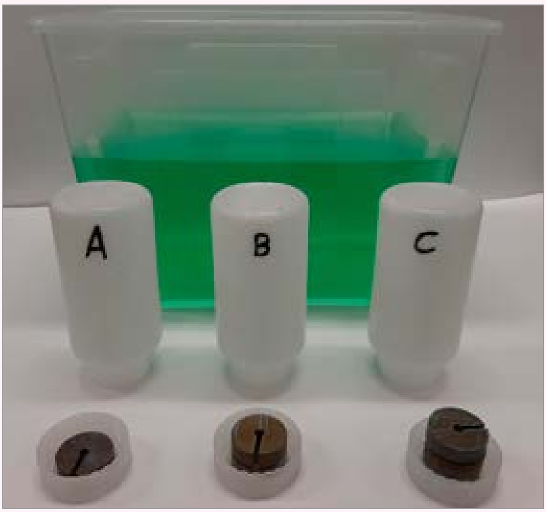
Three supposedly identical objects are placed in a water tank, but their level of flotation shows that there are differences – this demonstration explores those differences by focusing in the number of particles with each object. The demonstration emphasises conceptual, non-mathematical approach to density

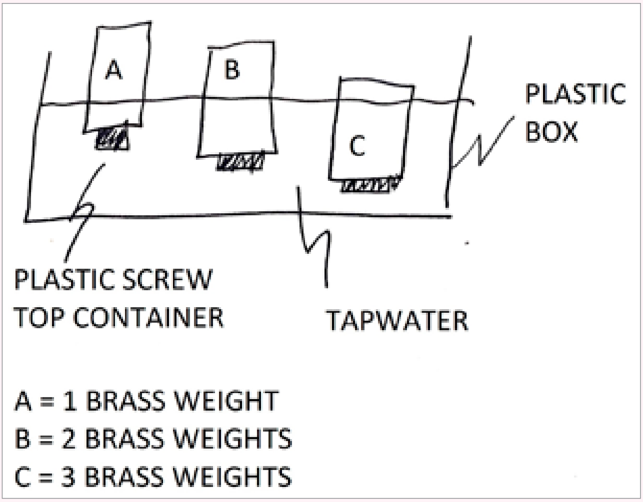
You will need….

- ✓ Felt-tip marker
- ✓ Three identical opaque, screw-top plastic containers
- ✓ Six identical brass weights
- ✓ Water
- ✓ Food colouring (cake colouring paste)

Follow these steps:

1. Mark the containers A, B and C.
2. Place one brass weight in A, two brass weights in B and three brass weights in C.
3. If this is not an immediate follow-on to the Titanic Model demonstration, three-quarters fill a transparent plastic box with tap water (ocean), adding some food dye also.
4. Before placing the containers into the "ocean", ask your students if they are identical size and shape.
5. Then ask the students to predict what should happen if all the containers are placed in the "ocean".
6. Students observations will generally not match their predictions, so it is important to ask: "If size and shape are the same, what is different that could explain the different floatation levels?"
7. The ensuing discussion can be nudged gently by being alert to students attempting to use particles (or corresponding words from their own vocabulary)
8. Then the contents of each container can be revealed.
9. Here it is especially important to tell students that each single brass weight is a "particle", and of equal mass.
10. This question can then be posed: "Does the number of particles in each container explain what we observed? How?"





So what happened?

The height of containers A, B and C above the water corresponds inversely to their mass (density): the higher the container the lower its mass. As the containers are labelled and sitting in coloured water its is easy to see this.

This can be linked back to the Titanic Model at various stages of sinking.

What next?

- This can be linked to the stability of ships on the ocean as container A is more easily pushed (tipped) to one side than either B or C: this has implications for ships in storms, or when turning in heavy seas.
- Ships which have adjustable ballast tanks of water, to increase stability when sailing, especially if cargo holds are empty.
- It is possible to revisit this model when teaching forces (buoyancy). This may be helpful as students will already have a clear link to mass being a factor, and may have also completed pressure as a topic.
- This demonstration is the second of three consecutive demonstrations, and is best done following the Titanic Model demonstration, (see Titanic Model and Relative Floatation 2).

Dynamics and Statics

Relative Floatation 2

(Ireland)

Background

Building on concepts established by the Titanic Model and Relative Floatation Model 1 demonstrations, this demonstration emphasises that the floatation of an object depends not only its density i.e. the number of particles in a fixed space, but also on the density of the liquid in which it floats. Students may already be somewhat familiar with this through the density tower of liquids.

This model builds on previous density concepts by adding a layer of complexity/student understanding in a modelling scenario that emphasises a conceptual, non-mathematical approach to density, using only simple measurement for comparison purposes. Rivers/lake and oceans are modelled using tap water and salt water.

You will need….

- ✓ Felt-tip marker
- ✓ One opaque, screw-top plastic containers
- ✓ Two identical brass weights
- ✓ Water
- ✓ Mass balance
- ✓ Table salt/NaCl
- ✓ Two large beakers (or two large cut-down plastic drinks bottles)
- ✓ Retort stand
- ✓ Metre stick

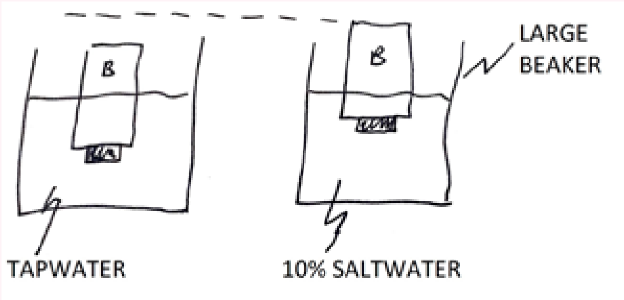
Follow these steps:

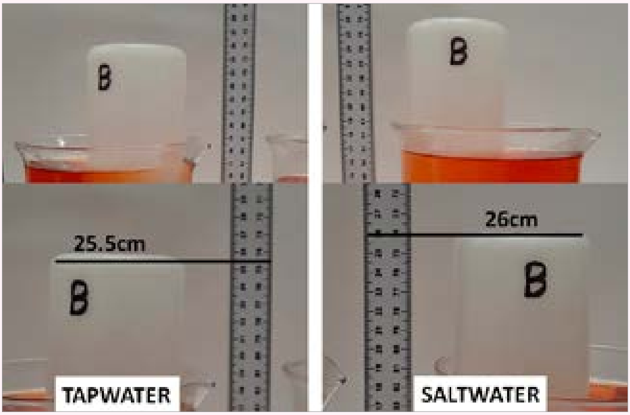
1. Container B from the previous demonstration can be used. It is possible to use two identically weight containers, but to eliminate any extraneous factors in the minds of students, using a single container is advised.
2. Three quarters fill a large beaker, with tap water.
3. Fill a second large beaker in the same way, adding 10% of the waters mass in table salt.
4. Stir the salt mixture until all the salt is fully dissolved.
5. Seawater is approximately 4% salt, however this difference in water density would not be enough to show a meaningful difference on this scale, so a higher concentration is used in order to demonstrate a principle with sufficient clarity.
6. Place both beakers either side of a meter stick that has been suspended from a retort stand.
7. Zero the metre stick to the surface of the water.
8. Don not tell students the purpose of the demonstration, simply that they are to note observations, and use these in combination with the previous two demonstrations to explain a question that will be posed at the end.
9. Place B into the tap water and note its height reading.
10. Remove B from the tap water, dry any excess water on its surface and place into the saltwater.
11. Note the height of B above the water.
12. Compare the two heights. The difference will be small but measurable.
13. Students can then be asked “If Container B is unchanged, why did it float higher in the second beaker than the first?

So what happened?

Container B was the same density throughout so both beakers did not contain the same liquids, but liquids of similar appearance but different densities.

Salt water has a greater density because of the added salt. The difference in densities between B and saltwater is greater that between B and tap water, which causes B to float higher in salt water.





What next?

- This can be linked to the stability of ships as they pass out of ports into oceans, as water density in a part may be less than outside it. This is especially so if a port sits in a river estuary, as ships might than pass from fresh-water to salt water. This is one of the reasons that ships avoid sailing with empty cargo holds, as without cargo they have to use their ballast systems carefully.
- Ships which have adjustable ballast tanks of water, to increase stability when sailing, especially if cargo holds are empty.
- As there are layers of density in the ocean (haloclines), submarines have to adjust ballast levels carefully as they pass from one layer to another.
- This difference in salt layers can also create effective sound barriers as the speed of sound changes between layers, allowing submarines to move between layers to avoid sonar detection.
- It is possible to revisit this model when teaching forces (buoyancy). This may be helpful as students will already have a clear link to mass being a factor, and may have also completed pressure as a topic.

This demonstration is the third of three consecutive demonstrations, and is best done following the Relative Floatation 1 demonstration, (see Titanic Model and

Dynamics and Statics

Polydensity Bottle

(Ireland)

Background

There are a number of versions of this demonstration available online, but the inspiration for this demonstration comes from the magazine Chemistry In Action (Issue 110, pp.30-31)

Using two colourless liquids of differing density and craft beads of two different densities an enclosed density model can be made that allows teachers to pose a variety of questions about relative densities.

You will need….

✓ 1 litre soft drinks bottle
✓ 400 cm^3 of propan-1-ol (rubbing alcohol)
✓ 400 cm^3 deionised/distilled water
✓ 100g sodium chloride (or kosher salt but not table salt)
✓ 100 Pony craft beads of a single colour (lower bead layer - acrylic)
✓ 100 Hama/Perler beads of a different single colour (upper bead layer - polyethene)

Follow these steps:

1. Place the propan-1-ol and deionised water into the empty bottle and shake until mixed.
2. Add the 200 g of sodium chloride and shake until fully dissolved. Upon settling it will be possible to observe a water alcohol layer sitting on a saltwater layer.
3. Add both sets of beads; they will form two layers at the interface of the liquids.
4. For students "Why are the plastic beads sitting I the middle and not floating at the top?", followed by "If there are two layers of colourless liquids in this bottle does that help explain why the beads float the way they do?"
5. If the bottle is now shaken the liquid slayers mix temporarily and the beads move quickly to the top and bottom of the bottle.
6. For students: "Why did the beads shoot to the top and bottom after shaking? And why did they return to their start positions?"
7. Within two minutes the layers separate out and the beads return to their original positions.

So what happened?

Water is a polar solvent so will accept propan-1-ol alcohol and sodium chloride as solutes forming solutions. But as sodium chloride is more ionic than propan-1-ol two liquid layers form. The alcohol layer retains some water.

The Pony beads float in saltwater, so form the lower layer of beads. The Hama/Perler beads sink in the alcohol solution so form the upper bead layer.

When shaken, an emulsion of the two liquids is formed, this has a density between the densities of the two liquid layers. The Pony beads sink to the bottom and the Hama/Perler beads rise to the top. As the layers separate the beads move back to their initial positions, (see the table)

What next?

- This demonstration can be flexibly used at JC, TY or LC Physics levels
- It can be set as a revision demonstration or extension exercise.
- Solubilities and ionic strengths are topics in LC Chemistry that can be explored with this model also.

Before... | Mixing | Beads separating out in emulsion | Liquids separating out of emulsion with beads | After...

How not to sink!

(Ukraine)

Background

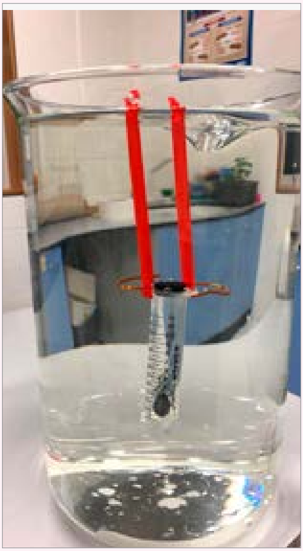
When swimmers are in trouble in the water they will often frantically put their arms above their head which causes them to sink.

You will need:

- ✓ syringe
- ✓ drinking straw
- ✓ weights
- ✓ wire
- ✓ hot glue gun

Follow these steps:

1. Heat the end of the syringe and then pinch with a metal tongs to seal.
2. Add a weight inside the syringe (or some sort of heavy mass)
3. Push wire through the plastic top of the syringe, making it into an S shape.
4. Cut the straw into two equal lengths and heat and seal each end.
5. Fix one end of each sealed straw to the wire, one on each side.
6. As you rotate the wire the straws should move up or down.
7. Insert the plug (from the plunger) into the top of the syringe. Once you have checked that it is working seal top with hot glue.
8. Place it in large beaker of water and observe what happens with arms up (straws up) and arms down (straws down).



So what happened?

The syringe will float when the arms are down and will sink when the arms are up.

More mass above the water reduces bouyancy.

Dynamics and Statics

Euler's Disc

(Ireland)

Background

Euler's disc was invented by Joe Bendik in the late 1980's. He named it in honour of the 18th century Swiss mathematician Leonhard Euler. Euler was very interested in the math and physics of "spolling" (spin & roll) of rigid bodies.

Many of us have spun a coin on a smooth surface but a heavy Euler's disc takes this activity to another dimension.

Many papers have been published by mathematicians and physicists on the complex motion.

Teachers and students can make their own version.

You will need….

- ✓ The platter disks from old computer hard drives (as many as possible)
- ✓ Clamp and glue
- ✓ A flat surface- ideally a glass concave mirror such as a magnifying cosmetic mirror
- ✓ A stop watch such as on a smart-phone
- ✓ A green laser **CAUTION** Use laser safety glasses Do not stare into the beam.

Follow these steps:

1. Glue the hard drive together using the glue and clamp
2. Spin your disk on the mirror
3. Time how long it takes to stop
4. Repeat observing your mark on the disk this indicates the disks rotation
5. Repeat shining the green on the upper surface spolling

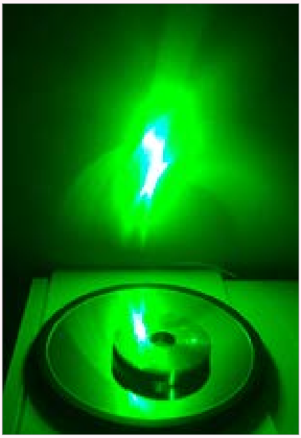
disk. The image produced can viewed on a nearby wall or ceiling

So what happened?

It is very obvious that the disk spins for a very long time before it comes to a stop. A very distinctive sound is also heard.

At the beginning the disk has both potential and kinetic energy. The potential energy results from the initial tilt and the kinetic energy from the rotation and precession or wobble. The energy is dissipated by the vibration, sound, and friction with the surface and the air. This highlights the importance of using both a smooth disk and surface.

While the rotation speed remains approximately constant,



the velocity of the precession increases continually. This can be observed by the increasing frequency heard and the decreasing radius of the circular laser projection.

The motion can also be described in terms of angular momentum. Just like a spinning top, the Euler's disk uses its angular momentum to remain upright. As the disk spolls there is a balance between the gravitational force (weight) and the reaction of the surface.

What next?

- Students could record the distinctive sound of the disk and analyse it's frequency with FFT (Fast Fourier Transform) software such as http://audacity.sourceforge.net and others.
- A graph of the change of frequency with time could be plotted.
- Observe the spolling of the disk on different surfaces: glass, wood, wet, dry etc. investigating the resulting times.
- Pose the question "what would happen if the experiment was performed in a vacuum?"
- If the disk is viewed edged on, it forms "a figure-of-eight pattern "this can be described by a function of differential geometry called "Viviani's curve". Students could video and analyse this with software such as https://physlets.org/tracker/ or others.

Ketchup Cartesian Diver

(Ireland)

Background:

Lots of good physics can be taught and learnt through the use of science toys, many can be packaged as 'magic tricks'

There are many versions of the Cartesian Diver, ranging from bought fishing games, to divers made from droppers, test tubes and pen tops.

The ketchup sachet diver has to be one of the simplest.

All Cartesian Divers can be used to introduce and explore the principles of: Archimedes, buoyancy, flotation, density, compression of gases and liquids.

You will need:

✓ Flexible transparent plastic bottle with cap
✓ Tomato ketchup sachet
✓ Water
✓ Bowl or jug

Follow these steps:

1. Place a few ketchup sachets into a bowl or jug of tap water
2. Choose one that floats in the water
3. Remove any labels from the bottle and fill it all the way to the top with water.
4. Add the ketchup sachet to the bottle and screw the cap on tightly.
5. Slowly squeeze the bottle and the sachet magically on your word of command should sink to the bottom of the bottle.
6. When you stop squeezing, the packet will float back up to the top.

So what happened?

Squeezing the bottle increases pressure on the condiment packet, compressing any air inside. When the higher pressure compresses the air in the packet, the packet displaces less water, thus decreasing its buoyancy and causing it to sink. When you release the pressure the air inside the packet expands once again. The packet's buoyancy increases and the diver rises.

The Greek philosopher Archimedes was the first person to notice that the upward force that water exerts on an object, whether floating or submerged, is equal to the weight of the volume of water that the object displaces. That is, the buoyant force is equal to the weight of the displaced water.

What next?

- Try the experiments with food condiments such as mustard, brown sauce vinegar etc.
- Try with different sized bottles and shapes such as shampoo or mouthwash bottles
- Change the temperature of the water does it change the floatation?
- Try with liquids of differently densities such as salty water, vinegar, oil etc.

Dynamics and Statics

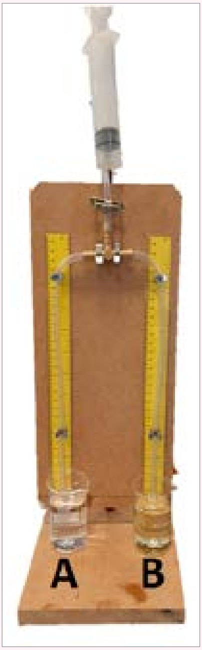
Hare’s Apparatus

(Ireland)

Background

Hare’s Apparatus allows a reference liquid to be used to find the density of another liquid, by comparing the heights that both liquids reach in a system where they can be drawn up equally through vertical tubes.

Details of how to construct the device can be found at this link bit.ly/SonS2019



You will need:

- ✓ Retort stand
- ✓ 1 m plastic tubing
- ✓ 6 tube clips
- ✓ 1 Mohr clip
- ✓ 1 Pasteur pipette
- ✓ Scissors
- ✓ Screwdriver
- ✓ Glue
- ✓ Laminated paper rulers
- ✓ T-junction
- ✓ 50 cm^3 plastic syringe
- ✓ 2 small beakers
- ✓ Water
- ✓ Cooking oil

Follow these steps:

1. To set up the device for use, make sure the syringe has been removed and the Mohr clip is fully open.
2. Place an equal amount of water in one beaker, A, and a sample of cooking oil in the other, B. Allow several minutes for the capillary action in each tube to settle.
3. Make sure the piston of the syringe is fully closed, before reattaching to the apparatus.
4. Draw out the syringe piston approximately halfway.
5. Quickly close the Mohr clip to maintain the applied suction.
6. Read the height of each liquid from the graduations behind each tube.
7. Enter the heights into the formula and calculate the density of the cooking oil.

So what happened?

The ratio of the densities of two liquids is equal to the ratio of the column heights of these liquids under equal pressure. If one of the liquids is water we can take its density to be 1.0 g/cm^3. This then changes the formula so that by measuring the height of water and another liquid we can calculate the density of the second liquid.

This means that Hare’s Apparatus provides a straightforward method for measuring densities, using water as a reference liquid.

The difference in the column heights can be explained by the fact that both columns of liquid have the same mass and exert the same hydrostatic pressure.

In general, oils have lower density than water and so the oil column would usually be higher than the water column.

What next?

- Hare’s Apparatus could be used to explore ratios in addition to students using experimental reading in a formula to quantify relative densities of liquids compared to water
- The experimental results could also be used to predict density layers in a density column and confirming predictions by constructing the density column.

$$\frac{\rho_1}{\rho_2} = \frac{h_1}{h_2}$$

$$\frac{1.0}{\rho_2} = \frac{h_1}{h_2}$$

$$h_2 = \rho_2 h_1$$

$$\rho_2 = \frac{h_2}{h_1}$$

Centre of mass

(Ukraine)

Background

The centre of mass of an object is the point at which the object can be balanced.

Mathematically, when an object is in a state of equilibrium the sum of the moments around any point is zero.

You will need:

- ✓ a cork
- ✓ matchstick or toothpick
- ✓ a wire clothes hanger
- ✓ metre stick

Follow these steps:

1. Place the matchstick in the bottom of a cork.
2. Take a hanger or strong wire and make a Z shape.
3. Place the wire in the top side of the cork as in Figure 1.
4. Try to balance the cork on the matchstick on the end of the metre stick as in Figure 2.

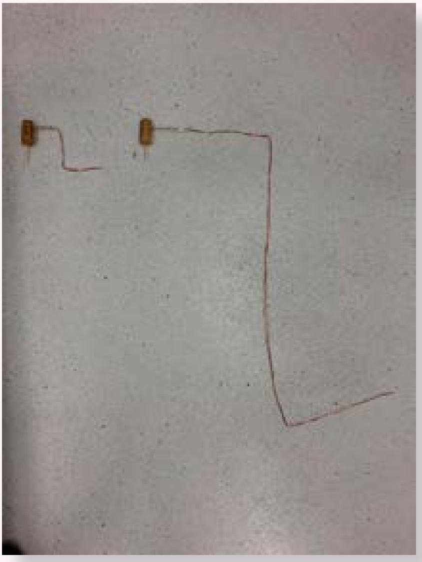
So what happened?

The cork stays balanced (in equilibrium) as the sum of the moments around the fulcrum is zero.

A short wire won't balance as the moments are not balanced.

What next?

Progress to the hanging hammer on a metre stick (see Science on Stage 2017 booklet).



How big is surface tension?

And how can it be measured?

(Ireland)

Background

It is a well know fact that the surface of water acts as if the water had a kind of ‘skin’. Many kinds of insects can run around on it.

If the narrow edge of a glass slide is brought in contact with the surface of water, the water clings to the edge and a small force is required to pull it away again. If this procedure is repeated using the long edge of the slide then a larger force is required to withdraw it.

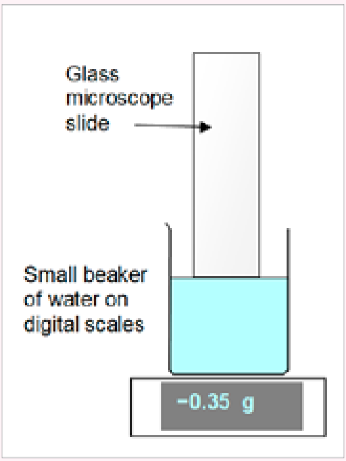
Surface tension is the **force per unit length** along the surface of a liquid.

You will need...

- ✓ Digital scales (measuring to 0.01 g or 10 mg,),
- ✓ small beaker,
- ✓ glass microscope slide

Follow these steps

1. Place a small beaker of water on the digital scales. Set the reading to zero. (Press ‘Tare’.)
2. Hold the glass slide vertically and carefully lower it until the narrow edge touches the water. The water will cling to the edge of the slide.
3. Slowly and carefully withdraw the slide. Note that as it is raised a **negative reading** appears on the scales. This corresponds with the surface tension around the edge of the slide, i.e. **twice** the width and twice the thickness. This is typically about 52 mm.
4. Convert the reading on the scales from grams weight to newtons. (Multiply by 9.8 / 1000)
5. Calculate the force per metre. For clean water this is about 0.07 N m^{-1} (= 72.8 millinewtons per meter at 20 °C).



Surface tension effects

Several phenomena are directly related to surface tension.

(Ireland)

Background

Surface tension is involved many phenomena, including:

- ✓ The ability of many insects to walk on water
- ✓ Capillary action
- ✓ The spherical shape of drops
- ✓ Superheating of water and other liquids
- ✓ Formation of clouds and condensation trails

Capillarity

Capillarity is a consequence of surface tension. Surface tension is the force per unit length. In this case the length is the **internal circumference of the capillary tube**, i.e. $2\pi r$.

The force is the **weight of the column of water** that it pulls up, i.e.
volume × density × g.

The volume is $\pi r^2 h$ and, in the case of water, the density is 1000 kg m^{-3}.

Remember to get the weight of the water column in **newtons** and all lengths in **metres**.

Surface tension (γ 'gamma') is the force divided by the length:
$= (1000\ \pi r^2 h\ g) \div (2\pi r)$
$= 500\ r\ h\ g$

If the surface tension is already known, then the internal diameter (d) of the tube can be found.

Surface tension
$= (1000\ \pi r^2 h\ g) \div (2\pi r)$
$= 500\ r\ h\ g$
$= 4905\ r\ h$

Verify that: $r \approx 15 \div h$
(if r and h are in mm)

Bubbles

Consider a spherical drop of water (or a spherical air bubble in water). Because of surface tension there is **greater pressure inside** a curved surface than outside.

The excess pressure:
$F/A = (2\ \pi\ r\ \gamma) / (\pi\ r^2) = 2\ \gamma / r$

If r = 1 mm then the excess pressure is 145 Pa

If r = 1 µm then the excess pressure is 145, 000 Pa

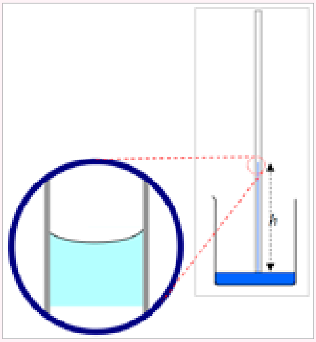
(i.e. 45% more than atmospheric pressure!) So very small bubbles tend to get squashed out of existence.

In boiling liquids bubbles tend not to form in the bulk of the liquid but on surfaces where they can start with a large radius.

Soap bubbles

Since soap bubbles have two surfaces (inside and outside) the **excess pressure** is given by: $\mathbf{4\ \gamma / r}$

However, the value of the surface tension of water is greatly reduced by the presence of soap or detergent.



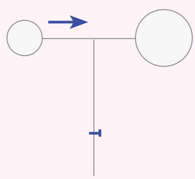
Cloud formation

Similar reasoning can be applied to the formation of clouds. Small droplets tend not to form, even in so-called 'supersaturated' air, unless small solid particles (e.g. dust, smoke) are present.

The exhaust from jet engines provides such particles and so gives rise to condensation trails ('contrails').

Bubbles on a T-tube

If bubbles of different size are formed on the arms of a T-tube, the smaller bubble deflates into the larger bubble because the pressure inside it is greater. .



Surface tension demonstration

(Ukraine)

Background

Buoyancy or upthrust, is an upward force exerted by a liquid that opposes the weight of an immersed object. If the weight is greater than the upthrust the object will sink and if the weight is less than the upthrust the object will float.

Surface tension is the property of the surface of a liquid that allows it to resist an external force, due to the cohesive nature of its molecules.

You will need:

- ✓ a cork
- ✓ thin plastic tube
- ✓ plastic dish
- ✓ nut/weight
- ✓ hot glue gun

Follow these steps:

1. Cut out a circle from a plastic dish.
2. Push the plastic tube through the cork.
3. Attach the nut/weight to the end of the plastic tube as in Figure 1.
4. Attach the plastic circle securely to the tube on the other side of the cork using hot glue or any other suitable means.
5. Place the device in a large beaker of water, as in Figure 2, and observe what happens.
6. Push it under the water and observe what happens.
7. Push gently so the plastic circle just meets the surface of the water and observe what happens.

So what happened?

The cork will float in the water when placed in the beaker as the upthrust is greater than the weight of the object. When pushed under the water it will bounce back up for the same reason.

However, if you gently let the plastic circle meet the water in the beaker the surface tension will be just enough to allow it to stick to the plastic, holding it in place, as in figure 3.

What next?

Investigate different areas of disks and find the minimum area needed.

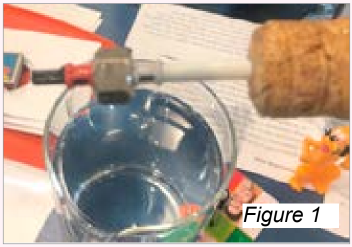


Figure 1

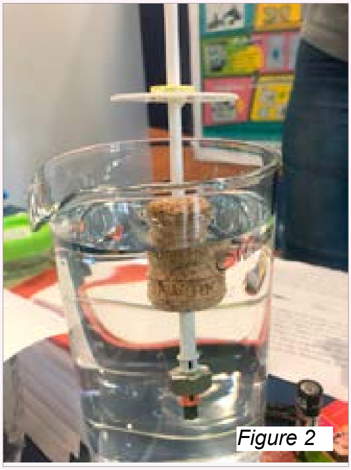


Figure 2

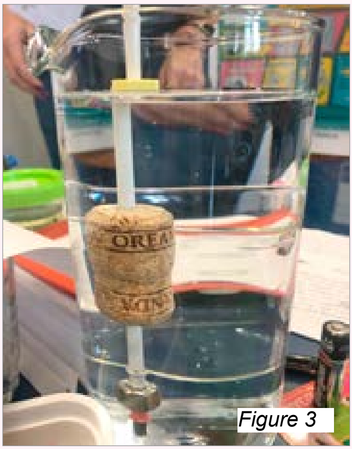


Figure 3

Inverted glass of water

A demonstration of the surface tension of water

(Ireland)

Background

Many, if not most, of the explanations for this demonstration that you may find on the Internet are incorrect.

They usually say that atmospheric pressure pushes the card up and holds the water in the inverted glass.

If this were a complete explanation then the 'trick' should work with other liquids, especially ones that are less dense than water, such as cooking oil. But it doesn't.

You will need...

- ✓ clean water
- ✓ a drinking glass or jam jar
- ✓ stiff cards, or thin rigid plastic sheets, of larger diameter than the glass
- ✓ a fine net
- ✓ an elastic band
- ✓ a hole punch or other means of making holes in cards (1 to 5 mm)
- ✓ a basin

Follow these steps

(a)

1. Pour some water into the glass. (It does not need to be full.)
2. Cover the glass with a card.
3. Carefully invert the glass, while holding the card in place, over the basin.

(b)

4. Repeat the process using a card with a hole in it.
5. Repeat the process using a card with several holes in it.
6. Repeat the process but instead of a card use a fine net held in place with an elastic band.
   (A **jam jar** works best for this because it has a large lip that will prevent the net from slipping off.)

So what happened?

As long as the water is clean and the holes in the card (or net) are not too big, then the water should stay in the inverted glass.

The explanation

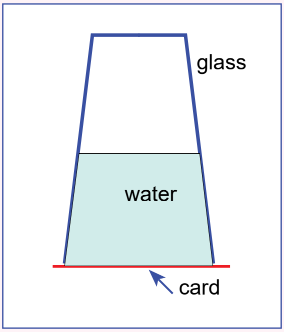
Contrary to what many books will tell you, the key to this is not atmospheric pressure but **surface tension**.

When the glass is inverted the card drops a little and a concave water surface forms around the rim of the glass.

The pressure on the convex side (water side) is less than that on the concave side (air side).
The pressure difference is about 150 Pa if r = 1 mm.

This will also work even if there are holes in the card (up to a few mm in diameter)

It works with water, which has a high surface tension,

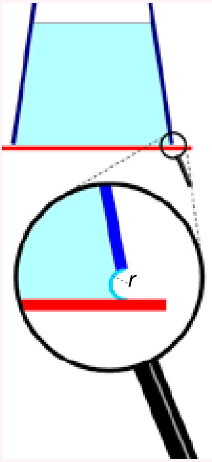


but will not work with most other common liquids.

It does not work if detergent is added to the water.
(The surface tension of water is lowered significantly by detergent.)

What next?

Investigate how big the holes in the card can be and still hold the water in the glass.



Is it pure gold?

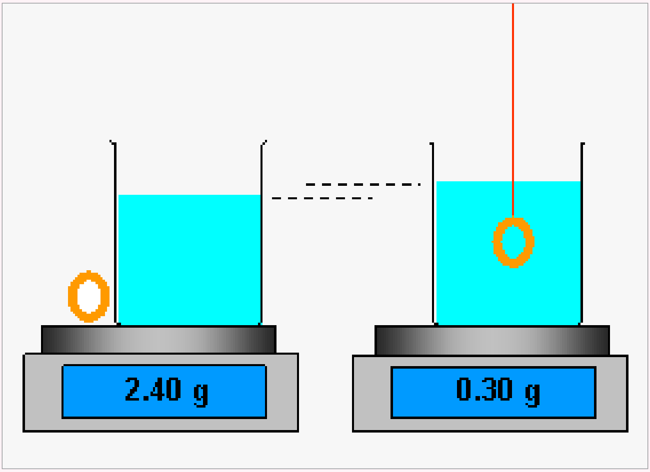
Archimedes' principle in practice

(Ireland)

Background

Archimedes' Principle
(as applied to water)

A body immersed in water displaces some water and feels lighter. The weight of the displaced water is exactly equal to the apparent loss of weight of the body.



You will need...

- ✓ Electronic balance
- ✓ small beaker with water
- ✓ object to be tested (e.g. gold ring)
- ✓ very thin wire (to suspend the ring)

Procedure

1. Place the beaker of water on the scales. Press 'Tare' to zero the reading.
2. Place the ring on the scales (beside the beaker) and take the reading. This is the mass of the ring (*m*).
3. Then suspend the ring in the water and take another reading. (This causes the water level to rise slightly.)

So what happened?

The water exerts an upthrust on the ring and the ring exerts an equal and opposite force on the water and so on the scales. The second reading is the weight of water displaced.

Since the density of water is approximately 1 g cm^{-3}, the volume of the ring in cubic centimetres (V) is **numerically equal to the mass, in grams, of water displaced**.

Using the figures shown in the diagram the density (ρ) of the ring would be

$$\rho = m/V$$
$$= 2.4 \div 0.3$$
$$= 8 \text{ g cm}^{-3}$$

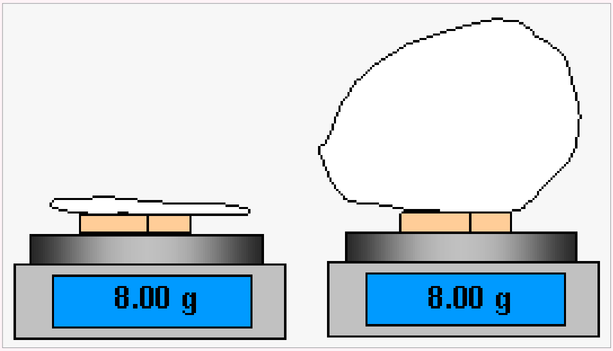
(so it's not gold!)

Metal	Density
Platinum (100%)	21.4
'950 Platinum'	20.1
Gold (24 carat =100%)	19.3
22 carat	17.7 to 17.8
18 ct Yellow	15.2 to 15.9
18 ct White	14.7 to 16.9
14 carat	12.9 to 14.6
9 carat	10.9 to 12.7
Silver (100%)	10.5
Sterling Silver (92.5%)	10.2 to 10.3
Copper	9
Steel	7.75 to 8.05

Trying to weigh air?

What's really happening

(Ireland)



Background

The principle of Archimedes applies to the weight of objects immersed in fluids, i.e. in liquids or gases.

You will need...

- ✓ Electronic balance
- ✓ a light plastic bag
- ✓ a clothes peg

Follow these steps

1. Weigh an empty plastic bag and a clothes peg.
2. Then inflate the bag without blowing into it and seal it with the clothes peg.
3. Weight it again.
4. Explain why the weight is the same.

So what happened?

The density of air is about 1.2 g cm^{-3} (i.e. 1.2 kg m^{-3}).

Any object that is weighed in air will appear lighter by an amount that is exactly equal to the weight of air it has displaced. (Archimedes' Principle)

If the plastic bag has a volume of, for instance, 1 litre then when it if full of air it should be about 1.2 grams weight heavier. However, it will be lighter by the weight of air that the bag of air has displaced — which is also about 1.2 grams weight.

Extension: hot air balloons

The table below shows the density of air at various temperatures.

Temp. (°C)	Density (kg m^{-3})
0	1.29
10	1.25
20	1.20
80	1.00
100	0.95

1. A commonly used size for a hot air balloon is 2800 cubic metres. What mass of air does it contain at 10°C? (See table left)
2. What mass of air does it contain at 100°C?
3. If the contained air is at 100°C and the outside air temperature is 10°C, what is the maximum total mass the balloon can lift (i.e. the balloon material, burner, fuel tanks, basket and passengers)?

Image: Wikimedia Commons (by Kropsoq)

Answers

1. 3500 kg (i.e. 2800 ×1.25)
2. 2660 kg (i.e. 2800 ×0.95)
3. 840 kg (i.e. 3500 - 2660)

The rationale for Archimedes' principle

(Ireland)

Archimedes' principle

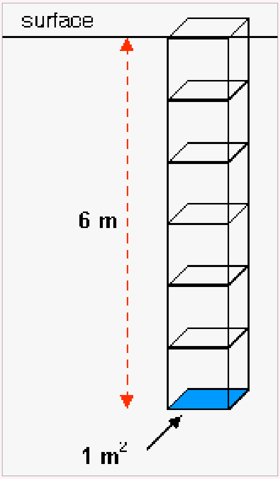
Brief statement of Archimedes' principle:

A body immersed in a fluid displaces some of the fluid and appears to be lighter. The weight of the displaced fluid is exactly equal to the apparent loss of weight of the body.

Why does it work?

Pressure in a liquid is due to the weight of the liquid above a specified area.

- Consider a square metre at a depth of 6 metres in water. The volume of water above it is 6 cubic metres.
- The mass of this water is 6000 kg (ρ =1000 kg m^{-3}) so the weight of this water is almost 60,000 N (6000 kg × 9.8 N kg^{-1}).

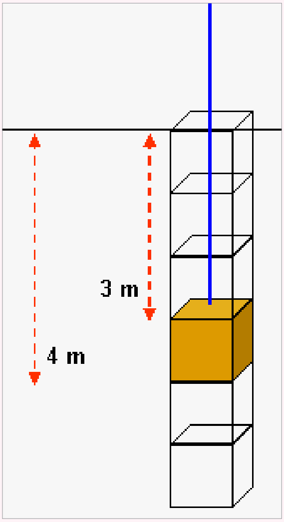


- Therefore the pressure at that depth is about 60,000 N m^{-2} (or 60,000 pascal)
- In summary, $p = h \times \rho \times g$

Buoyancy

Buoyancy is an upward force exerted by a liquid (or a gas). It results from the pressure difference between the bottom and the top of the object.

- Consider a cubic metre (e.g. of metal) suspended in water to a depth of 4 m.
- The pressure below it is 40,000 N m^{-2}
- The pressure above it is 30,000 N m^{-2}
- The difference is 10,000 N which is **exactly equal to the weight of water displaced** by the object.



The buoyancy (or upthrust) is exactly equal to the **weight of liquid displaced** by the object.

Note that the upthrust does not depend on the density of the immersed object but **only on its volume**.
(It does of course depend on the density of the liquid.)

Archimedes' principle:
"A body immersed in a fluid experiences an upthrust that is equal to the weight of the displaced fluid."

Buoyancy correction

Standard laboratory masses are often made of brass. (ρ = 8.73 g cm^{-3}).

The manufacturers apply a buoyancy correction on the assumption that the masses will be used in normal laboratory conditions. (20°C, air density 1.20 g cm^{-3}).

Question

What is the actual mass of a 'standard' laboratory brass mass marked 100 g?

For more details see: http://publications.npl.co.uk/npl_web/pdf/mgpg71.pdf

Answer:

100 g + (100/8.73) (1.2/1000) = 100.0137 g

Water bottles drop

(Ireland)

Background:

Students often expect heavier objects to fall faster than lighter ones. This simple activity recreates “Galileo’s falling bodies experiment”.

You will need:

- ✓ Two empty plastic water bottles
- ✓ Tap water
- ✓ Some food colouring
- ✓ A safe place to drop the bottles

Follow these steps:

1. Remove any labels form the bottles
2. Fill one bottle with water and food colouring and the other with approximately 1/3
3. Hold both bottles at arms-length and the same height
4. Ask your students which bottle will hit the ground first
5. Carefully drop the two bottles together
6. The students will see that the bottles hit the floor simultaneously
7. This can be reinforced if the students close their eyes and listen for the sound of the bottles falling together

So what happened?

Students will expect the fuller bottle to strike the ground before the other one because it is heavier. They simple activity recreates “Galileo’s falling bodies experiment”.

Sometime between 1589 and 1592, Galileo Galilei is said to have dropped two spheres of different masses 57m, from the top of the Leaning Tower of Pisa. The two hit the ground at the same time. His aim was to demonstrate that their time of fall was independent of their mass. In our case the two bottles are similar in size and shape so they experience the same air resistance and also fall with the same rate of acceleration

What next?

Pose the following questions to your students

- What would happen if the bottles had different sizes or shapes?
- What would happen if the bottles had different equal amounts of different liquids such as water and oil?
- What would happen if the bottles were dropped on different planets?
- What would happen if the bottles had different sizes or shapes?

- ✓ See Physics on Stage 3 book/ video Forces 12 Anyone For Tennis? for an experiment dropping two identical tennis balls –one filled with water! https://bit.ly/2y66B7h and https://bit.ly/2WytU2K

- ✓ This experiment was performed from the top of the Leaning Tower of Pisa by Prof, Steve Shore in 2009 using water bottles view at https://bit.ly/BottleDrop
- ✓ In 1971 Commander David Scott of the Apollo 15, dropped a geologic hammer and a feather and they hit the moon’s surface at the same time watch at https://bit.ly/MoonHammer
- ✓ Watch Prof. Brian Cox’s video of a bowling ball and a feather falling in the world’s largest vacuum at NASA’s Space Power Facility in Ohio https://bit.ly/3dL8Qfp

Sound

Crowing cup, mooing bucket

(Czech Republic)

Background

Sound is a form of energy, which is caused by vibrations. Changing the way an object vibrates can change the pitch and volume of the sound produced.

You will need:

- ✓ A yoghurt cup
- ✓ A larger cup
- ✓ A bucket
- ✓ A bigger bucket
- ✓ String
- ✓ A wet cloth
- ✓ Large paper clips

Follow these steps:

1. Poke a small hole in the bottom of the cups and buckets. The hole should be large enough to just allow a string through.
2. Pull a long string of equal length through the hole in the bottom of each of the buckets and cups.
3. Tie one end of the string to the paper clip. The string should hang through the body of the cup, with the paper clip on the outside.
4. Dampen a cloth with water.
5. Hold the cup in one hand and the string in the other.
6. Using a wet cloth, pinch the string near the cup and drag the wet cloth downwards in a jerky motion.
7. Listen to the sound.
8. Repeat the procedure for each cup and bucket.
9. Compare the sounds created by each bucket using the terms pitch and volume.

So what happened?

Friction between the wet cloth and the string caused vibrations through the string. The vibrations from the string were almost silent without the cup, but when you add the cup, the funnel-like shape of a cup spreads the vibrations and amplifies them (makes them louder.) The bigger the cup/ bucket, the louder the sound.

What next?

- Try using different length or different thickness of string. How does this change the sound?
- Discuss why a wet cloth works better than a dry cloth or a soapy cloth.

More sound experiments available here http://kdf.mff.cuni.cz/~mandikova/kurz/materialy/sound.pdf

Balloons and air pressure

(Ukraine)

Background

The air around you has weight. As a result it causes pressure which acts in all directions. Atmospheric pressure is the force per unit area exerted on a surface by the air above it as gravity pulls it to Earth.

An atmosphere (atm) is a unit of measurement equal to the average air pressure at sea level at a temperature of 15° C. One atmosphere is 101.3 kPa.

The Earth's atmosphere is about 480 kilometres thick, but 90% of it is within 16 km of the surface. At sea level, air pressure is about 1 kg weight cm^{-2} or 10 N cm^{-2} or 100,000 N m^{-2}

You will need:

✓ Two balloons

Follow these steps:

1. Blow up a balloon just under half way, and tie a knot in it.
2. Take the knot and push it through to the other side of the balloon.
3. Holding the knot, twist the balloon and tie another balloon or string around it to hold the knot in place.
4. The balloon should now be inverted as in figure 1.
5. Push against the white board/wall/door and let go.

So what happened?

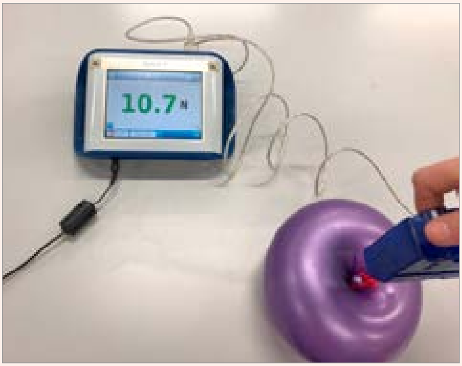
The balloon sticks to the whiteboard.

When you push on the balloon, flattening it against a smooth surface, the air underneath is forced out. This results in a partial vacuum under the balloon, i.e. near zero air pressure.

The air pressure underneath the balloon is now less than around the air pressure surrounding the balloon so the balloon sticks to the whiteboard. After some time some air leaks back in and the balloon falls off.

What next?

Attach a force sensor to the knot and **pull** to see how much force is required to remove it.



Estimating atmospheric pressure (1)

(Ireland)

You will need...

- ✓ luggage scales (or force meter, measuring up to 50 N)
- ✓ a 20 cm^3 syringe
- ✓ a plug to seal the nozzle of the syringe
- ✓ a length of string (ca. 30 cm)

A suitable plug can be made from a short length (2 cm) of clear plastic tubing (e.g. Tygon). Heat one end of the tubing and when it become soft squeeze the softened with pliers for a few seconds.

Follow these steps

1. Expel all air from the syringe and then seal the nozzle.
2. Record the force (F) required to pull the plunger to the 5, 10, 15 and 20 cm^3 marks.

Measuring the force may be facilitated by attaching a loop of string to the flange at the top of the plunger.

So what happened?

You should notice that the required to pull the plunger to the 5, 10, 15 and 20 cm^3 marks are roughly the same — typically about 30 N, or about 3 kg using the luggage scales).

Can you explain why?

Explanation

Since there is a negligible amount of air in the syringe there is negligible pressure on the inside of the plunger.

However, pressure on the other side of the plunger is atmospheric pressure. Its value does not change as the plunger is being pulled.

Estimate atmospheric pressure

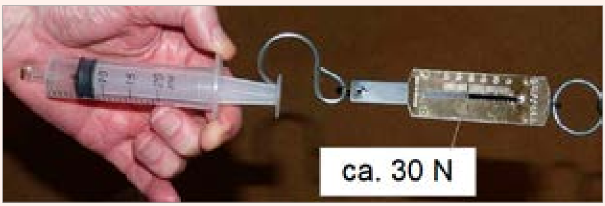
Pressure is **force** per unit **area** ($P = F/A$). To measure atmospheric pressure we need to find the value of the area ***A***, the area of cross-section of the plunger. This can be found by measuring the internal diameter (d); the radius is half of that value ($r = d/2$) and $A = \pi r^2$.

Calculate the pressure in N cm^{-2} and N m^{-2}.

Notes

1. Within the limits of measurement, the values are all the same. This is because atmospheric pressure is pushing the plunger in while there is little or no force pushing it out.
2. An **alternative way to find the area** of cross-section is to divide the marked volume (V) of the syringe by the length of the scale on the syringe (h).
   If the length of the scale on a 20 cm^3 syringe is 6.5 cm then the area of cross-section is 20 / 6.5 or about 3 cm^2.
   If the force was 30 N then the pressure exerted by the atmosphere is 30 N / 3 cm^2 or 10 N cm^{-2} or 100,000 N m^{-2}
3. This can be written in the following equivalent forms:
   100,000 Pa,
   100 kPa or
   1000 hPa.

   (100,000 pascals,
   = 100 kilopascals
   = 1000 hectopascals)



Estimating atmospheric pressure (2)

(This method presumes Boyle's Law)

(Ireland)

You will need...

- ✓ bathroom scales
- ✓ a 20 cm^3 syringe
- ✓ a plug to seal the nozzle of the syringe

Follow these steps

1. Set the plunger at the 20 cm^3 mark. Then plug the syringe.
2. Invert the syringe and press the plunger against the bathroom scales. Record the 'weight' when the volume has been reduced to 10 cm^3.
3. Remember that, on Earth, the weight of a kilogram is about 10 newtons.
   So convert the kilogram readings to newtons by multiplying by 10.
4. Find the area of cross-section of the plunger as described in the previous experiment.
   ($A = \pi r^2$. or $A = V / h$)

5. Calculate the excess pressure required to halve the volume of the air in the syringe.
   What does this excess pressure represent?

Teacher Notes

Magdeburg hemispheres are a pair of hemispheres which fit together to form an air-tight seal.. They were used to demonstrate the magnitude of atmospheric pressure.

When the hemispheres were joined and the air was pumped out, the sphere contained a vacuum and could not be pulled apart by teams of horses.

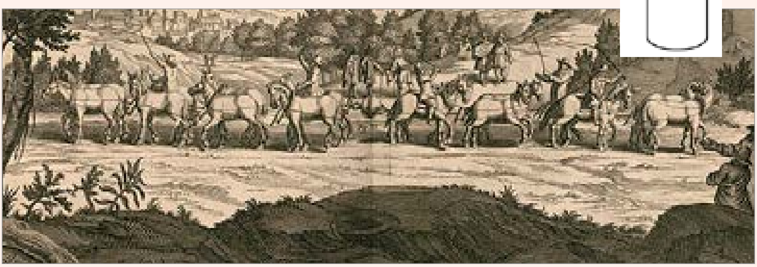
When the air was allowed in the hemispheres were easily separated.

They were designed by a German scientist, Otto von Guericke, to demonstrate the air pump that he had invented, and the concept of atmospheric pressure.

What next

Estimate atmospheric pressure by measuring the diameter (*d*)of a suction cup and the force required to pull the suction cup from a smooth flat surface (*F*)

Pressure = force / area



Pressure

Biscuit Tin Balloon

(Ireland)

Background

This demonstration links particle theory and pressure concepts. The expansion and contraction of particles when heated and cooled, can cause pressure differences that can be explored in interesting ways.

You will need….

- ✓ 1 balloon
- ✓ 1 cylindrical biscuit tin (e.g. SMA babyfood tin)
- ✓ Approximately 15 cm^2 of newspaper
- ✓ Matches
- ✓ Oven gloves
- ✓ Half-full basin of water

Follow these steps:

1. Half-fill a shallow basin with water
2. Blow up and tie off a balloon such that it sits into the rim of your tin, without falling into it.
3. Holding the mouth of the tin to students ask: "Is this tin empty?". Students need to keep their answer to this part in mind for later.
4. Light a roughly 15 cm x 15 cm piece of newspaper, place in your tin and allow to burn until the embers stop glowing.
5. Sit the balloon on the rim of the tin. For students: "Why did the balloon not burst?"
6. Using heat gloves, and gently holding the balloon in place, place the tin into the basin of water. For students: "This water will cool the tin, so what do you think is happening inside the tin at the moment?"

7. After ~2 minutes the whole apparatus can be lifted at the balloon knot. The balloon can also be bounced up and down without the tin slipping off the balloon. For students: "Thinking about your answers to previous questions, can you explain why the balloon and tin do not separate, even when I bounce them up and down vigorously?"

So what happened?

The tin is full of gas particles (air), which gain energy when the burning newspaper is placed inside the tin. This heat energy causes the already moving gas particles to move faster and with increased kinetic energy. The many particles escape the tin, leaving a reduced number inside.

Placing the balloon on the rim seals the tin, preventing any further particles from escaping. Placing the tin into a basin of water cools down the particles in the tin rapidly. Removing the heat energy means they begin to slow down and stop moving apart, and come closer together.

As there are now less gas particles inside the tin but the same number of gas particles outside (atmospheric gas), the balloon is partly forced into the tin. There is no suction.

The pressure outside the tin is greater than the pressure inside, but not so great it can compress the balloon enough to force it completely into the tin.

What next?

As well as revision of particle theory concepts this demonstration can be used to

- Reinforce/review pressure concepts
- Show the interrelationships of particle theory concepts, pressure and density in a conceptual manner
- Internal pressure differentials are used in a number of ways:
  - Venturi suction pumps that can attach to lab taps
  - Venturi effect within Bunsen burners
  - Negative pressure of biohazard labs – the internal pressure is lower than atmospheric pressure to help prevent pathogens from escaping
  - Positive pressure biohazard suits – the internal pressure of the suits is higher than atmospheric pressure to prevent pathogens form entering the suit if there is a rip/tear.

Pressure

Defying gravity – 2

Two demonstrations of the Bernoulli effect

(Ireland)

Background

According to Bernoulli's Principle an increase in the velocity of a fluid is accompanied by a decrease in its pressure and/or a change in its gravitational potential energy.

($\Delta p \propto \Delta v^2$)

You will need….

(a)

✓ a drinking straw

✓ a piece of paper (8×8 cm)

(b)

✓ a table tennis ball

✓ a (glass) funnel

Follow these steps:

(a)

1. Fold the piece of paper to form a little 'bridge' and place it a table as shown below.
2. Using the straw, blow a stream of air under the paper. You might expect the paper to lift off the table.

(b)

1. Place the table tennis ball in the funnel.
2. Try to dislodge the ball by blowing into the stem of the funnel.
3. Continue blowing and invert the funnel.

So what happened?

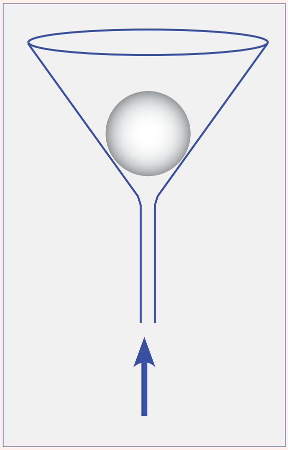
(a)

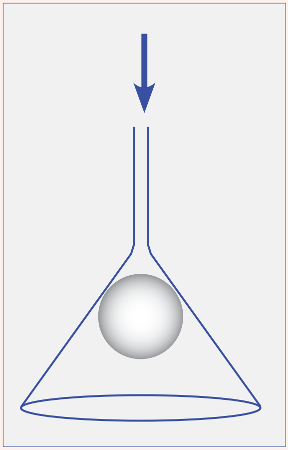
The stream of air moving under the paper bridge causes a drop in pressure. The paper bridge does not lift off the table but actually bends downward towards the table.

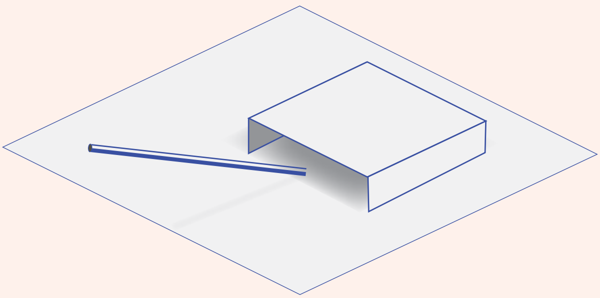
(b)

The ball cannot be blown out of the funnel even when it is inverted.

The fast flowing air stream between the ball and the inside of the funnel causes a drop in pressure which holds the ball in place.







Thumb Tack Cushion

(Ireland)

Background:

Many students and teachers will be familiar with The Bed of Nails Trick. But how does it work? What are the principles of physics that make it possible for someone to safely lie down on one?

The Thumb Tack Cushion can be used to answer to answer these questions as well as being a fun activity. It is cheaper, easier to make and much more portable than the big bed of nails.

You will need:

- ✓ A sheet of A4 squared graph card
- ✓ Laminator and pocket
- ✓ Approximately 400 thumb tacks
- ✓ Piece of polystyrene
- ✓ Glue
- ✓ A balloon
- ✓ Some spare time

Follow these steps:

1. Laminate the graphed card
2. With the piece of polystyrene on one side push the thumb tacks in from the other side. Use the graph lines as a guide to place the thumb tacks as close as possible
3. Use a spot of glue to keep each thumb tack in place
4. Show that one thumb tack would burst an inflated balloon
5. Gently press the inflated ball on the cushion

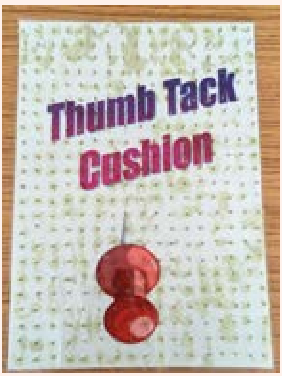
So what happened?

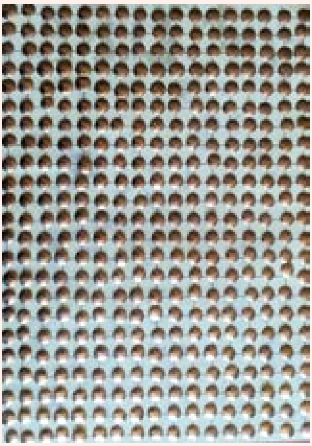
How come the bed of nails doesn't hurt or the balloon doesn't burst?

Pressure is the force on a specific area or P=F/A If the area is large then the pressure is less. With the cushion the points of the thumb tacks are close together so this is equivalent to a large surface area in contact with the balloon. Not enough pressure is exerted on a single thumb tack for it to penetrate the rubber and burst the balloon.

What next?

- Teachers can place the cushion on a hard chair and gently lower themselves so they can sit on it.
- Students can research how nail mats are used to relive pain and are used for meditation.





Make a graphite resistor

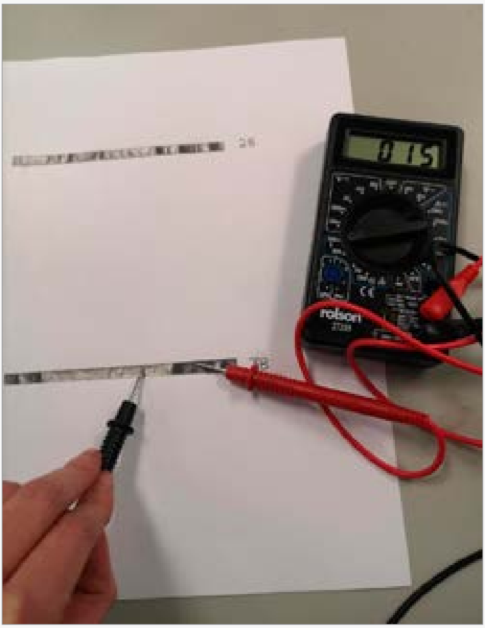
(Bulgaria)

Background

Pencil ‘lead’ is made of graphite mixed with clay. Graphite is a form of carbon, and is a conductor of electricity. In this activity, students investigate the resistance of pencil drawn rectangles varying in thickness, length, and width.

You will need:

- ✓ Pencil (HB or softer)
- ✓ Piece of paper
- ✓ Alligator clip leads
- ✓ Measuring ruler
- ✓ Multimeter as an ohmmeter



Follow these steps:

1. Using a ruler, draw rectangles of varying length and equal width.
2. Fill in the rectangles with the pencil. Make sure the entire rectangle is completely filled.
3. Using a multimeter and two alligator clip leads, test the resistance of each graphite rectangle by attaching the alligator clips to either end of the resistor rectangle.
4. Record the value of resistance in ohms for each length in a table.
5. Repeat the experiment but this time vary the width of the rectangle and keep the length of the rectangle the same. Record the value of resistance for each rectangle of varying widths.

So what happened?

The resistance in the graphite rectangles increased as the length of the rectangles increased.

The resistance in the graphite rectangles decreased as the width of the rectangles increased.

What next?

- What happens if you make the drawing with harder (e.g. 4H) or softer (e.g. 6B) pencils?
- Light an LED by connecting it to a circuit drawn by a pencil and a battery.

Why is a stream of water deflected by an electric charge? The real reason.

(Ireland)

Background

Many text books state that a stream of water is deflected by an electric charge because water molecules are polar.

For many reasons this makes no sense. It is easy to show that non-polar substances can be attracted by an electric charge.

The real reason for the deflection is that water is a **conductor** of electricity.

You will need...

- ✓ Insulating block (e.g. Styrofoam box)
- ✓ a plastic bottle
- ✓ a plastic rod
- ✓ a dry cloth or piece of fur

Follow these steps:

1. Make a hole (about 1 mm in diameter) near the bottom of the bottle.
2. Half fill the bottle with water and place it on top of an insulating block about 20 cm high. (Part of another bottle can be used as an insulating stand.)
3. Arrange a can to catch the stream of water.
4. Bring a charged rod near the stream of water. It is deflected at first but the deflecting decreases. Then touch the bottle and observe the effect on the stream of water. The deflection increases suddenly.

So what happened?

Water is a conductor of electricity. If a positively charged rod is brought near the stream of water electric charge is redistributed on the bottle of water. Near the rod it becomes negative and so the remaining water becomes positive.

As the water flows out it brings negative charge with it and the bottle of water becomes increasingly positively charged.

The deflection by the rod decreases.

Touching the bottle restores negative charge and the deflection of the stream increases.

What next?

- Insulate the container that catches the water. Does it become charged? Is it positive or negative?
- Attach the bottle to an electroscope and repeat the process. Record what happens.

Logic

If the polarity of water explained the deflection of a stream of water then it would not matter if the stream of water were continuous or broken into separate drops.

In fact, it **must be continuous,** at least in the vicinity of the charged rod and above. Only then can the rod induce a charge onto it.

This is the principle on which the Kelvin high voltage water dropper operates.

Electricity & Magnetism

Lenz's Cooking Foil

(Ireland)

Background:

The Russian physicist Heinrich Friedrich Emil Lenz 1804-1865 formulated the law that states that the direction of an induced current in a conductor opposes the change causing it.

Many teachers may be familiar with experiments that demonstrate this law. A popular one involves dropping a strong magnet into a hollow tube, made from a non-magnetic metal such as copper or aluminium. There can be difficulties sourcing suitable tubes and magnets. Kits can be bought from suppliers but can be expensive.

This low cost variation uses common kitchen cooking foil and works very well.

You will need:

✓ A strong neodymium magnet
✓ A small non-magnetic object
✓ Some aluminium cooking foil tubes (ideally different heights)
✓ A timer such as on a smart phone

Follow these steps:

1. Hold the aluminium tube so that it is vertical
2. Drop the non-magnetic object into the tube
3. Note the time it takes to fall through
4. Repeat with the neodymium magnet noting the time it takes to fall through
5. Compare the two times

So what happened?

As the magnet falls it induces an electrical current in the tube. This current has a magnetic field. According to Lenz's law, the polarity is opposite to the polarity of the falling magnet and there is a force of repulsion according to the Lorentz Force. This force is not strong enough to stop the falling magnet, but it is large enough to noticeably slow it down.

What next?

- Investigate the effect when using different strengths and sizes of magnets and tubes.
- Challenge students to explore applications that use Lenz's law such as: metal detectors, braking systems on trains, induction motors etc .

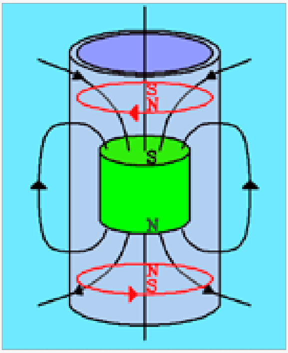


Image credit: lockhaven.edu

Washing machine electricity generator

(Ireland)

Background:

It is well known that an electric motor can be used in reverse to generate electricity by the dynamo effect.

This recycling of an old washing machine water pump motor shows the principle of alternating current (AC) generation.

You will need:

- ✓ Washing machine water pump motor
- ✓ Two LEDs one green, one red
- ✓ Soldering iron and solder

Follow these steps:

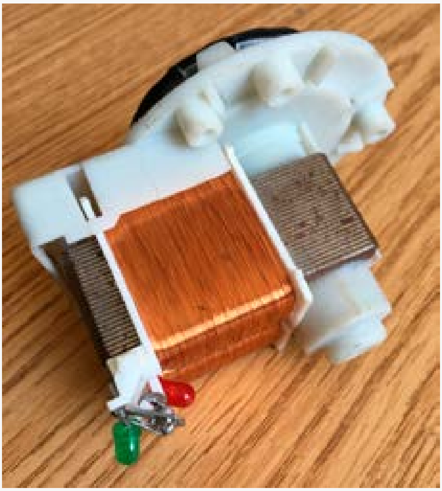
1. Solder the LEDs to the connection terminals of the motor as shown.
2. Make sure they are in opposite bias with the anode of one soldered with cathode of the other.
3. Turn the rotor and observe the LEDs one after the other.

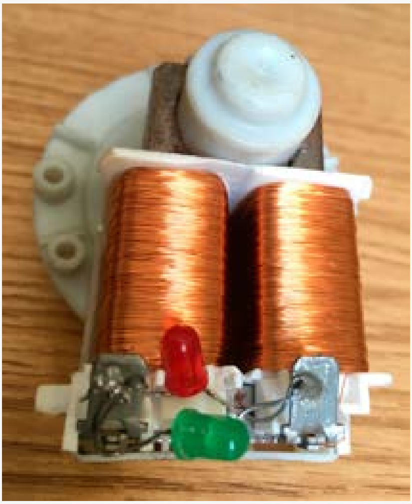
So what happened?

An emf (voltage) is induced when turning the magnet on the rotor changes the magnet flux in the copper wires. The induced alternating current generated lights whichever LED is forward bias. As the direction of the current changes the LEDs alternatively flash in turn.

What next?

- Students could analyse the output current by connecting a cathode ray oscilloscope
- Let the students experiment by turning the rotor faster and observing the effect.
- How could the output be converted to a direct current?
- Investigate how other generators work such as windup and Faraday torches.





Things to do with a USB current monitor

(Ireland)

Background

USB voltage and current monitors are now quite inexpensive. They are easy to set up and can be used to demonstrate voltage-current relationships. The data generated can be the basis of further more challenging assignments.

USB devices typically draw less then 100 mA. The USB sockets on computers can usually deliver at least 100 mA; some can deliver over 500 mA.

Many low power devices, such as small lamps and motors, can be powered from computer USB sockets.

USB leads contain four wires, two for power and two for data.

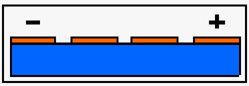
The USB terminal connections are arranged as shown in the diagram (for both the socket and the plug).
The positive terminal is 5 V ± 0.25 V; the negative terminal is the ground connection of the computer (‘GND’ or 0 V).

You will need...

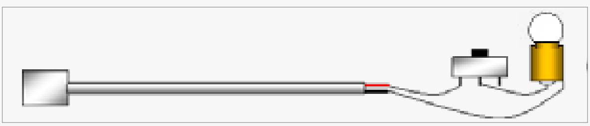
- ✓ A computer with a USB socket
- ✓ A USB voltage and current monitor
- ✓ A USB lead
- ✓ A 5 or 6 volt lamp, or other device, as a load
- ✓ A small switch

Follow these steps

1. Cut a spare USB cable in two and remove about 2 cm of the plastic cover from the cut ends.
2. Identify the positive and negative wires; they are generally coloured red and black respectively.



3. If the wires are not coloured then use a continuity tester to identify them.
4. Cut back the two unwanted wires. Attach a small switch and a bulb holder in series with the two wires.
5. Insert a suitable bulb in the bulb holder, e.g. 6 V, 150 mA.
6. Insert the USB voltage monitor into the USB socket on the computer and connect the prepared lead. Check that the lamp and switch are working correctly.
7. Switch off the lamp and record the voltage (E); it will typically be 5.0 V. The current should show 0.0 A.
8. Then turn on the lamp and record the current (I) and the voltage (V), e.g. 0.14 A and 4.75 V. The drop in voltage is due to the ‘internal resistance’ (r) of the current source. Using this data the resistance (R) of the lamp can be calculated ($R = V \div I = 34\ \Omega$).
9. Note that as the current through the filament of the bulb increases, so does its temperature and resistance.



Finding the internal resistance of the source (r)

$$V = R\,I$$

$$E = (r + R)\,I$$

$$E = r\,I + R\,I$$

$$E - V = r\,I$$

$$r = (E-V)/I$$

$$= (5 - 4.75)\,/\,0.14$$

$$= 1.8\ \Omega$$

Switching from series to parallel

(Ireland)

Background

It is relatively easy to set up a double pole, double throw, switch (DPDT) to facilitate switching a pair of lamps from series to parallel. It is even more useful if the switch has a centre-off position.

A DPDT slider switch has six connections. Each side is effectively a separate change-over switch whose common connection is the centre pin.

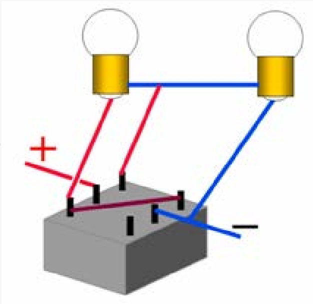
This can be used with the USB current monitor previously described.

You will need...

- ✓ A USB voltage and current monitor
- ✓ A USB lead
- ✓ Two 5 or 6 volt lamps
- ✓ A double pole, double throw, centre-off slider switch.

Follow these steps

1. Cut a spare USB cable in two and remove about 2 cm of the plastic cover from the cut ends.
2. Identify the positive and negative wires; they are generally coloured red and black respectively.
3. If the wires are not coloured then use a continuity tester to identify them.
4. Cut back the two unwanted wires.
5. Set up the circuit with the DPDT switch and two lamps as shown in the diagram. With this arrangement the lamps can be switched from a series arrangement to a parallel arrangement.
   (The diagram shows one way of wiring the switch. The + and – connections go to the + and – of the USB plug.)
6. Connect th + and − connections of the USB lead to the centre connections of the DPDT switch.
7. Insert the USB voltage monitor into the USB socket on the computer and connect the prepared lead. Check that the lamp and switch are working correctly.
8. Note the effect of removing one bulb in each of these configurations.



So what happened?

When the lamps are switched from series to parallel the current more than doubles and the voltage drops slightly..

Use the values of current and voltage to calculate the resistance of the lamps in both series and parallel.

What next?

Make up a USB lead with crocodile clips instead of a bulb holder. Measure the voltage and current for other loads such as motors and buzzers.

Electricity & Magnetism

Make a Curie motor

(Poland)

Background

The Curie motor is a thermo-magnetic motor based on the loss of ferromagnetic properties of a material at its Curie temperature.

The Curie temperature is the temperature above which the ferromagnetic substance rapidly loses its magnetic properties and becomes paramagnetic. The Curie temperature for nickel is approximately 353°C.

You will need:

- ✓ Neodymium magnet
- ✓ nickel wire/strip
- ✓ copper
- ✓ wire/strips
- ✓ candle

Follow these steps:

1. The first step is to make the rotor's support structure. Use a non-ferromagnetic material, such as aluminium, copper or brass. You can attach the copper wire to a nut that can rotate around a bar as shown in Figure 1.
2. Wrap nickel wire/strip around the end of the wire.
3. Attach strong neodymium magnets to a support frame so the nickel wire will be attracted to it as in Figure 1.
4. Light a candle and place under the nickel.

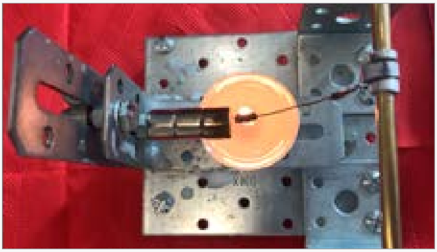


Figure 1

Figure 2

Figure 3

So what happened?

When the nickel reaches the Curie temperature it loses its magnetism and falls away from the magnets.

As it swings it cools and becomes ferromagnetic again. It is then attracted back to the magnets.

This process repeats.

What next?

Experiment with different motors. See Figure 3

Diffraction of light from LEDs

(Hungary)

Background

Breadboards provide a neat way of setting up electronic circuits. They can be used with a TY class to teach an electronics module.

This simple circuit uses LEDs connected in series to demonstrate how different wavelengths of light behave differently when passed through a diffraction grating.

Multiple colours can be used and the circuit can be set up in series or in parallel.

Red and yellow tend to light whereas the blue, green and white will not. This is because red has a lower forward voltage than blue.

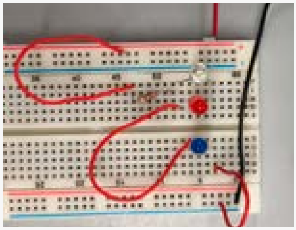
When the LEDs are in parallel each one must have **its own resistor** in series.

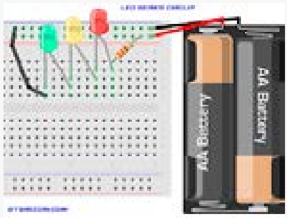
You will need:

- ✓ prototyping breadboard,
- ✓ wires
- ✓ wire stripper
- ✓ LEDs (red, white and blue)
- ✓ resistors (220 Ω)
- ✓ a suitable battery and battery clip
- ✓ diffraction grating (100, 300, 600 lines per mm).

Follow these steps:

1. Use the wire stripper to cut and strip some jumper leads for the breadboard.
2. Connect the LEDs in series with a resistor on the bread board, making sure that you only connect the battery last. The resistor will protect the LEDs from burning out.
3. Arrange the LEDs in a straight line as it is more effective.
4. Place the diffraction grating over the LEDs and observe their spectra. (Placing the diffraction grating over the lens of your camera gives an even better image when observed on your phone).

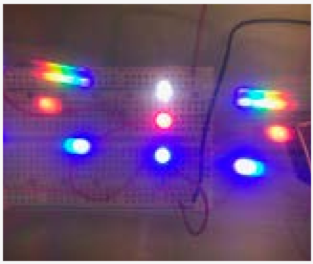


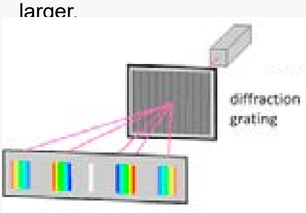


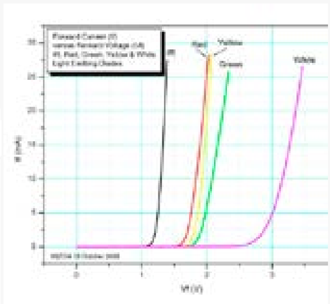
So what happened?

It can be seen very clearly in that red is diffracted the most and blue the least. The zero order for white light is white whereas the first order is a spectrum.

We can see from the formula $n\lambda = d \sin\theta$ that if λ increases so does θ. Hence, as red light has a longer wavelength than blue it is diffracted the most, i.e. the angle between the zero order and the first order is much larger.







Which Balloons Pop?

(Belgium)

Background

White objects look white because they reflect all the wavelengths of light that shines on them. Black objects absorb all wavelengths of light that shines on them.

Coloured objects, on the other hand, reflect only some of the wavelengths and absorb the rest. So if you see a green balloon, it's reflecting green light and absorbing light in the red and blue regions of the visible light spectrum.

You will need:

- ✓ Balloons – black, green, red and white.
- ✓ Powerful green laser 303 with focus lens (Available online at aliexpress.com) Focus = +/- 15 cm

Follow these steps:

1. Inflate a black, white and green balloon to approximately the same size.
2. Attach each balloon to a cup using Sellotape so that the balloons stay in place.
3. Aim the laser pointer at the black balloon. Record what happens.
4. Aim the laser pointer at the white balloon. Record what happens.
5. Aim the laser pointer at the green balloon. Record what happens.

6. Aim the laser pointer at the red balloon. Record what happens.

Tip: Sometimes, the laser only burns a small hole in the balloon. When this happens, the balloon slowly releases the air from inside the balloon and does not pop. To overcome this, you should press on the balloon to get a higher internal pressure while shining the laser at the balloon.

So what happened?

- When the green laser is aimed at the;
- Black balloon - the black balloon pops. It pops because the black balloon absorbs the green laser light. That absorption gets converted into heat.
- White balloon – the white balloon does not pop as it reflects the green light.
- Green balloon – the green balloon does not pop as it reflects green light.
- Red balloon – the red balloon pops as it absorbs the green wavelengths of light.

What next?

- Draw a large black dot onto the white balloon, and aim the laser at this dot. Notice what happens.
- Repeat the experiment using a powerful red laser. What happens the green and red balloon?

Can you burst a balloon inside another balloon?

(Belgium)

Background

Transparent materials allow most light to pass through whereas opaque materials block most light from passing through.

You will need:

- ✓ Black balloon
- ✓ Transparent clear balloon
- ✓ A Hand balloon pump
- ✓ Pencil
- ✓ Magnifying glass
- ✓ Sunlight

Follow these steps:

1. Push the deflated black balloon inside the transparent deflated balloon using a pencil.
2. Remove the pencil and inflate the black balloon to approximately half size.
3. Tie a knot in the neck of the black balloon and push the knot of the black balloon into the neck of the transparent balloon.
4. Inflate the clear balloon to approximately full size, so the black balloon can move freely inside the clear transparent balloon.

5. Using a magnifying glass, concentrate the sun's rays through the transparent balloon onto one spot on the black balloon.
6. Record what happens.

So what happened?

The black balloon popped while the outer transparent balloon stays inflated. The transparent outer balloon allowed the sun's rays to pass through. The black balloon absorbed the sun's rays causing the balloon to heat up. The heat caused the bonds of the black balloon to weaken until it could no longer contain the air on the inside.

What next?

Change the colour of the internal balloon. What colour balloon takes a longer time to pop and what colour balloon takes a shorter time to pop?

Optical sets using gelatine

(Poland)

Background

Gelatine is a translucent, colourless, flavourless food ingredient, derived from collagen. It's great for illustrating some basic optical principles such as refraction. Students can use the gelatine to create lenses or other transparent shapes. Using lasers, students can model the path of a refracted ray.

You will need:

- ✓ Knox Unflavoured Gelatine
- ✓ Water
- ✓ Casserole dish
- ✓ Saucepan
- ✓ Knife
- ✓ Lasers/A flashlight and a sheet of cardboard
- ✓ Refrigerator

Follow these steps:

1. Add one pouch gelatine into 550 ml hot water. (Read the gelatine package for specific recipe)
2. Stir constantly until granules are completely dissolved.
3. Slowly pour the solution into a clean, flat bottomed glass tray to form a layer about 10-15 mm thick.
4. Scoop away any bubbles on the surface.
5. Place the solution on a level surface in the refrigerator until set.
6. Remove the gel from the tray.
7. Cut the transparent gelatine into different shapes such as the shape of a convex and concave lens/prism/long strips. Make cuts with very smooth edges; rough edges will strongly scatter light.
8. Shine a laser pointer through the different shapes to demonstrate refraction of light.
9. Direct a number of parallel rays onto the convex lens. Observe what happens.
10. Direct a number of parallel rays onto the concave lens. Observe what happens.

Tip:

- ✓ The Gelatine should be prepared the day before use.
- ✓ The Gelatine needs to be firm enough so that the shapes can be handled without falling apart.

So what happened?

As the laser light entered the gelatine, the change in medium caused a change in the speed of the light. This change in speed caused the direction of the beam to refract, or bend. Lenses, depending on their shape, refracted light in different ways.

What next?

- Demonstrate how short-sightedness/myopic can be corrected with a concave lens.
- Demonstrate how farsightedness/hyperopia can be corrected with a convex lens.

Lasers and fluorescence in olive oil

(Belgium)

Background

Fluorescence describes a phenomenon where light is emitted by an atom or molecule that has absorbed light or electromagnetic radiation from another source. When a fluorescent substance absorbs electromagnetic radiation, electrons in its atoms become excited – that is, electrons in the molecule temporarily transition from the ground state to an excited state. On returning to the ground state, light of a certain colour is emitted. Different colours of light have different amounts of energy. In most cases, the emitted light has a longer wavelength, and therefore lower energy, than the absorbed electromagnetic radiation.

You will need:

- ✓ Extra virgin olive oil
- ✓ Water
- ✓ Medium sized Beaker
- ✓ Green laser and a purple laser from aliexpress.com

Follow these steps:

1. Add 250 ml of water to a medium sized 500 ml beaker.
2. Add 150 ml of extra virgin olive oil to the top of the water in the beaker.
3. Shine a green laser into the beaker containing the olive oil and water. Record observations.
4. Shine a purple laser light into the beaker containing the olive oil and water. Record observations.

So what happened?

The green laser beam fluoresces red in the extra virgin olive oil. Molecules in the olive oil absorb energy from the green laser and become excited. On returning to their ground state, they emit light of a longer wavelength red (lower energy).

The olive oil has a refractive index of approximately 1.44 – 1.47, so the laser beam refracts towards the normal. The beam then enters water and refracts away from the normal. The refractive index of water is approximately 1.33.

What next?

- Extra Virgin olive oil is more expensive than other vegetable oils. Can you distinguish an extra virgin olive oil from other oils (e.g. sunflower oil/corn oil) using a laser light?
- Investigate the fluorescent properties of Quinine using Tonic water, a green laser and a violet laser.

Exploring multiple reflections – 1

(Ireland)

You will need:

✓ two mirrors
✓ adhesive tape
✓ some large printed text

Follow these steps:

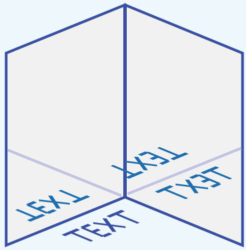
1. Place one mirror flat on the table, reflective side up.
2. Place the second mirror on top of the first, reflective side down.
3. Tape the mirrors together along one edge only so that they form a flexible hinge.
4. Set the mirrors standing at right angles to one another, with the hinge vertical.
5. Place some text in front of one of the mirrors.

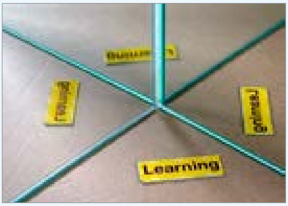
So what happened?

Three images of the text appear in the mirrors. (If not, then check that the angle between the mirrors is 90°.)

Note that the text is reflected vertically in one mirror and reflected horizontally (i.e. laterally) in the other. In each case some letters look the same as the original.

These two reflections are (theoretically) superimposable; they just have different orientations. One can be considered a '**rotation**' of the other.



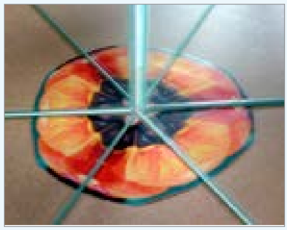


The text reflected in both mirrors looks like the original text. It has been reflected twice and ends up as a '**rotation**' of the original through 180°.

Other angles

6. Change the angle of the mirrors and note the changing number of reflections. What is the relationship between the number of images (including the original) and the angle? *

7. Note that text is **reversed and rotated** by an **odd number** of reflections. Text is **rotated** by an **even number** of reflections but is **not reversed**.
8. Place other objects between the mirrors and note the reflections.



What next?

Set the angle of the mirrors at exactly 90°. Look at your own reflection in the pair of mirrors. What do you notice?

* The **number of images** (including the original) is equal to 360° ÷ (angle between the mirrors). Check this out.

Exploring multiple reflections – 2

See what you really look like!

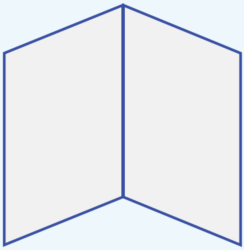
(Ireland)

You will need:

✓ two mirrors
✓ adhesive tape

Follow these steps:

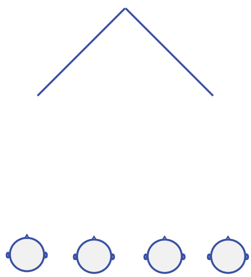
1. Tape the mirrors together along one edge only so that they form a flexible hinge.
2. Set the mirrors at right angles to one another, **at face level.**



3. Look at your own reflection in the pair of mirrors.
4. Move from side to side and note any changes in the reflection. Does the reflection appear to move with you or in the opposite direction?
5. Raise your right hand and observe the reflection.
6. Hold some large text (e.g. a book cover) facing the mirror. What do you notice?
7. Arrange a number of people in a line (beside one another) facing the pair of mirrors. What do they see?

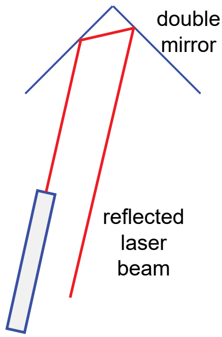
So what happened?

1. Since the mirrors are perpendicular to one another you should see an image of yourself that has been reflected twice and is therefore 'the right way round'. You then see yourself as other people see you. (In a single plane mirror your image is reversed.)
2. When you move from side to side you still see your own image. In other words, you do not need to be 'directly in front' of the pair of mirrors.
3. When you raise your right hand, your reflected image also appears to raise a right hand - but it is on the opposite side to where it would appear in a single mirror. This can be a bit disconcerting.
4. Text held in front of the double mirror appears the right way round because it has been reflected an **even number** of times.



people in a row looking into the double mirror

5. People in a row (beside one another) facing the mirrors will each see themselves only (unless they are very close together).
6. Shine a light (e.g. a laser) at the double mirror. The reflected beam is parallel to the incident beam.



Light

Exploring multiple reflections – 3

(Ireland)

Background

Shine a light (e.g. a laser) at the double mirror. The reflected beam is parallel to the incident beam.

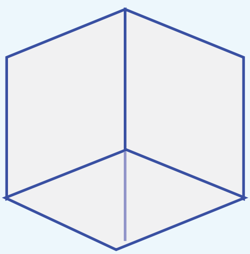
This effect also works in three dimensions. If a beam of light shines into a ‘corner reflector’ then the reflected beam returns in the same direction (or at least parallel to it.)

You will need:

- ✓ three square mirrors
- ✓ adhesive tape
- ✓ a bicycle reflector
- ✓ a laser or narrow-beam torch

Follow these steps:

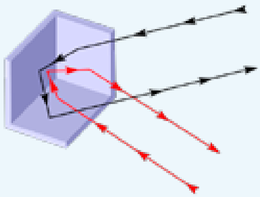
1. Tape the mirrors together at right angles to one another to form a corner. This arrangement is called ‘**a corner reflector**’.



2. Shine light into the corner from a range of different directions.
3. Look at your own reflection in the corner reflector. Is it reversed (left to right)? Is it upside down?

So what happened?

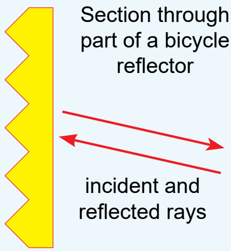
1. A beam of light that is reflected by a ‘corner reflector’ returns along the same path (or at least parallel to it).



2. If the light is reflected from all three surfaces then it is inverted and rotated. Your own reflection in the three mirrors of a corner reflector will appear upside down and reversed left-to-right. (This is quite different from the reflection in just two mirrors.)

Applications

1. Corner reflectors are used on boats to facilitate radar detection. These metal reflectors typically have eight corners. (Image right) (Photographs from Wikipedia)
2. Bicycle reflectors work in a similar way. The outer surface is flat but the inner surface is an array of little corner reflectors. Light from a motor car is reflected back in the direction from which it came.



3. The Apollo astronauts set up an array of corner reflectors on the Moon. This array is used to measure the changing distance to the Moon by timing the return of a laser pulse.

How to send a message around the bend

(Ireland)

Background

Along a reflective surface (e.g. mirrors) the incident angle is equal to the reflected angle.

Here students investigate converting words (text) into light (energy) then back to words. This exercise is to represent what happens inside a data terminal where the words we send on one device to another (e.g. Phone/computer) are scrambled into light packets and then unscrambled back into words.

You will need:

- ✓ Plane mirrors
- ✓ Retort stand
- ✓ Flash light
- ✓ Fibre optic cable (optional)
- ✓ Morse code chart

Follow these steps:

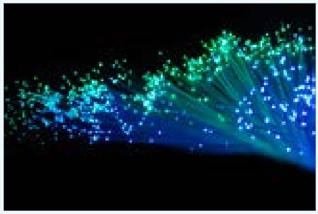
1. Both students look at the Morse code. One student practices sending a letter to the other student by flashing the torch through Morse. The other student is to unscramble the light packet and work out which letter they just sent.
2. One person in the group creates a sentence in Morse, writes it down on paper & sends it to the other through light packets - Morse code.
3. The receiver is to decode the message.

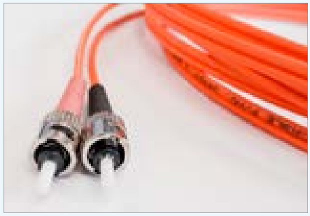
So what happened?

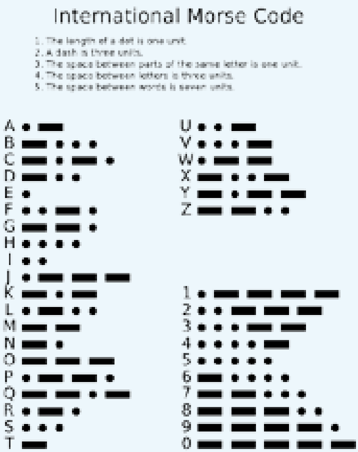
The message was sent to the other student. They are now modelling what happens inside a data terminal when we send messages to one another.

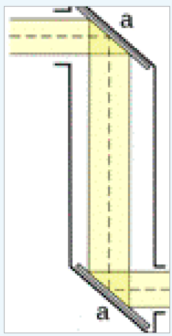
What next?

Repeat the exercise but this time both students are to go to the corner of the desk and crouch down so they can't see each other. They are to repeat the exercise using plain mirrors and a retort stand and see if they can communicate with each other and send a message around the bend. They can then repeat the exercise using a fibre optic cable.









Text to light

— using a torch and Morse code

(Ireland)

Background

Students investigate converting words (text) into light (energy) then back to words. This exercise is to represent what happens inside a data terminal where the words we send on one device to another (e.g. Phone/computer) are scrambled into light packets and then unscrambled back into words. In internet communications these light packets would travel down a fibre optic cable to their intended destination.

You will need:

- ✓ A torch
- ✓ List of four letter words
- ✓ Morse code alphabet (Google search this)

Follow these steps:

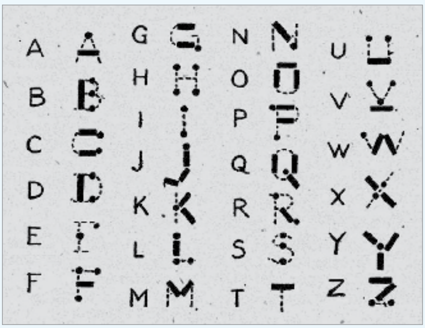
1. Both students look at the Morse code. One student practices sending a letter to the other student by flashing the torch through Morse. The other student is to unscramble the light packet and work out which letter they just sent.
2. One person in the group creates a sentence in Morse, writes it down on paper & sends it to the other through light packets - Morse code.
3. The receiver is to decode the message.

So what happened?

Students are modelling what happens on an ongoing basis inside sections of our modern-day internet communication systems. Data terminals are converting light packets into text and vice versa.

What next?

Repeat the exercise but shine the light down a fibre optic cable. Create your own code in pairs, decide on what the code is in advance and send a message to each other.



Modelling total internal reflection within a fibre optic cable using plain mirrors

(Ireland)

Background

Along a reflective surface (e.g. mirrors) the incident angle is equal to the reflected angle.

When passing information along a fibre optic cable it undergoes total internal reflection. The fibre optic cable has external cladding (coating e.g. plastic) to minimise light scattering thus prevent the loss of information.

You will need:

- ✓ Plane mirrors
- ✓ Bulldog clips
- ✓ Retort stand
- ✓ Obstacles (pencil cases, water bottles, boxes, etc.)
- ✓ Laser pointer
- ✓ Fibre optic cable (optional)
- ✓ Object to act as a target (this can be anything you wish)

Follow these steps:

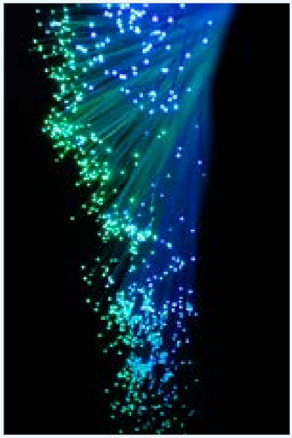
1. Leave a laser pointer turned on - using the clamp in a retort stand.
2. Place an object to act as a target on the wall at the same height as the laser pointer.
3. Set up obstacles along the table in between the target and the laser pointer.
4. Students are to move the mirrors and guide the laser pointer to the target.

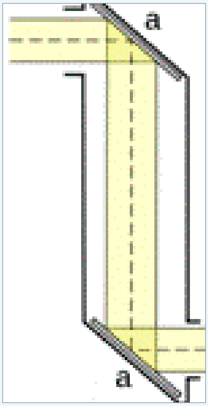
So what happened?

The mirror arrangement reflects the laser to the target.

What next?

- Introduce a fibre optic cable, remove the mirrors and repeat the experiment.
- The light reflects down the cable due to total internal reflection.





Light

A timeline of light

(Ireland)

Background

Light has been used throughout history as a medium for communication. Looking initially to the Sumerians (4500 – 1900 BC) where they used the earliest known forms of glyphs. To the more commonly known form of Egyptian hieroglyphs where they used up to 1,000 distinct characters. They all needed light to be observed. From Stonehenge to Newgrange using the reliability of light has been used throughout history to communicate to each other. Today we use light to send light packets of data along fibre optic cables from our home nearly instantaneously.

You will need:

✓ A white board
✓ Marker
✓ Internet access

Follow these steps:

1. Ask students how do we communicate today – list their replies on the white board
2. Students go home and ask parents how did they communicate with each other when they were children
3. Then students should investigate in pairs the history communication by using light.

So what happened?

They can come across the use of heliographs and flashing mirrors.
Finally they should make a timeline of how communication improved as time progressed. They should then be ready to investigate how modern day fibre optic works.

What next?

Start investing how light behaves. Work through the other worksheets; 'How can we use light outside of earth (VIDEO 106)', 'How laser light is different to normal light (VIDEO 104)', 'How to direct light over long distances (VIDEO 98)', 'How to move light around corners (VIDEO 95)'

What's the best colour of light for fibre optics?

(Ireland)

Background

In internet transfer the infrared regions are most suitable to send information. These messages are converted into infrared messages and sent down fibre optic cables at nodes. However, these terminals that convert information from text to infrared light overheat and the most suitable wavelengths for transferring information aren't always the ones that are outputted. The heating effect at the terminals warps the wavelength outside the desired range ~1310 to 1550 nm. Thus the main cost for our internet transfer across the globe is the cooling of these terminals so they can operate at the ideal temperature and send messages in the infrared region. Thus, the name for the sequence of activities "The internet too hot to handle"

You will need:

✓ A mobile phone

✓ Remote control

Follow these steps:

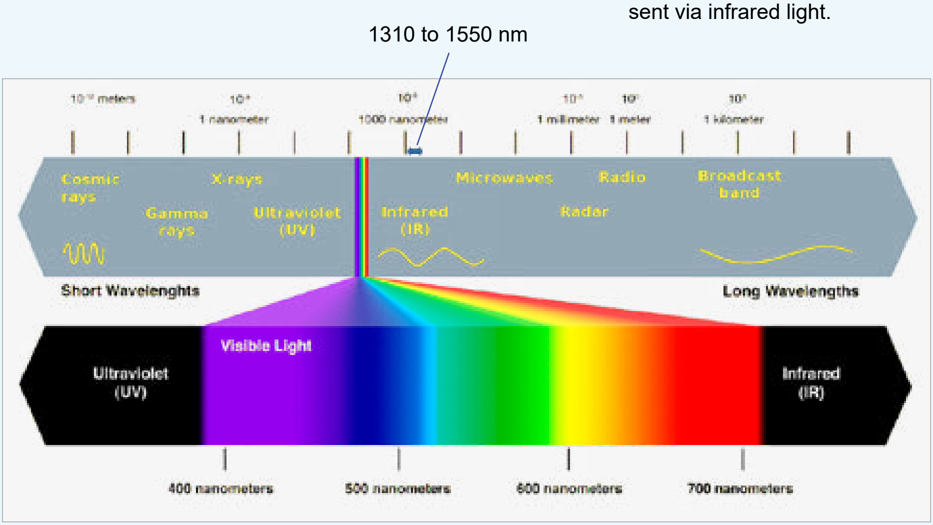
1. Face a remote control towards a mobile phone.
2. Turn on the camera function on the mobile phone.
3. Press some of the buttons on the remote control.
4. Observe the camera screen on the mobile phone.

So what happened?

The mobile phone camera can observe the infrared signal given off by the remote control, but our eyes can't.

What next?

Have students discuss why the receivers in data terminals are infrared sensitive and why the light packets are sent via infrared light.



Light to text

(Ireland)

Background

Data terminals find it difficult to decode light packets if the light packet (wavelength) is sent in is too broad and messages can't be read and understood by the receiving machine.

This widening of wavelengths happens when the machine that sent the message gets too hot. The cooling and maintaining of the nodes that scramble light is the largest cost for modern day communications. Students will replicate the difficulty with the following experiment.

You will need:

✓ Light source
✓ Orange filter (orange polypocket)
✓ Skittles/M&M's
✓ Blanket

Follow these steps:

1. Jumble up the coloured sweets.
2. Separate them apart by colour.
3. Now jumble them up again.
4. Put your head underneath the blanket with an orange light source.
5. Try and separate the sweets again.

So what happened?

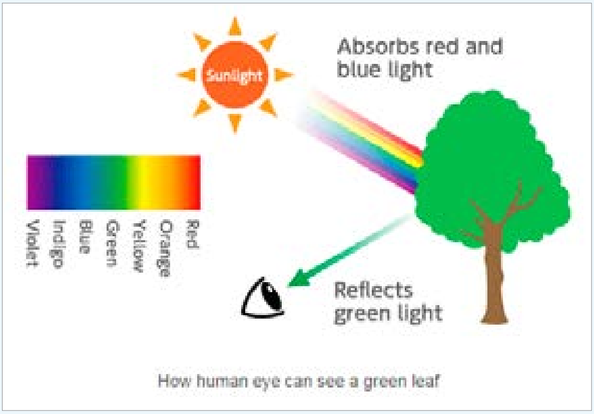
When an orange filter is applied a certain bandwidth of light is available for reflection off the sweets. This orange bandwidth of light is relatively large and covers a range orange hues. This is what makes the task hard separating the similar colours to orange apart.

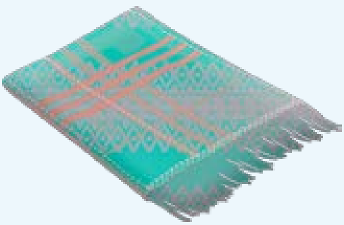
Red ~ 700–635 nm,

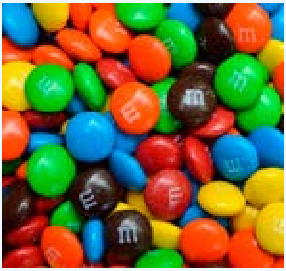
Orange ~ 635–590 nm

Yellow~ 590–560 nm.

The wavelength of light we use to send light packets along fibre optic cables is just outside the visible range. Looking at the electromagnetic spectrum it's to right of the colour red in the infrared region ~700 – 1750nm.





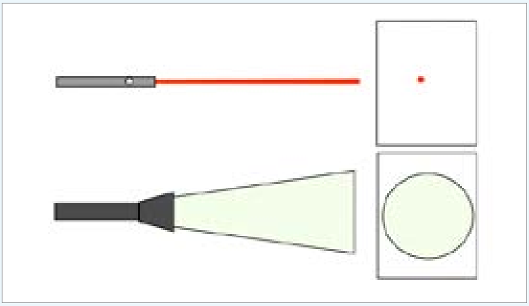


How laser light is different from non-laser light

(Ireland)

Background

Laser light can be dispersed by a simple frosted plastic bag (clear bin bag liner). A clear plastic bag acts like a gradient when it is exposed to laser light. Laser light's nature (wavelength) is close enough to that of the pores within the plastic bag and can have its direction slightly altered – we see this as a dotted pattern. The laser light has a narrow band of wavelengths and is easily directed into a dotted pattern. The LED light on the other hand has too wide a range of colours (wavelengths) within itself and does not disperse to form such a dotted pattern. The nature of laser light makes it the optimum choice to send scrambled light packets of information down fibre optic cables.



You will need:

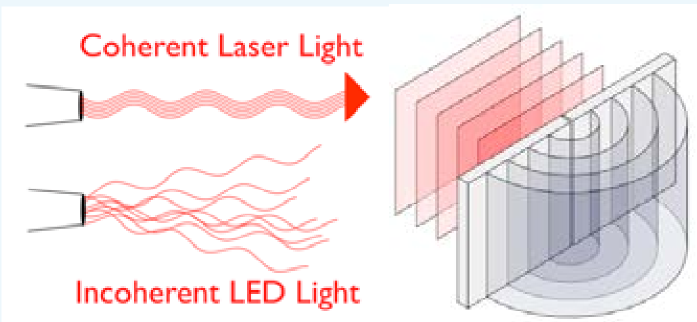
- ✓ A laser pointer
- ✓ Red LED light/red light
- ✓ Section of a clear plastic

Follow these steps:

1. Shine laser pointer through the section of the clear plastic bag towards the surface your working on.
2. Keep the plastic bag still and begin to pull the laser pointer away and watch the pattern the emerges.
3. Repeat steps 1 & 2 with a red torch/LED and compare both patterns created.

So what happened?

Laser light was dispersed and the non-laser light was not dispersed.



Light intensity - from space to street lamps

(Ireland)

Background

LDRs are built into mobile phones, street lamps and space satellites. They all measure the light they are exposed to. A light dependant resistor (LDRs) has many uses from powering street lamps or readjusting the brightness on a mobile phone. Measuring light intensity is how we decode a light packet in modern day communication systems after it has been sent. Here we are going to looking at other uses of measuring light intensity.

You will need:

- ✓ A mobile phone,
- ✓ Android app of choice – Sensors Multitool,
- ✓ Two or three differently sized balls to represent different planets,
- ✓ Light source.

Follow these steps:

1. Turn on light source.
2. Place phone in its direct path.
3. Turn on the app and interact with the sensor on the mobile phone by placing the different balls to represent planets in between the light and the phone.

So what happened?

The light intensity decreased and increased depending on how much light interacted with the light sensitivity meter on the phone.

What next?

Investigate how ESA and NASA use more sophisticated versions of these devices to study where planets are positioned and how large they might be in comparison to one another.

Black absorbs heat radiation

(Ireland)

Background

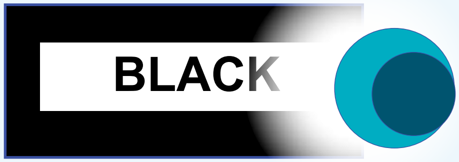
Thermochromic film changes colour if its temperature changes, within certain limits.

You will need...

- ✓ thermochromic film
- ✓ an incandescent lamp
- ✓ black text in a large typeface (preferably upper case about 4 cm high)

Follow these steps

1. Place the printed text on the thermochromic film and hold them together so that there is no space between them.
2. Quickly move the text across in front of the lamp. (Two or three seconds should be enough.)
3. Move it away from the lamp and quickly drop the printed text.



So what happened?

An image of the black text should be visible on the thermochromic film. (The edges will be slightly fuzzy.)

The black text gets hot as it absorbs infrared radiation from the lamp. Some of the heat is conducted to the thermochromic film causing it to change colour.

What next?

- Place a sheet of thermochromic film about 20 cm in front of the lamp. Time how long it takes to change colour.
- Repeat the above but place various materials in between.
  For example, a sheet of glass or clear plastic, a clear container of water, a black bin bag etc.
  Estimate how well each material transmits infrared radiation.

Note

Before each test make sure that the thermochromic film has cooled down to room temperature.

Fluorescence and total internal reflection

(Ireland)

Background

If light is incident on one end of a transparent rectangular block it cannot emerge from the sides if the refractive index of the block is greater than 1.414 (i.e. the square root of 2) regardless of the angle of incidence; the light undergoes total internal reflection and emerges from the other end.

Molecules of **fluorescent** substances absorb light and enter a higher energy state. After a short delay (e.g. a few nanoseconds) they emit light, usually of lower energy and different colour, and return to their original state.

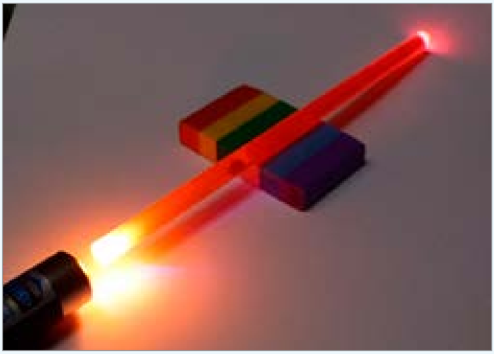
The behaviour of laser light shining through a fluorescent acrylic rod varies with the colours of the lasers used..

You will need:

- ✓ Laser pointers with different colours
- ✓ A fluorescent acrylic rod (orange or yellow preferably)

Follow these steps:

1. Shine laser light from a variety of sources into one end of the acrylic rod and observe the results.



Green laser light causes fluorescence. No laser light emerges from the far end of the rod.

So what happened?

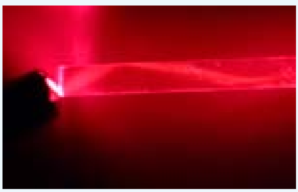
When **red laser** light is shone in at one end of an orange fluorescent acrylic rod, a small amount is scattered but most of the laser light shines out the other end.

Green laser light does not shine through from end to end but instead it induces orange fluorescence in the first few centimetres and the rod seems to light up. **No laser light** emerges at the other end but only scattered orange light.(top image)

If a **blue laser** is used then more intense orange fluorescence occurs over a shorter distance. **No laser light** emerges at the other end.

What next?

1. Some of both the fluorescence and the scattered light emerges from the sides of the rod but much of it is reflected internally and emerges at both ends of the rod.
2. In the case of the red laser some scattering occurs along the path of the light through the rod. If the angle of incidence of the laser beam is varied the laser beam is totally reflected within the rod and its **helical path** is revealed by the scattered light. (*image below*)



Experiments with UV beads

(Portugal)

Background

UV Beads contain pigments that change colour when exposed to UV light. The beads are white in ordinary, visible light but in UV light, you'll see different colours depending on the pigment added to each bead.

When you expose bare skin to sunlight, your skin will either burn or tan. UV radiation wavelengths are short enough to break chemical bonds in your skin tissue and, with prolonged exposure, your skin may wrinkle or skin cancer may occur. These responses by your skin are a signal that the cells in your skin have been damaged by UV radiation for a long time.

Wearing a hat, sunglasses, using sunscreen, and being aware of the UV Index report from your local weather forecaster can help reduce your skin exposure to UV radiation.

You will need:

✓ UV beads
✓ UV lamp and UV index chart (can be found online),
✓ Plastic bags/plastic test tubes
✓ sunglasses
✓ sunscreen,
✓ glass
✓ polaroids.

Follow these steps:

1. Place an equal amount of UV beads in 4 plastic bags or plastic test tubes.
2. Place an equal amount of sunscreen of varying strength (SPF 10, SPF 30, SPF 50) on each bag and allow it to dry. Leave one bag with no sunscreen on it as the control.
3. Shine the UV lamp on each bag for the same amount of time (few seconds) or if no UV lamp is available, place in the sunlight outside for a few minutes.
4. Observe any colour change and compare to the UV index.
5. Repeat for different sunglasses.
6. Repeat in a beaker of water and shine the UV lamp through the water or through a glass block.

(All of the above can be done in natural sunlight if a UV lamp is unavailable.)

So what happened?

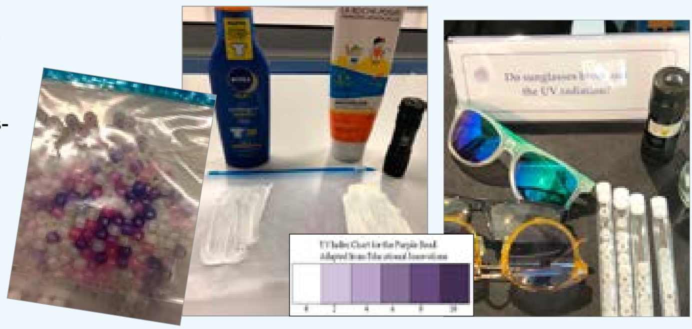
When the beads are exposed to UV light, a chemical reaction occurs that changes the colour of the bead. The greater the colour change the higher the UV index.

The higher the SPF the less the beads change colour. The sunglasses should reduce the amount of UV radiation so the beads should not change colour or only change very slightly.

Glass blocks out UVB radiation but not UVA. Most UV lamps are UVA which has a lower frequency and is not absorbed by the glass. Half a metre of water will block out 40% of UVB but not UVA.

What next?

- Repeat using two pieces of polaroid and rotate one on top of the other by 90°.
- When the one of the polaroids are rotated by 90° no UV radiation should get through and the beads remain unchanged in colour.



Finger LED colour mixing

(Ireland)

Background

Colour mixing can be now easily demonstrated with coloured Light Emitting Diodes (LED). These Finger LEDs which are disco lights for your fingers are readily available, easy to use, inexpensive and fun.

Additive mixing of the three primary colours red, green and blue can produce the secondary colours of yellow, cyan or magenta. And with suitable intensities white light can be formed.

You will need:

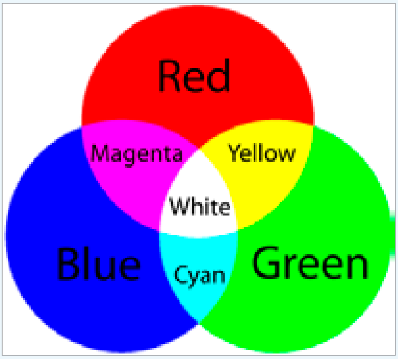
- ✓ Some Finger LEDs- ideally enough for a whole class working in pairs small groups
- ✓ White surfaces such as paper sheets to act as a screen
- ✓ Ability to darken the room

Follow these steps:

1. Darken the room
2. Shine the LED lights on the white surface
3. Vary the colours and distances (intensities)
4. Observe the secondary colours and white light that can be formed.

What next?

- Students could view the pixels of their mobile-phones or plasma televisions.
- Students explore the subtractive process of coloured paint mixing and the colours used in coloured printing.



Exploring area and volume

(Italy)

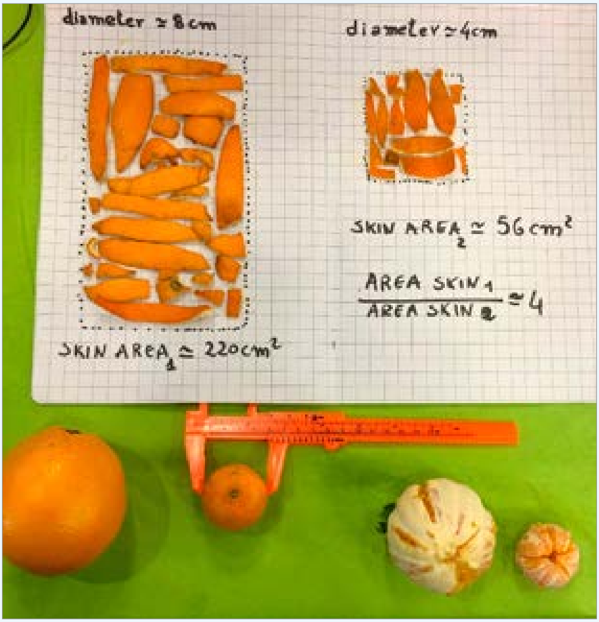
Background

This is a lovely investigation that students could carry out as part of maths or science class when studying area and volume or enlargements.

In enlargements, the ratio of any two **corresponding lengths** in two similar geometric figures is called a Scale Factor.

The area of a scaled object will be equal to the scale factor **squared**.

The volume of a scaled object will be equal to the scale factor cubed.



You will need:

- ✓ Fruit with skin e.g. citrus fruit,
- ✓ Vernier callipers
- ✓ graph paper

Follow these steps:

1. Use the Vernier callipers to get the diameter of your fruit.
2. Carefully peel your fruit and arrange them into a rectangle shape, for easier calculations, on a piece of graph paper. See figure 1.
3. Calculate the area taken up by the skin i.e. the surface area of the fruit.
4. Work out the scale factor for the diameter (or radius):
5. Work out the ratio for the area:

So what happened?

The area increases by a scale factor of k^2.

What next?

Students could use an overflow can and work out the volume of the pieces of fruit and compare.

The volume increases by a scale factor of k^3.

Mathematics

Sensory integration in mathematics

Use of sensory analyzers in the teaching of fractions
Olena Kovalova's award winning project in the Inclusive Science category

(Ukraine)

Background:

The study of fractions is one of the most difficult topics for students of secondary school, especially those with special needs, such as autism, dyslexia and intellectual disabilities. Tactile sensations and visual enhancements are very useful for children with sensory impairment. Using a variety of materials with a rough, soft, durable, smooth surface stimulates and activates the tactile and visual analysers of a child. Teaching with the help of "Sensory Math-Lapbook", we have made this process easy, interesting, and creative!

You will need:

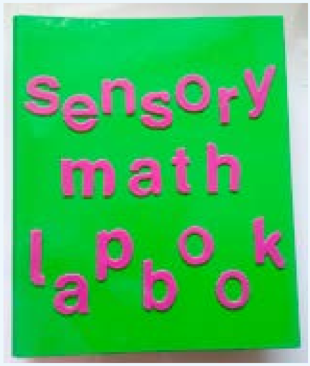
- ✓ to create a "Sensory Math-Lapbook" that includes various cards and objects with various surfaces and colours, tables;
- ✓ cards with different colours and surfaces (rough, soft, solid, smooth)
- ✓ soft baby sponges with various structures in the shape of fruits (orange, strawberries, etc.);
- ✓ children's soft designer "Benchams" (fur balls)
- ✓ circles and squares with different densities and structures can be made from sponges and clothes for washing dishes.
- ✓ one large card-field with a rough surface of bright colour which consists of 100 cells;
- ✓ printed task tables for each page or card to show fractions.

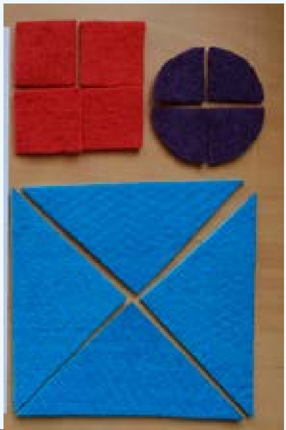
Follow these steps:

1. Show students,using cards with different surfaces (fruit cards), how one whole can be divided into equal parts.
2. Invite students to show the fraction on the card and write in the table;
3. Students compare fractions on cards using circles, squares, stripes of different structure and colour, writing the result in a table.
4. Students learn addition and subtraction of fractions using cards with circles and squares, writing the result in a table.
5. Students study decimal fractions in the next stage. They use card-field which consists of 100 cells and designer "Benchams" (fur balls). Students show and write the decimal fractions in the table.

So what happened?

Sensory support is very important for children with special needs.





Olena Kovalova

Using the "Sensory Math-Lapbook" students mastered the topic of fractions, showing a greater understanding and confidence. They can easily see the connection between the number of equal parts and the name of each part. Sensory stimulation also helps a child to stay more focussed and attentive, as well as easily remembering the new topic.

What next?

Introducing and including new cards, tasks and tables, and following the principles can help with the teaching of other topics such as "Converting fractions" and "Decimal to percent conversion".

You can watch a video about the project at https://bit.ly/OlenaSonS

Mathematics

Height vs. circumference of a cylinder

(Ireland)

Background

Humans are not very accurate at estimating the length of a curve. With using a measuring device they often find the process difficult, leading to inaccurate results. This may be due to the phenomenon of light travelling in straight lines.

The following can be used as an introduction to π and the mathematical formula for the circumference of a circle $L = 2\pi r$

You will need:

✓ A cylinder, such as a drinking glass or ideally a transparent 3 tennis ball.

✓ A piece of string, rope or even a shoe-lace

✓ An adult hand that can stretch to indicate the height of the cylinder

Follow these steps:

1. With the tennis ball tube, ask your students which is the greater length the height of tube or the rim (circumference) of the tube?
2. The majority of students will probably choose the height of the tube.
3. Wrap the string around the rim of the tube; hold this length.
4. Carefully place this length of string beside the tube to compare it with its height.
5. It will be considerably longer.
6. It can also be demonstrated by comparing the circumference and height of the cylinder with outstretched fingers.

So what happened?

Now for the maths!

Explain that the widest part of the top surface is the diameter which equals twice the radius (r) of the cylinder.

The circumference

$L = 2\pi r$

$= 2(3.14)\ r$

$= 6.28\ r$

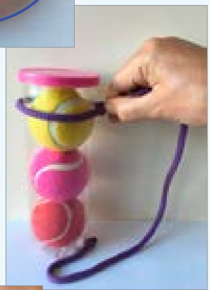
Each tennis ball also has radius (r)

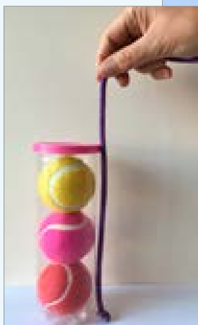
Height of tube = 6 r

So the circumference is greater than the height

What next?

- Set an extension activity for your students to carry out the experiment with different heights and circumferences of cylinders.
- Set a challenge to find a cylinder where the circumference length is as close as possible to the height.
- Verify this with by measuring the height, the diameter and using $L = 2\pi r$





The Möbius Zip

(Ireland)

Background:

Many teachers and mathematicians will be familiar with the Möbius Strip that can be made from a narrow piece of paper. This is variation can be used over and over again without any waste or harm to the environment. It is said that it was discovered independently by the German mathematicians August Ferdinand Möbius and Johann Benedict Listing in 1858.

A Möbius strip can be created by taking a strip of paper, giving it a number of half-twists, then taping the ends back together to form a loop. If you take a pen and draw a line along the centre of the strip, you'll see that the line apparently runs along both surfaces of the loop.

By cutting along this line you will produce one large loop or (depending on the number of half twists), a number of interlocking loops.

You will need:

- ✓ A large zip that can be separated into two halves
- ✓ Four sticky Velcro hooks and loops pads

Follow these steps:

1. Stick the a Velcro pad on each side and end of the closed zip
2. Join the ends of the zip firstly with no twists
3. Fully open the zip- note you now have two separate loops.
4. Repeat with one half twist when you open the zip you will end up with one long loop.
5. Repeat with one full twist this time the result will be two interlocking loops
6. Investigate what happens with more twists?
7. Is there a relationship between the number of half twists and loops resulting?

What next?

- This simple activity can be used to introduce students to the mathematical topic of topology
- Students can research real world applications for the Möbius Strip such as large convey belts that use this design. The entire surface area of the belt gets the same amount of wear and so they last longer

Mathematics

Lissajous figures

(Belgium)

Background

Lissajous figures (or Bowditch curves) are patterns produced by the intersection of two sinusoidal curves, the axes of which are at right angles to each other.

They were first studied by the American mathematician Nathaniel Bowditch in 1815 and then by French mathematician Jules-Antoine Lissajous in 1857–58.

Lissajous used a narrow stream of sand pouring from the base of a compound pendulum to produce the curves, as can be seen in Figures 1 and 2.

Mathematically, Lissajous Figures are a special case of parametric equations, where x and y are in the following form:

$$x = A \sin(at + \delta)$$

$$y = B \sin(bt + \gamma)$$

You will need:

- ✓ PVC pipes and connectors (figure 3) or clamp stands and a pipe
- ✓ bottle,
- ✓ sand or salt
- ✓ string
- ✓ black card,
- ✓ GeoGebra (app)

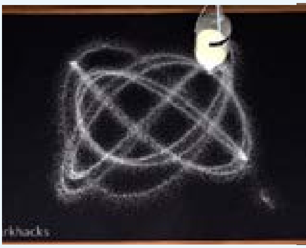


Figure 1

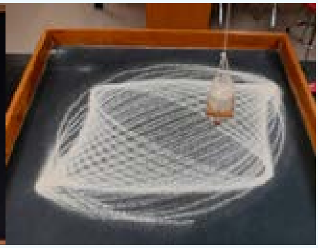


Figure 2

Follow these steps:

1. Connect the PVC pipes together as in Figure 3.
2. Make a holder for the sand by either using a cone made from card/plastic (Figure 3) or a bottle with a narrow hole in the lid (Figures 1 and 2).
3. Tie string in loops to the top of the stand which can be moved.
4. Attach another string in a loop to the first string, as in Figure 3, and then to the bottle itself.
5. Cover the hole with your finger and add fine sand or salt to the bottle.
6. Pull the bottle to a corner and release.
7. Repeat for different positions of the bottle or change string length/positions.

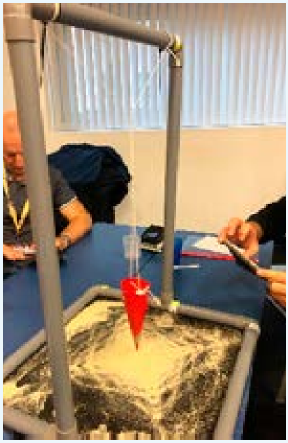


Figure 3

So what happened?

The sand traces out Lissajous patterns. If the frequency and phase angle of the two curves are identical, the resultant is a straight line. By varying the phase relation, ellipses are formed with varying angular positions. A phase difference of 90° (or 270°) produces a circle around the origin. If the curves are out of phase and differing in frequency, intricate meshing figures are formed.

Inverse Square Law

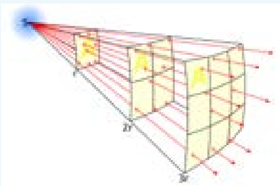
(Italy)

Background

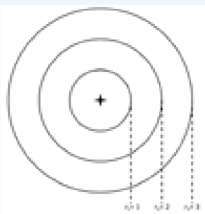
A look at how the hidden mathematics in fruit and vegetables can help in understanding some important concepts, reveals a simple model of the Inverse Square Law using oranges.

If you wish to use the images shown here, they can be access through this link bit.ly/SonS2019

The Inverse Square Law states that a specified physical quantity is inversely proportional to the square of the distance from the source of that physical quantity. The intensity of starlight, or emissions from a mobile phone mast, may be represented as in Fig. 1. The intensity decreases rapidly the further you are from the source.



This can be imagined as a set of concentric spheres with increasing radii, like layers of an onion, as in Fig. 2.



This is a difficult concept for students to grasp. However, if the skins of two oranges, of diameters *d* and 2 *d*, are peeled and the area they cover compared, there should be a 4:1 ratio as in Fig. 3.

You will need:

- ✓ A large orange
- ✓ A small orange (half the diameter of the large)
- ✓ Laminated 1 cm^2 grid paper
- ✓ Vernier calliper
- ✓ Calculator
- ✓ Dry wipe marker

Follow these steps:

1. Find two oranges of diameters *d* and 2*d*, using Vernier callipers
2. Peel the large orange and place its skin flat onto the grid paper as in Fig 4.
3. Repeat for the smaller orange.
4. Rounding to the nearest cm allows you to calculate the ratio in whole numbers.

So what happened?

As a statement, law or diagram this can be a very abstract concept. Using oranges concretises the concept in a manageable way without undermining the principle you wish to show.

It also allows the students to image concentric spheres, sitting in layers like an onion, with the centre being a point source of energy/radiation, that becomes weaker the further from the centre it is as the same amount of energy has to be spread over a much larger area (which is a sphere in 3 dimensions).

What next?

- JC Science Earth & Space – a backwards working of the light intensity from a star allows astronomers to calculate the distance of stars from Earth, in conjunction with light intensity data of stars built over centuries.
- This law can also be used to explain why mobile phone masts are considered safe as any radiation emitted by them drops off very quickly after a short distance.

Predict, Observe, Explain

— teabag on fire

(Slovakia)

Background

Predict – Observe -Explain is a teaching strategy that probes understanding by requiring students to carry out three tasks.

Students are required to predict the outcome of an event or experiment in teams by choosing one answer from multiple choices.

The experiment is then performed and observations are made.

Students compare their predictions with the result of the experiment.

What is needed?

✓ Teabag
✓ Scissors
✓ Lighter/matches

Question:

What happens if we set an empty tea bag on fire?

Predict:

1. The tea bag burns with a green flame.
2. The tea bag does not start burning.
3. The tea bag rises into the air and starts flying.

Observe:

1. Unfold the tea bag and empty out the tea leaves.
2. Turn the tea bag into a cylinder.
3. Place the cylindrical tea bag upright on a non-flammable surface
4. Light the top of the tea bag on fire. Observe what happen.

Explain:

When you set fire to the tea bag, the heat from the fire causes the air molecules inside the tea bag to move more quickly and spread out to take up more space. As the air molecules spread out, the air inside the cylinder becomes less dense. Less dense air rises above cool, dense air.

So what happened?

When predictions and observations are inconsistent with each other, students are asked to explain the reason, which then leads to further exploration.

What next?

- Try using the Predict-Observe-Explain strategy for this question:
- What equipment do we need if we want to lift an iron nail up without touching it?
  a) a fork, a key, and a 4.5V battery
  b) one more iron nail and a 4.5V battery
  c) an iron bar, a wire, and a 4.5V battery

The Evidence based Practice in Science Education (EPSE) Research Network has developed some multiple choice questions for electricity, force and motion, matter and change, and the particle model of matter. Available here

https://www.scoilnet.ie/go-to-post-primary/collections/junior-cycle/diagnostic/

Coin goes through rubber

— or so it seems!

(Scotland, UK)

Background

This magic trick is a real crowd pleaser! Everyone who sees it can't believe their eyes! How could a coin disappear through an elastic sheet and leave no hole?

You will need...

- ✓ Cup or jam jar
- ✓ elastic band
- ✓ a coin
- ✓ a sheet of latex rubber dental dam (source from your local dentist or HenrySchein.ie)

Follow these steps:

1. A thin rubber sheet, with a coin on top, is placed so as to cover the opening of an empty cup.
2. The edges of the sheet are held against the sides of the cup either by the magician, or a rubber band.
3. A member of the audience is then invited to push down on the coin with his/her finger.

So what happened?

As the audience member pushes down on the coin, the rubber stretches a little, and then, suddenly, the coin appears to go through the rubber, and falls to the bottom of the cup.

(*top pictures*)

The elastic deformation is what underlies the trick where a coin, apparently on top of a rubber sheet covering a cup, appears to go through the rubber and fall into the cup.

The coin, is in fact always under the rubber sheet and is held in an invagination which is stabilized by elasticity and by friction.

The dental dam is made rubber latex, which consist of long polymers. When you stretch these materials, the polymers straighten out and slide alongside and over one another. When you let go, small forces between the polymers pull them back together, like a contracting spring.

Because of this these materials are called "elastic," which means they spontaneously return to their normal shape after they are stretched or compressed. However the key to this trick is that when you stretch the dental dam enough it becomes transparent. Placing the coin underneath the stretched dental dam makes it appear to the audience as if it is on top of the dental dam.

Pushing down sufficiently hard on the coin (or equivalently, applying sufficient tension at the edges of the rubber) causes the invagination to become unstable, the coin is released and falls to the bottom of the cup. Magic!!

What next?

Dazzle your audience with how many kebab skewers you can push through a balloon as shown below.

(Vaseline on the skewers makes the trick easier to do!)

This is great for open nights in school.

Head-shrinking illusion!

(Scotland, UK)

Background

If your audience watch a continuously rotating spiral, the motion detectors in their eyes become adapted to that motion. Then, when they look at your head it will seem to grow or shrink, depending on the direction of rotation of the spiral.

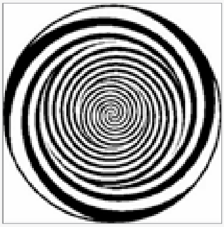
You will need...

- ✓ Spiral pattern disk
- ✓ Stiff card
- ✓ Variable-speed electric drill (works well because it can be reversed)
- ✓ Machine bolt (e.g, 8 to 10 cm in length) and matching nut or wingnut, plus two large washers to hold the card on the bolt.

Follow these steps

1. Stick the sprial pattern to the card. Trim it to form a circle.
2. Make a hole in the centre of the card and mount it on the bolt between the two washers and held tightly in place by the nut or wingnut.

3. Insert the free end of the bolt into the drill and tighten the chuck to hold it in place.



4. Once you start rotating the disk get the audience to look at the spinning spiral pattern for 60 seconds.
5. Then ask them to immediately focus their gaze at your head and not the effect.
6. Repeat this with the disk rotating in the opposite direction.

Alternative version

Mount the spiral disk on a short pencil and use it like a spinning top..

So what happened?

Some nerve cells in the visual cortex fire more when objects move outward from the centre of your field of view, and others fire more when objects move inward.

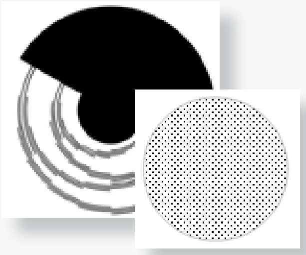
When you're looking at something that's standing still, the inward and outward channels are in balance with one another; they send equally strong signals to your brain. When you stare at this moving pattern, however, one detector channel adapts and its response is reduced. Then, when you stare at the person, the detector that hasn't been working sends a stronger signal to your brain than the adapted one does.

If, for example, the spiral seemed to be moving inward, the audience will think your head is expanding. If you rotate the spiral in the other direction, so that it seems to be moving outward, the audience will think your head is shrinking!

Very funny experience!

What next?

Try Benham's Disk which is a black and white disk that produces the illusion of colour, or the 'squirming palm disk'.



See https://www.exploratorium.edu/snacks/benhams-disk for the patterns to print for your disks.

For more examples see: https://www.youtube.com/watch?v=kqPGHE4Ubew

Levitation illusion!

(Scotland, UK)

Background

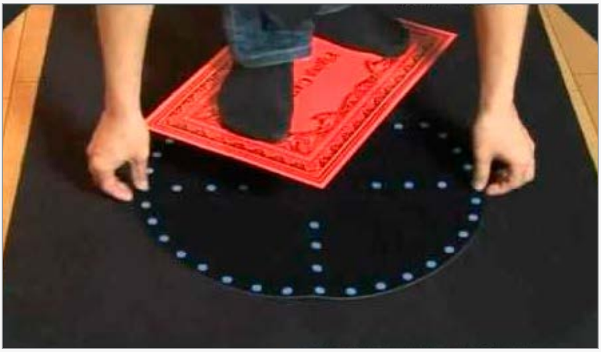
The audience will think you are levitating above the ground with this magic illusion.

You will need:

- ✓ Tenyo flying carpet (available on Amazon) or else make your own version:
- ✓ Blue laminated circles
- ✓ Black cloth mat
- ✓ Black circular card ($d \approx 40$ cm)
- ✓ Design your red flying carpet on PowerPoint
- ✓ 3-D glasses (Chromadepth glasses)

Follow these steps:

1. Cut out and stick your blue circles to the black cloth as shown below and place it on a black mat.
2. Place the flying carpet on the blue dots as shown.



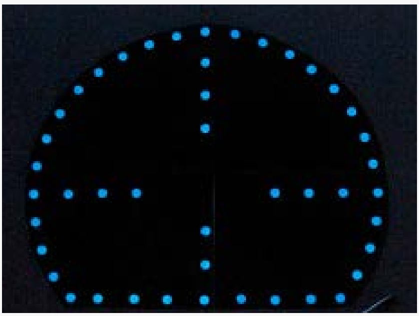
3. Get a member of the audience to put on the 3-D glasses.

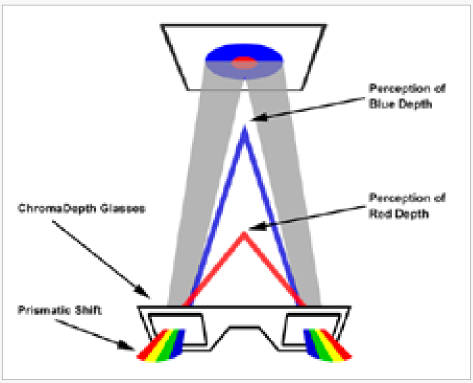
So what happened?

You will appear to be levitating above the black mat. Chromadepth glasses exacerbate chromatic aberration and give the illusion of colours taking up different positions in space, with red being in front, and blue being behind, hence the illusion of levitating.

What next?

Investigate different colours to see the difference in height above the mat.





Sustainable Development in Science Education

Sinéad Kelly | St. Oliver's Community College | Louth | Ireland

The Importance of Water

The need to raise awareness of a Water Footprint

While studying the conservation of water & discussing how we could make the little amount of water on earth that is made available to us more sustainable, students researched & completed projects on 'The Water Footprint', 'Water for Life'; they made models of the Water cycle and a Water filter system.

Collaborating with a primary school we tested their beach water samples for micro-organisms.

Available water on earth

70% of the earths surface is covered in water

2.5% is Fresh Water

1% is **only** accessible for us to use

The *water footprint* measures the amount of water used to produce each of the goods and services we use.

Every Water Droplet Saved Counts.

Inclusive Science

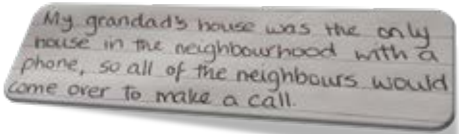
Thomas Mc Mahon | Firhouse Community College| Dublin| Ireland

Internet Inequality In Europe

The internet too hot to handle

24 student responses to
'How do we communicate today?'

They brought the **community's** voice into the classroom



Students *studied* the *history* of **how** we used light for communication. How the military used light through flashing mirrors to modern day internet fiber optic systems. They looked at the *development* of communications and what each improvement *brought* with it. Looking at different European countries and how they provide internet to their citizens.

Conclusion: Students developed an understanding of how internet access across Europe varied from country to country. Depending on internet access or the lack thereof, the effects it has on education, industry and communities.

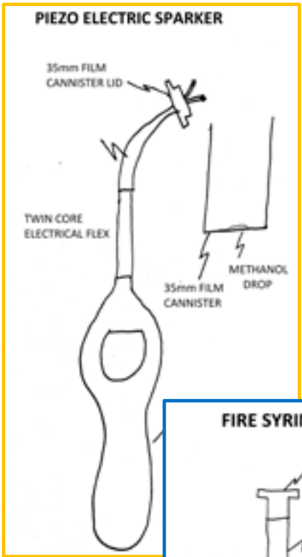
Low-Cost and Recycled Science

SCIENCE ON STAGE 2019 CASCAIS

Seán Kelleher| Coláiste Choilm | Dublin | Ireland

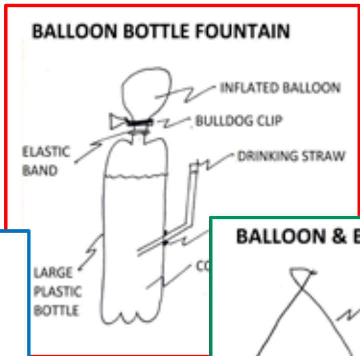
Modelling density and pressure through particle theory

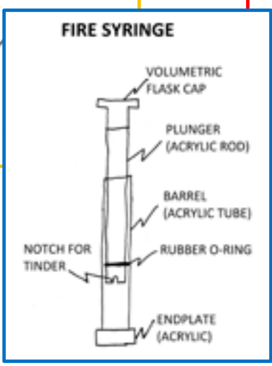
SCAN ME

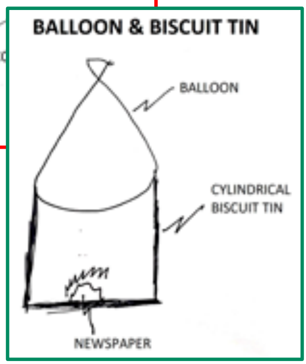


Particle theory is a fundamental theory which is taught to all lower secondary students.

In addition to explaining changes of state, physical and chemical changes, particle theory can be used as the gateway to introducing and integrating density and pressure concepts.







This project aims to apply particle theory concepts in explorations of density and pressure concepts using simple models constructed from low-cost/recycled materials. Modelling allows concepts to be explained by example, and consolidated by using novel/alternative methods

Conclusion: Carefully chosen hands-on models can be used in conjunction with particle theory to explain density and pressure concepts, for deeper student understanding.

Science in Early Years

Jane Shimizu | Scoil Chaitríona Junior| Galway | IRELAND

STEM Learning with Projectiles

Using projectiles to engage early years primary school students in STEM education.

Using space and rockets/projectiles as a theme to encourage students to become interested and engaged in mathematics, science, technology and engineering and arts.

Encouraging active learning by

- Questioning
- Observing
- Decision-making
- Designing
- Making and researching
- Being enthusiastic

Using space as a topic to encourage young students to take an active interest in STEM and STEAM subjects.

Focus on ▪ curiosity ▪ collaboration ▪ creativity ▪ critical thinking ▪ communication ▪ inquiry-based learning

Active Learning is FUN!

Joint Projects

Line Nygård Mikkelsen, Baunehøjskolen, **Denmark** Declan Cathcart, Temple Carrig School, **Ireland**

"How did we get here?"

An evolutionary journey

This Irish-Danish collaboration explored active and game-based approaches to teaching evolution, where students carried out a variety of classroom and outdoor activities. These included role-play, games, narratives, virtual labs, and bioinformatics. Lesson activities were sequenced to scaffold student learning. We put an emphasis on numeracy, digital skills, and biological literacy, as well as student misconceptions about evolution. Activities were designed to be low-cost and useful in science classrooms everywhere.

Evolution Activities:

- ***Hunting Jelly Beans***
- ***Beaky feeding frenzy***
- ***They have some neck!***
- ***The Survival Game***
- ***Game of Clones***
- ***My Cousin is a Fruit Fly***

Conclusion: We have developed a suite of hands-on group activities - games, investigations, role-play and digital labs - that enable students to collaborate, share and discuss ideas, while allowing teachers to assess learning and identify misconceptions. These activities also encourage numeracy, biological literacy and digital skill development.

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Biology

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SCIENCE ON STAGE
FESTIVAL
2019 CASCAIS PORTUGAL
SKILLS FOR THE FUTURE
31 OCTOBER – 3 NOVEMBER 2019


CHECK-IN


Water
Footprint



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Demonstrations and teaching
Ideas selected by the Irish team

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