SCIENCE

on Stage 2022

Demonstrations and teaching ideas

selected by the Irish team

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SCIENCE ON STAGE EUROPE

Science on Stage 2022
Demonstrations and teaching ideas
selected by the Irish teams

ISBN 978-1-911669-56-2

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Don't let anyone rob you of your imagination, your creativity, or your curiosity. It's your place in the world; it's your life. Go on and do all you can with it and make it the life you want to live.

Mae Jemison

Measure what can be measured, and make measurable what cannot be measured.

Galileo Galilei

All sorts of things can happen when you're open to new ideas and playing around with things.

Stephanie Kwolek

The scientist is not a person who gives the right answers, he's one who asks the right questions.

Claude Levi-Strauss

Disclaimer

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

This science teaching resource presents demonstrations and teaching ideas prepared and selected by the Irish Science on Stage team that attended the 12th European Science on Stage festival took place from 24-27 March 2022 in Prague, Czech Republic. At the largest European educational fair for STEM teachers around 350 primary and secondary school teachers from over 30 countries came together to exchange best practice teaching concepts.

Every two years, Science on Stage Europe (www.science-on-stage.eu/) brings together science teachers from all over Europe to exchange best practice teaching ideas and practical strategies at the biggest science teaching European festival for teachers. Science on Stage Europe believes that the best way to improve science teaching and to encourage more schoolchildren to consider a career in science or engineering is to motivate and inform their teachers. The non-profit organisation was founded in 2000 and reaches over 100,000 teachers Europe-wide.

Each Science on Stage Festival is held in a different country and Prague in the Czech Republic had the pleasure of being the host of #SonS2022. The festival is the culmination of national events in the participating countries. Following the principle “from teachers for teachers” the festival is also a starting point for a wide range of national follow-up activities as the best teaching ideas from the festival find their way into teaching materials and strategies in the participants own countries.

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 2022 contributors: Declan Cathcart, Eilish McLoughlin, Jane Shimuzu, Jennifer Egan, Julia Dolan, Karen Marry, Máire Duffy, Michael Kavanagh, Paul Nugent and Sinead Kelly. In particular, sincere thanks to Rory Geoghegan for his role in copy-editing this booklet for publication. All of these teachers work full time, yet, despite this, they tested and produced this excellent collection of demonstrations selected from the 2022 Science on Stage festival and this publication would not have happened without their very professional commitment.

It has been a pleasure to collaborate with these inspiring science teachers and educators in co-ordinating the SonS2022 programme and producing this booklet, which we hope you will find an invaluable classroom resource. This project was made possible by the coordination and support of CASTeL at Dublin City University. The printing of this resource has been supported by the Science on Stage Europe and the Professional Development Service for Teachers (PDST).

For further information on Science on Stage in Ireland and for electronic copies of all the Science on Stage booklets and resources, please visit: www.scienceonstage.ie/

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

SonS2022 Team and Contributors

A team of ten delegates represented Ireland at the European Science Teaching Festival, 24-27 March 2022 in Prague, Czech Republic. The team consisted of:

- Declan Cathcart, Temple Carrig School, Wicklow.
- Eilish McLoughlin, School of Physical Sciences & CASTeL, Dublin City University -Team lead
- Paul Nugent, Santa Sabina Dominican College, Sutton, Dublin and member of Science on Stage Europe Executive Board.
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- Jennifer Egan, Goatstown Educate Together Secondary School, Dublin.
- Julia Dolan, Clonkeen College, Blackrock, Dublin.
- Karen Marry, Scoil Bhride, Cannistown National School, Meath.
- Máire Duffy, Clonkeen College, Blackrock, Dublin.
- Michael Kavanagh, St Augustine's College, Waterford.
- Sinéad Kelly, St. Olivers Community College, Drogheda, Louth.

Irish Science on Stage team in Prague, March 2022:
Eilish McLoughlin, Máire Duffy, Jennifer Egan, Karen Marry, Julia Dolan, Jane Shimizu,
Back: Paul Nugent, Sinéad Kelly, Declan Cathcart, Michael Kavanagh.

SonS2022 ELIXIR FOR SCHOOLS AWARD

At the 2022 European Science Teaching Festival in Prague a Special Category Award was made to Irish teacher Seán Kelleher from Coláiste Choilm Swords. Seán received the Elixir Award for Schools Award for the High Impact of his SonS 2019 project in the Czech Republic. Over 290 replicas of "Seán's Bottle" were made across 290 schools in the Czech Republic and "Seán's Bottle" was seen by 9000 children and 7500 adults at schools, science fairs and festivals across the Czech Republic.

Using algae to investigate photosynthesis

Spain

Background

Algae can be used to investigate photosynthesis in the school laboratory instead of the traditional method of using aquatic plants. Bicarbonate indicator is used, which changes colour in response to small changes in the carbon dioxide concentration due to photosynthesis.

You will need:

- ✓ Tube of algal culture (e.g. *Scenedesmus*)
- ✓ 10 x Bicarbonate indicator
- ✓ Distilled water
- ✓ 4 x Small clear vials with lids (e.g. pill boxes)
- ✓ Small beaker
- ✓ Graduated pipettes
- ✓ Calcium chloride solution
- ✓ Sodium alginate solution
- ✓ Spatula
- ✓ Sieve
- ✓ A straw

Follow these steps:

1. Equilibrate 50 mL of 1x bicarbonate indicator by gently blowing exhaled air through it until it turns from purple to yellow orange.
2. Allow the algal cells to settle overnight, then tap the cells from the bottom of the tube using a narrow-tipped pipette.
3. Prepare immobilised algal beads by mixing the algae cell suspension with 2 - 3% sodium alginate solution and slowly dropping the mixture from a syringe into a 1.4% calcium chloride solution, at a height of about 10-15 cm.
4. Allow the beads to harden for 10 minutes and then rinse in a sieve under the tap.
5. Put an equal number of beads into each of the small clear vials and fill the vials with prepared yellow bicarbonate indicator.
6. Place the vials at different distances (e.g. 0, 5, 10, 15cm) from a bright light source (e.g. 250 CFL, or LED panel).
7. Measure the light intensity at each vial using a light meter app. on a phone.

So what happened?

The algal beads closest to the light will change colour the most.

2

Biology

Which antibacterial surface cleaner is the best?

Ireland:

Background

Many surface cleaners claim to be antibacterial.

This simple test to measure and compare the antibacterial properties of a surface cleaner uses food-grade yoghurt bacteria, *Lactobacillus*, as a model organism.

MRS agar is used which is selective for *Lactobacillus spp*. and greatly reduces the chances of contamination. Small discs of filter paper are made using a hold punch. A disc is dipped into the surface cleaner to be tested and placed onto the surface of the agar.

After incubation, the diameter of the clear zone of no growth around the paper disc is a measure of the effectiveness of the antimicrobial.

You will need:

- ✓ Sterile Petri dishes of MRS agar
- ✓ Filter paper
- ✓ Paper hole punch
- ✓ Live yoghurt
- ✓ Graduated pipette or micropipette
- ✓ Plate spreader (disposable or glass)
- ✓ Incubator

Follow these steps:

1. Place 2-3 drops (or 100µl) of live yoghurt onto the surface of a Petri dish containing MRS agar.
2. Sterilise a glass plate spreader using alcohol and a flame, or use a disposable plastic spreader.
3. Spread the yoghurt evenly over the surface of the agar.
4. Make some small filter paper discs using a paper hole punch.
5. Place sample of the surface cleaners to be tested into a small tube
6. Using a forceps, dip a filter paper disc into the sample and briefly touch the disc to a paper towel to remove excess liquid.
7. Place the disc onto the surface of agar. A number of discs can be placed on one agar plate.
8. Incubate the agar plates upside down at 30°C for 48-72 hours.

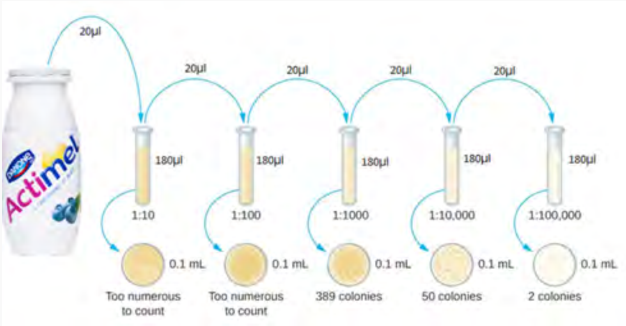
So what happened?

Measure the diameter of the clear zone around the discs.

Replicates are easily done and averages calculated. The larger the zone of clearing, the more effective the antimicrobial is.

How many bacteria are there in a yoghurt?

Ireland and the Netherlands



Background

The number of bacterial cells in a sample can be estimated using the plate-dilution method. This involves carrying out a serial dilution of the yoghurt and spread-plating a standard volume of each dilution on a separate MRS agar plate.

This activity is excellent as an introduction to microbiology in schools, with students learning about aseptic technique, bacterial nutrition, reproduction and the importance of mathematics in biology.

You will need:

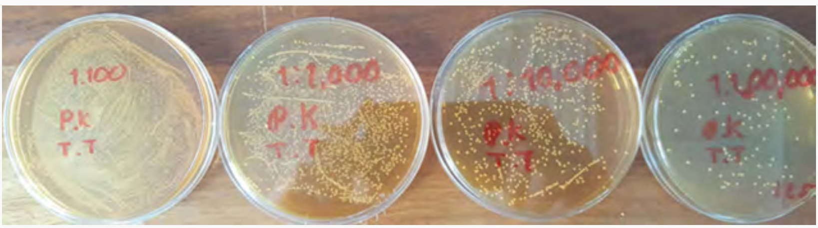
- ✓ MRS agar plates
- ✓ Plate spreaders
- ✓ Sterile 0.11% NaCl solution
- ✓ Microcentrifuge tubes
- ✓ Micropipettes/graduated droppers
- ✓ Permanent marker

Follow these steps:

1. Prepare 10-fold serial dilutions of the yoghurt in the sterile saline solution. Ensure to mix each dilution well before carrying out the next one. Use a fresh dropper or pipette tip each time you make a new dilution. 5 or 6 dilutions should be enough.
2. Label the base of a series of MRS plates, one for each dilution.
3. Place 100 µL of diluted sample on the corresponding MRS plate.
4. Using disposable sterile plate spreaders, or a glass one sterilised by dipping in alcohol and passing through a flame, spread the diluted yoghurt sample evenly on the surface of the agar.
5. Incubate the Petri dishes at 30°C for 2-3 days, until individual colonies are large enough to count.

So what happened?

Since most yogurts contain billions of cells of *Lactobacillus*, only the plates with the highest dilutions will have countable numbers of colonies. The first couple of dilutions will have so many bacteria on them that colonies will have merged to form a lawn of bacterial culture. 50-100 colonies is an ideal number to make a reasonable estimate. Calculate the number of cells in the original yoghurt. For example, if 100µl the 10-4 dilution results in 120 colonies, then the original 100µl of undiluted yoghurt would be estimated to contain 1.2 $\times 10^6$, or 1.2 $\times$ 10^9 in a 100 mL pot of yoghurt.



Biology

A simple yeast respirometer to measure the rate of respiration

Ireland

Background

A simple respirometer can be made using a plastic pipette containing yeast and glucose inverted into a container of water. As the yeast respire, they produce carbon dioxide which escapes through the tip of the pipette as bubbles which can be counted.

Factors such as temperature can be varied to study their effect on the rate of respiration measured as bubbles per minute.

You will need:

- ✓ A 100 mL graduated cylinder, or large test tube.
- ✓ Test tube rack
- ✓ Graduated 3 mL plastic pipettes
- ✓ Metal hex nuts
- ✓ 1 thermometer
- ✓ Permanent marker
- ✓ 20% glucose solution
- ✓ Dried yeast

Follow these steps:

1. Make up 10 mL of 20% yeast suspension in a 100 mL beaker
2. Using a pipette to add 1 mL of glucose solution to 10 mL of yeast mixture.
3. Close the tube and invert a few times to mix thoroughly.
4. Use the same pipette to take the yeast-glucose mixture into the pipette.
5. Flip the pipette upside down to get all of the mixture into the bulb. Tap the bulb on the bench if necessary to ensure all of the mixture is in the bulb.
6. Slide a metal hex nut over the tip of the transfer pipette loaded with the yeast-glucose as shown in the figure above and place this simple respirometer (still inverted) into a test tube rack.
7. Nearly fill a boiling tube or graduated cylinder with water at the temperature to be tested. Place that tube into a beaker of water at the same temperature to ensure the tube temperature remains relatively constant.
8. Slowly lower the respirometer into the tube of water. The level of the water needs to be above the tip of the inverted pipette.
9. Start the timer and count the number of bubbles per minute that are released from the respirometer

So what happened?

Measurements of respiration rate can made at different temperatures, and a graph drawn of temperature against rate of respiration.

Proteins and their 3D shapes

See the difference between the fabulous shapes

Ireland and the Netherlands

Background

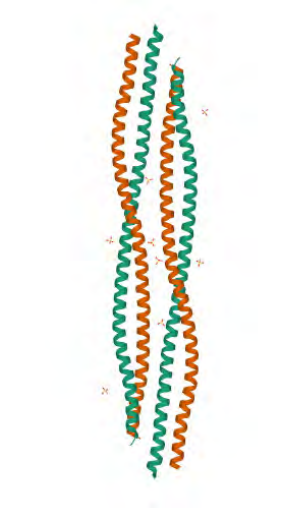
Students come across different proteins and enzymes throughout the course of the leaving certificate course. This digital activity allows the students to see the structural difference between the proteins. They then also get a greater insight into the 3 D shape of the proteins.

You will need:

- ✓ Access to digital devices or a main classroom computer and data projector.
- ✓ Website www.rcsb.org
- ✓ List of proteins to look up

Follow these steps:

1. Access to digital devices or a main classroom computer and data projector.
2. Use the website www.rcsb.org
3. Students make a list of proteins/enzymes that they have used throughout their studies.
4. An example of a list: pepsin, trypsin, lipase, myosin, actin, keratin.
5. In the search bar key in the protein and *homo sapiens*, this is important as the proteins can differ slightly with the organism that it is found in.
6. You will also see differ types of the proteins; this can highlight to students that there are many different proteins with different folds to allow them to carry out their function.
7. Scroll down the page to see the image of the proteins.
8. These are images of examples of what students will see.



Keratin

Pepsin

So what happened?

Students can see the 3D folded shape that each protein has and the differences between the shapes.

What next?

Students could use the site the look at the shapes of proteins of interest.

6

Biology

3D Printed DNA

Background

3D printing is a process of making three dimensional solid objects from a digital file. The object is created by laying down successive layers of material, usually plastic, until the object is created. Many schools are now beginning to invest in 3D printers for technology which opens up the opportunity to create unique teaching aids right in your own school.

You will need:

- ✓ 3D printer
- ✓ digital file, downloaded from online resource bank such as thingiverse.com or created in school on a drawing package.

Follow these steps:

1. The digital file of the 3D model must be converted into something printable using slicer software compatible with the 3D printer and then loaded onto the printer, often by USB key.
2. Follow the printer instructions to build the 3D model.

So what happened?

A print job can take a few minutes or a few hours depending on the size and detail of the model. The DNA puzzle above was printed in about 2.5 hours.

What next?

Students can use skills learned in technical drawing to create objects that demonstrate their understanding across all areas of science.

Hydroponic plant growth

Ireland

Background

Hydroponics is a method used to grow crops in a totally liquid medium. Plants are supported in an oxygen rich solution that has all of the minerals required for healthy growth.

You will need:

- ✓ Spinach seeds
- ✓ liquid plant 'food'
- ✓ plastic tub
- ✓ small plant pots or hydroponic net pots
- ✓ aquarium air pump and tubing
- ✓ hydroponic clay pellets or packing foam.

Follow these steps:

1. Plant spinach seeds in compost about 2 weeks before they are required for this activity. Cut holes in the lid of a sweet tub to accommodate the plant pots. Allow space for four small pots per tub. Drill extra holes in the plant pots if not using net pots. Prepare a solution of water and liquid plant food in the tub at about 25% of the recommended dilution ratio.
2. This dilute solution is more suitable for hydroponics.
3. Carefully wash the compost from the seedlings and place one seedling in each pot supported by the clay pellets or packing foam. Turn on the aquarium pump so that the roots can get oxygen for respiration.

So what happened?

Spinach will grow quickly in a hydroponic system such as this and a crop can be obtained after about six weeks.

Adjust the dilution ratio for the plant food for best results. Alternatively, special hydroponic nutrient feed is available commercially.

What next?

Measure the growth of the plant each week. Change the light intensity, temperature, pH – using pH buffers, nutrient concentration etc. to see what affect each has on plant growth. Commercial hydroponic solutions are available for more efficient growth.

Biology

Measuring lung capacity

Spain

Background

Making the workings of our body visual can at times be challenging for teachers. Students learn about the breathing system; how the lungs work and that they have a lung capacity which can vary from others. It is the lung capacity that we are trying to model, visualise and measure through active learning.

You will need:

- ✓ A larger container to act as a water bath.
- ✓ A large see-through bottle.
- ✓ Tubing
- ✓ Masking tape (to allow pen marks to be made)
- ✓ Pen
- ✓ Water

Follow these steps:

1. There is an opportunity to just see students lung capacity or add to this and add in the measuring.
2. Half fill larger container with water.
3. Place masking tape down the side of the bottle; as seen in image 2.
4. Submerge and fill the water bottle as much as possible with water, it may not fill completely but it will still work.
5. Turn the water bottle upside down as shown below.

6. Mark the top of the water on the masking tape with pen.
7. Place tubing into bottle.
8. Student takes a deep breath and breaths into the tubing. One breath only do not take a second breath.
9. Mark on the tap where the water level is. If all the water disappears then a larger water bottle is needed.

So what happened?

Your lungs have a capacity, the amount of gas that they can hold.

This lung capacity is very hard to measure without VO_2 Max monitors.

This is a quick and fun activity for students to see what their lung capacity is.

Students take a deep breath and then empty their lungs by breathing into the tubing.

The air that they breath into the tubing displaces the water from the bottle into the water bath.

What next?

Add in measurement, using a graduated cylinder fill the water bath, recording the volume added. After the water in the bottle has been displaced into the water bath it can now be measured again and the difference is the lung capacity.

Or

Measure the water placed in the water bottle. Using the masking tape, make markings on the masking tape as the graduated cylinders are emptied. When the water has been displaced the measurements can be calculated and recorded.

Making a model of a bone

Spain

Background

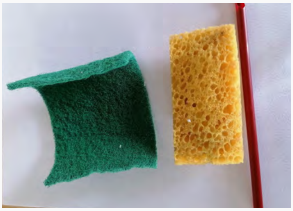
When teaching about the skeletal system we use images to support student learning.

This model of a bone will help students build the picture that there are layers to the bones and that the bones have a blood supply.

It also allows us the teacher to talk about the bone marrow as the site where cells are produced and how do these cells travel around the body to the areas of specificity.

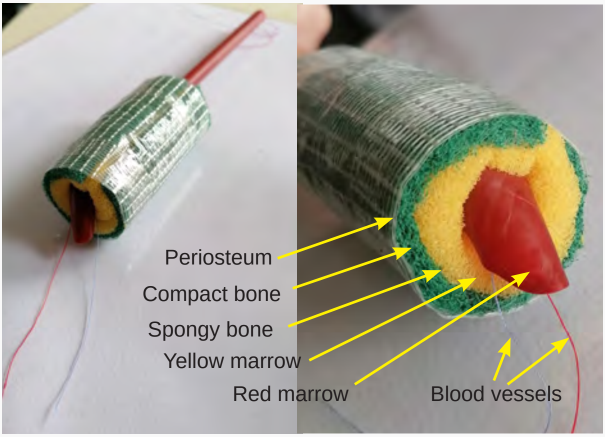
You will need:

- ✓ A green scouring pad
- ✓ A cleaning sponge
- ✓ A red straw
- ✓ Thick strong tape
- ✓ Red and blue thread / wool



Follow these steps:

1. Image 1 shows the materials needed.
2. Place the red straw in the centre of the yellow sponge.
3. Fold over the sponge and hold in place, cover the yellow sponge
4. with the green scouring pad.
5. Using the thick tape, wrap it all the way around the scouring pad and seal.
6. Thread the blue and red thread through the straw.
7. The images below show the end result.



So what happened?

As the students are building the model discussions students are learning about the anatomy of bone and

its functions.

What next?

Students can make links between bones and muscles to allow movement to happen.

Students can make a model of a moving limb and or a muscle.

Biology

Make a moving limb

Spain

Background

The study and discovery of the human body can be exciting for students. This modelling approach to learning how joints work is aimed to; motivate the students to learn more about the human biology while understand the workings of joints and ligaments.

You will need:

- ✓ An image of the bones / joints in the hand; as in image 1.
- ✓ Straws, scissors, card, pencil, Sellotape and thread.

Follow these steps:

1. Students look at images of the bones in the hand. They need to recognise where the joints are in the hand.
2. They can work independently or as a pair, making one limb each.
3. The fingers and thumb of the limb should be able to bend for the model to be successful.
4. The allow the limb to move the thread needs to be pulled collectively at the bottom of the palm area of hand as seen in image 3.
5. After students take the material needed let them explore how they should make the limb.
6. With guided practice build the approach they take with them. Showing exemplar models in progress.
7. See images for the end result.
8. Note: 1. Creasing the card at the joint areas before tapping on the straws and threading makes the limb more movable.
9. Image 2 shows the string taped to the back of the finger cut outs, this makes it easier for students to pass thread through the straws.

So what happened?

A joint is where 2 or more bones meet. The straws represent the bones, there are 2 joint areas in the finger and then the knuckle. The longer straws represent the bones in the palm area of hand. The thread passing through represents the ligaments as ligaments connect bones together and along with tendons and muscles allow moment to happen. When the student pulls on the thread in a central area at bottom of palm area the fingers of limb should move; replicating our finger and movement.

What next?

Students could then investigate muscles, there structure and muscle movement.

Maggots forensics

Determining the time of death by examining the life cycle of the blowfly.

Background

The presence of insects and maggots on a dead body is a critical clue towards determining the time of death for bodies dead for long periods of time.

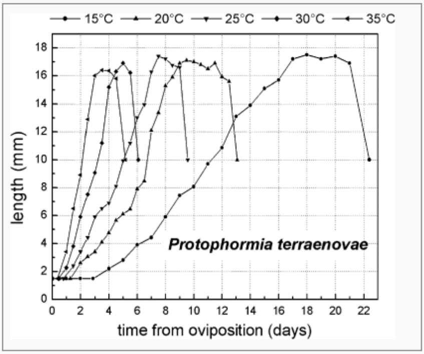
You will need:

- ✓ fake or real bones
- ✓ various size maggots(real or made of clay or playdough)
- ✓ fake blood
- ✓ tweezers

Follow these steps:

1. Set up the crime scene with the bones with or without flesh. On each bone place multiple maggots or the same length or size.

2. Examine the bones and discuss where the maggots came from and can they be examined to determine the time or date of the death.
3. Examine the life cycle of the blowfly. (image)
4. Using tweezers select a sample of 5 maggots.
5. Measure the length of each in mm.
6. The temperature of the environment affects the growth rate of the blowfly and therefore students must measure the temperature at the crime scene.
7. Using both the temperature and the length of the maggot, the students use the graph provided to determine the time from oviposition



So what happened?

The blowfly lays its eggs rapidly and their development times are predictable, under particular conditions therefore the time of death can be calculated by counting back the days from the state of development of the maggots.

What next?

Determine why there may be differences between the length of the maggots on other parts of the corpse.

Investigate why the temperature of the environment affects the size of the maggots.

Biology

Survival of the kingdoms

Spain

Background

Earth has unique conditions that support life as we know it. Other planets in our solar system have very different temperatures and are exposed to more/less radiation.

This experiment attempts to identify which living things could survive the harsh conditions that exist on other planets.

You will need:

- ✓ Milk (pasteurised)
- ✓ Live yoghurt.
- ✓ Moss
- ✓ Cress or broad bean seeds.
- ✓ Yeast (non fast acting)
- ✓ Flour (plain)
- ✓ Salt
- ✓ Water
- ✓ Fridge
- ✓ Freezer
- ✓ 5 beakers for each experiment.

Follow these steps:

A: To analyse the ability of bacteria (*biffidus*) to survive heat, cold and UV radiation.

1. Fill each beaker with 100mL of milk and label A, B, C, D and E.
2. Add 30 g of live yoghurt (with *biffidus* cultures) to the beaker of milk
3. Place the beakers where you can expose them to different environmental conditions for 24, 48 and 72 hours
4. At regular intervals, from 6 – 72 hours, check if the milk has turned into yogurt.

A	Control	Room temperature (not in direct light)
B	Extreme hot	Incubator/ air fryer/ near radiator
C	Extreme cold	Deep freezer (−24 °C)
D	Darkness	Room temperature (in darkness – use a cupboard, box, or dark room)
E	UV radiation	In direct sunlight.

B: To analyse the ability of fungi (yeast) to survive heat, cold and UV radiation.

1. Mix a teaspoon of yeast with 500g of plain flour, a half of a teaspoon of salt and 400mL of warm water in a large bowl.
2. Divide the mixture into 5 beakers.
3. Place the beakers where you can expose them to different environmental conditions for 24, 48 and 72 hours
4. At regular intervals, from 6 – 72 hours, check to see if the mixture has risen and become a dough.

For **B** and **C** use the same conditions as above in **A**.

C: To analyse the ability of plants (moss and/or cress and or broad beans) to survive heat, cold and UV radiation

1. Gather some moss from a drain or from between cobbles.
2. Divide the moss into 5 beakers.
3. Place the beakers where you can expose them to different environmental conditions for 24, 48 and 72 hours
4. Check to see if the moss has remained green and healthy looking at regular time intervals from 6 – 72 hours.

Alternatively, or along with the moss.

1. Germinate some cress seeds by giving them some water and allow them to sit at room temperature for 48 hours.
2. Once they germinate, Divide the moss into 5 beakers.
3. Place the beakers where you can expose them to different environmental conditions (as before) for 24, 48 and 72 hours
4. Check to see if the cress have grown and remained healthy looking at regular time intervals from 6 – 72 hours.

So what happened?

If the bacteria are active and have survived the harsh conditions then they will use the milk and convert it into yoghurt. It will become thicker and the smell will change as acids are produced.

If the yeast are active and have survived the harsh conditions then they will use the flour and convert it into dough. It will become thicker and the smell will change as alcohol is produced.

The moss/cress will grow and look healthy if the condition allow it or they will wilt/decompose if it cannot survive.

What next?

Look at species you have access to or can use to identify its ability to survive harsh conditions.

If you wanted to investigate the animal kingdom, then perhaps you might like to use silk worm eggs.

You could investigate the Protista kingdom by using amoeba.

Idea with thanks to María Pilar Orozco Sáenz

Biology

Comparing the vitamin C content of different foods

Czechia

Background

In this activity, the relative amounts of vitamin C (ascorbic acid) in foods can be compared using a redox titration with iodine and starch. Starch indicator solution is added to the food sample and as iodine is added during the titration, the antioxidant ascorbic acid is oxidised, while the iodine is reduced. Only when all the ascorbic acid has been oxidised will the excess iodine react with the starch, forming the blue-black starch-iodine complex.

You will need:

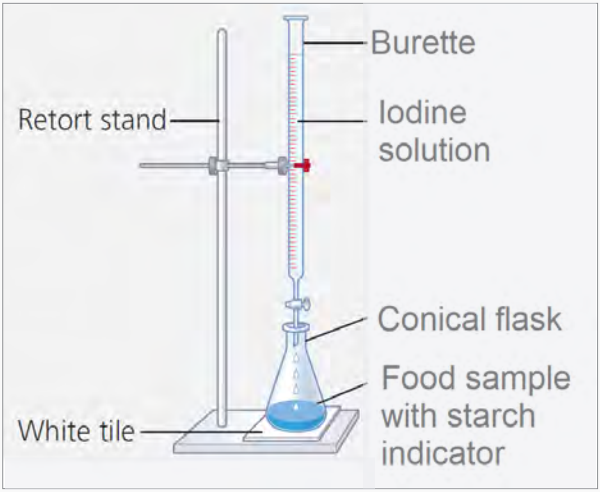
- ✓ Retort stand
- ✓ Burette
- ✓ 20 mL pipette
- ✓ 250 mL conical flask
- ✓ Iodine solution
- ✓ Starch indicator solution (0.5%)

Follow these steps:

1. Prepare the food samples by using a blender for solid foods, or grinding in a pestle and mortar, adding a small, measured amount of water if necessary. Filter to remove solid material such as pulp or seeds.
2. Pipette 20 mL of sample solution into the conical flask and add 150 mL of water with 1 mL of starch indicator solution
3. Titrate the sample with the iodine using the burette. The end-point of the titration is the first permanent trace of a dark blue-black colour.

So what happened?

Food samples such as fruit juices (fresh and processed) can be compared to each other or to a standard known concentration of ascorbic acid.



How to show that carbon dioxide is a greenhouse gas

Ireland

Background

Students learn that Carbon dioxide is a greenhouse gas. Greenhouse gases absorb heat and do not let it escape from earth. Greenhouse gases keep us warm. This demo allows students to see the greenhouse effect of carbon dioxide first hand.

You will need:

- ✓ 2 beakers (plastic ones work better)
- ✓ Alka-Seltzer tablet
  Note:
  Alka-Seltzer contains: - aspirin (acetylsalicylic acid) (324 mg per tablet), sodium hydrogen carbonate (1744 mg per tablet) and citric acid (965 mg per tablet)
- ✓ Water
- ✓ Graduated cylinder
- ✓ Infrared thermometer
- ✓ Cling film
- ✓ Elastic band
- ✓ Lamp and bulb (artificial sun)

Follow these steps:

1. Place 20 mL of water into each of the two beakers
2. Cut two pieces of cling film that are big enough to cover your beakers
3. Drop one Alka-Seltzer tablet into one of the beakers with water
4. Quickly cover the beaker with the cling film to catch the gas (carbon dioxide) that is produced
5. Cover the other beaker with cling film and secure with elastic band
6. Place both beakers under the lamp (the artificial sun) and turn it on.

7. At regular intervals record the temperature of each beaker.
8. Note if one is hotter than the other.

So what happened?

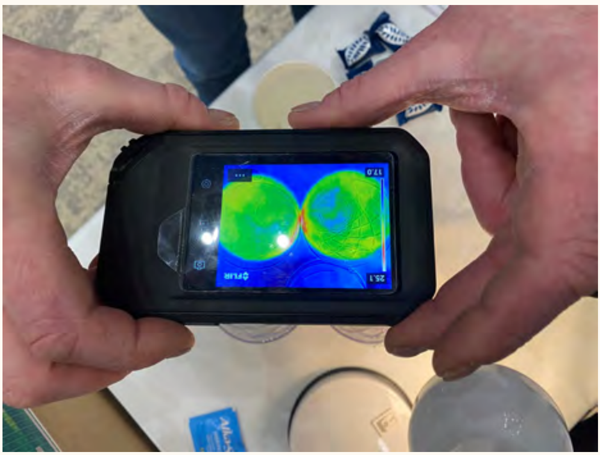
The beaker with the carbon dioxide absorbed more heat and was hotter than the beaker with no carbon dioxide.

What next?

Use vinegar and sodium bicarbonate as an alternative to Alka-Seltzer.

Use other controls e.g. bicarbonate only, vinegar only, air only and compare results.

Use an infrared camera to detect the temperature changes.



Chemistry

Making biofuels from waste

Netherlands

Background

This activity uses cellulase, immobilised in alginate beads, to convert cellulose in tissue paper to glucose. The glucose is then fermented by yeast to make ethanol.

Cellulase preparations are usually obtained as a mixture of endoglucanase, exo-glucanase, and cellobiase isolated from fungi and bacteria. In combination, these enzymes convert cellulose to glucose and oligomeric fibres.

This mixture can then be used as a substrate for yeast to ferment and produce ethanol.

You will need:

- ✓ Sodium alginate
- ✓ Cellulase enzyme preparation
- ✓ Calcium chloride
- ✓ Sieve
- ✓ 20 mL syringe
- ✓ 250 mL conical flask
- ✓ 250 mL beaker
- ✓ Potassium iodide
- ✓ Sodium hypochlorite (or household bleach)
- ✓ Incubator
- ✓ Water bath

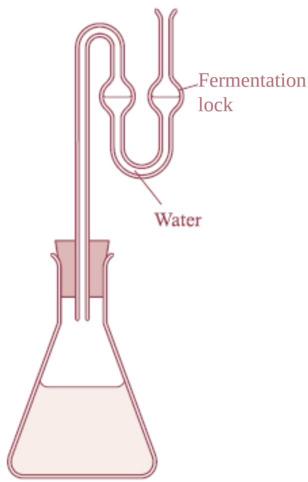
Follow these steps:

1. Prepare 20 mL of 2% sodium alginate solution and add cellulase to a final concentration of 1%.
2. Draw the mixture into a syringe and, from a height of 15 cm, slowly allow the mixture to fall, drop by drop into a beaker of 1.4% calcium chloride solution.
3. Allow the beads to harden
4. Soak shredded tissue paper in a small beaker in enough water to just cover them.
5. Warm the mixture to 30°C, and add the beads to the suspension.
6. Incubate at 30°C for one hour.
7. Use a fine sieve or filter paper to remove the tissue paper, and collect the filtrate.
8. Place the filtrate in a 250 mL conical flask, add 1 g of dried yeast, and insert a stopper and fermentation lock in the opening of the flask to produce anaerobic conditions.
9. Incubate the flask at 25°C to ferment for 24-48 hours. The fermentation is completed when no more bubbles of carbon dioxide are seen coming through the fermentation lock.
10. The presence of ethanol can be confirmed using the iodoform test. Add potassium iodide and sodium hypochlorite and incubate at 80-90°C for 10 minutes. A yellow precipitate indicates the presence of alcohol.

So what happened?

The presence of ethanol can be confirmed using the iodoform test.

Add potassium iodide and sodium hypochlorite and incubate at 80-90°C for 10 minutes. A yellow precipitate indicates the presence of alcohol.



Fire through a metal strainer

Switzerland

Background

Dry tissue held over a tea light candle will burn easily. However, tissue held in a metal strainer over a tea light candle will not burn at all.

You will need:

- ✓ A metal strainer
- ✓ Tissue cut into small pieces
- ✓ Tea light candle (or other candle)
- ✓ Matches

Follow these steps:

1. Cut or tear tissue into small pieces.
2. Put the tissue into a metal strainer.
3. Light a candle.
4. Hold the metal strainer over the candle.

So what happened?

The tissue in the metal strainer will begin to smoke but it will not go on fire.

Although the strainer heats up where the candle is, the heat is conducted away from the spot above the candle and dissipated to other parts of the strainer. A fundamental aspect of heat transfer is that heat flows from an area of high temperature to areas of low temperatures.

This keeps the temperature of the paper below the combustion temperature and so the tissue will not burn.

What next?

Make your own fire-proof paper. Here are some options that you may like to try (under the supervision of an adult):

1. Soak the paper in a mixture of 4 cups of hot water with ¼ cup of borax and ¼ cup of boric acid dissolved into it. Let the paper dry out before trying to ignite it. (This works best of all!)
2. Soak the paper in methanol (which evaporates much faster than water and so will allow the paper to dry more quickly) with 2 tablespoons of borax and 2 tablespoons of boric acid dissolved into it. Let the paper dry out before trying to ignite it.
3. Soak the paper in water to which some baking soda has been added. Continue to add the baking soda to the water until it doesn't dissolve any more. Let the paper dry out before trying to ignite it.

Chemistry

Atomic structure using role play

Italy

Background

Students create an accurate model of the hydrogen atom using role play such that students can identify where the protons, electrons and neutrons are located and how they behave.

You will need:

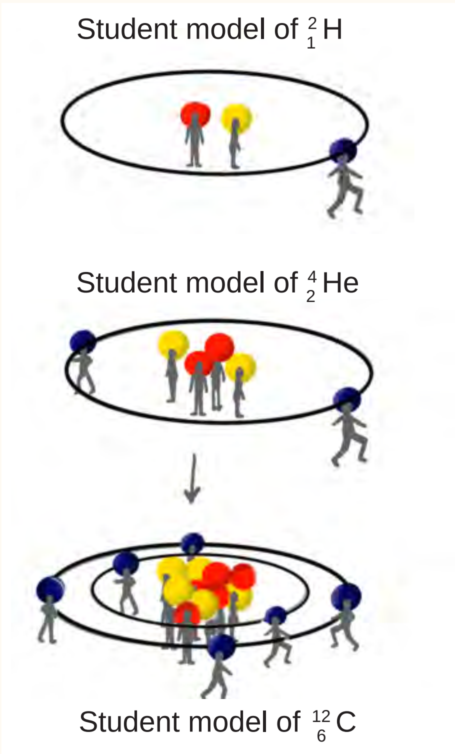
- ✓ Labels for each student (electron, neutron, proton).
- ✓ Prepared images or digital slides of certain chemical elements.
- ✓ Open space in the lab or gym.

Follow these steps:

1. Break the class into groups of three and assign a location in the room to each group.
2. To introduce them to modelling through role play, give each group 30 seconds to respond to prompts the teacher makes; square, circle, toaster etc. Students must try model each of these with their bodies.
3. The teacher then says ‘atom’. Students are given one minute to model an atom.
4. Students are shown the element hydrogen and the two numbers (atomic mass number and the atomic number).
5. Students have 3 minutes to model hydrogen.
6. Discussion about the number of protons, neutrons and electrons. There is space to talk about what the number mean (Atomic Number and Mass Number)

What next?

- Combine groups such that there are 6/7 students in each group. Display helium on the board and give students 3 minutes to model this atom. Provide mass number and atomic number as before.
- Combine groups again and display elements of greater mass number, until the whole class works to create carbon.



Particulate air pollution made visible

United Kingdom

Background

The aim is to help students understand more about air pollution and visualise what they ordinarily cannot see.

Pollution affects all our lives, and the number of pollutants can vary a lot within small areas.

This activity allows students to create matter traps and compare the particulate matter in the air in different places around their school.

You will need:

- ✓ 5 × A4 Poly pockets
- ✓ 5 × A4 white sheet of paper
- ✓ Pen
- ✓ Scissors
- ✓ Vaseline
- ✓ String
- ✓ Spatula
- ✓ Magnifying glass

Follow these steps:

1. Decide with your class the areas they would like to make comparisons between the presence of air pollution. These will be where the poly pockets need to be hung.
2. Write the name of the area and date on each sheet.
3. Place an A4 white sheet into each poly pocket
4. Rub Vaseline (petroleum jelly) on front of each poly pocket
5. Cut string to tie pocket into place, as seen in image
6. With your class decide where to tie the poly pockets the school grounds and how long for.
7. Remove the poly pockets after the designated time allowance and use as discussion points with the class as to why there is more pollution in one area than another.
8. The magnifying glass can be used to look closer at the particles.

Note: avoid hanging the poly pocket near shrubbery as small insects can get caught in the Vaseline.

Particles found will be small and appear as black dots.

So what happened?

The particle matter in the air will stick to the Vaseline on the poly pocket. The white paper simply acts as a backdrop to see the pollution. During the students course they will discuss and see images of types of pollution and pollutants, air being one of them. This activity allows students to visually see that pollution.

What next?

Students could recreate this activity at home and bring in results for further class discussions.

Chemistry

Limonene

Spain and Italy

Background

Limonene ($C_{10}H_{16}$) is a hydrocarbon. This means that it is composed of carbon and hydrogen only.

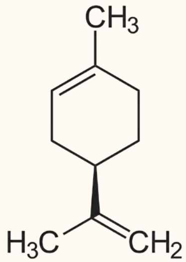


Image: Wikipedia

Limonene is a liquid at room temperature and is responsible for the smell in citrus fruits. It is a colourless substance that is not soluble in water. It is soluble in other substances such as hydrocarbons, oils and alcohol.

It is a volatile substance which is why it reaches our taste and smell receptors so quickly.

The main sources of limonene are the citrus peel oils of orange, grapefruit and lemon.

You will need:

- ✓ Balloons
- ✓ Lemons
- ✓ Oranges
- ✓ Scalpel

Follow these steps:

1. Inflate a balloon.
2. Place your finger gently on the balloon and apply a small amount of pressure.
3. Nothing happens to the balloon.
4. Cut some lemon peel off the lemon using a scalpel.
5. Squirt some of the limonene from the outer part of the lemon peel onto your finger.
6. Place your finger on the balloon and apply the same amount of pressure as before.

So what happened?

When you place your finger on the balloon and apply a small amount of pressure the balloon does not pop. You would need a large amount of pressure or a sharp edge to cause the balloon to pop due to its elasticity. The air in a balloon is at a higher pressure than its surroundings due to the elastic tension of the rubber in the balloon. When you put the limonene on your finger and place your finger on the balloon even though the pressure is the same this time the balloon pops. This is because the balloon is made of latex rubber which is also a hydrocarbon. When two hydrocarbons are in contact they will dissolve together. This creates a small hole in the balloon causing a force imbalance in the skin of the balloon. The high pressure air that was inside the balloon is now free to expand and creates a pressure wave that our ears hear as a bang.

What next?

Test different types of balloons.

Try extract limonene in the lab in the same way clove oil is extracted for LC chemistry and spray the limonene on the balloon.

Note: Vulcanized rubber is rubber that has been treated with sulfur. This is stronger than natural latex rubber and is harder to pop with limonene.

Energy and air pollution

United Kingdom

Background:

Explore the pupil's understanding of how coal-fuelled power stations, transport and household fires produce gasses. If fuels are not burned efficiently, then soot (carbon) particles enter the air around us, which can irritate our lungs and impact plants and animals, e.g. lichen. We cannot easily see the particles.

You will need:

- ✓ *Doffa's Reindeer* by Jules Pottle. It can be found here https://www.artfulfoxcreatives.com/book/1IZ-6KE4IvsVbzVPmvufYYv
- ✓ Youtube links: https://youtu.be/acJ62tHpV7s and https://youtu.be/Ne2HSJ9GWYg

Follow these steps:

1. In this activity, we will investigate the air pollution around their school or home.
2. Watch the video of Jules telling the story.
3. Demonstrate how burning wax (the fuel) creates soot using a tealight. Place a glass jar over the tealight flame (15 cm above). Lower It until the glass is touching the flame. As the sides of the tealight's metal container and the glass begin to restrict the amount of oxygen reaching the flame, it will be less efficient at burning. Soot particles will start to deposit on the base of the glass. (You may also notice the flame is more orange as it burns less efficiently.)
4. Elicit pupils' questions about what they've observed. Guide them to make their own soot (particulate matter) traps using Vaseline, paper, plastic wallet (See video) etc.
5. Videos: Watch the story video: https://youtu.be/acJ62tHpV7s
6. Watch the lesson to investigate air pollution: https://youtu.be/Ne2HSJ9GWYg

Encourage students to discuss

(a) How large should the traps be

(b) How long to leave the traps out

(c) Where they are expecting to find the most pollution

(d) Where will they place the traps

What will they count when they collect the traps – e.g. most vs least (5-7 years) or particles per square centimeter (7+ years)

Questions to ask 4 - 7-year-olds:

'How many particles can you see?' 'Where do you think the air is cleanest/dirtiest?' 'What makes you cough?'

Questions to ask 7 - 14-year-olds:

'Where does our electricity come from?' 'What Is a lichen?' 'Can you find out?' 'Why are lichens so sensitive to air pollution?'

So what happened?

How they will use the information they collect – e.g. promote a walk to school week to lower pollution around the school gates If The weather forecast might affect their investigation.

Explore pupils' questions to investigate the particulate matter in their school or home space.

A trade-off is between making electricity using these methods and looking after the environment. Humans are responsible for causing much of this pollution, so we must learn about the effects and try to mitigate them.

What next?

This experiment can be localised to the Irish curriculum under the strand energy and forces and strand units heat, materials and change.

Pupils can compare how air pollution varies in different parts of the country and in other countries using https://uk-air.defra.gov.uk/data/gis-mapping/

For more information, use the following link to find out more:

https://www.eea.europa.eu/themes/air/intro;

Chemistry

Solubility of carbon dioxide

Ireland

Background

Having learned that carbon dioxide is a greenhouse gas, students can see how the increasing temperature on earth will effect the solubility of carbon dioxide in the oceans.

You will need:

- ✓ Two bottles of sparkling/ fizzy water (place one in the fridge overnight and keep the other at room temperature overnight before the experiment)
- ✓ Ice
- ✓ Hot water (from a tap is sufficient).
- ✓ Two beakers/jugs or any containers that the bottles of water can stand in.

Follow these steps:

1. Fill one beaker/container with ice and cold water
2. Fill the other beaker/container with hot tap water
3. Open the two bottles of fizzy water and stand them in the containers of hot and cold water for 5 minutes (ensure to put the one from the fridge in the ice/cold water container).
4. After 5 minutes, count the number of bubbles popping at the surface.
5. Taste test each to see if one tastes fizzier or flatter than the other.

So what happened?

The bottle that was in the fridge/ice water was fizzier to the taste. The bottle that was warmer tasted flat. More bubbles of CO_2 escaped and popped at the surface in the warmer bottle of fizzy water as carbon dioxide is less soluble in warm solvents.

What next?

1. Drop a soluble table like Alka-Seltzer into the hot and cold bottles of fizzy water and immediately place a balloon on the spout to catch the gas that evolves. Compare the size of the inflated balloons. Again, the warmer water will not hold onto the gas and so you should see a larger balloon inflation.
2. Study the impact of the increasing temperature on Earth and the solubility of CO_2 in the oceans.

Paper clip and paper catalyst model

Ireland

Background

Students often have to be familiar with the action of a catalyst. This simple magic trick can be used by students to reinforce their understanding.

You will need:

- ✓ Two paper clips
- ✓ a strip of paper a bank note will do nicely

Follow these steps:

1. Pose the question: How many times would you need to throw two paper clips into the air for them to land interlink? Obviously a very large number.
2. Place the two paper clips on the strip of paper as shown
3. Pull the two ends of the paper fly up into the air and magically land interlinked.

So what happened?

When the strip of paper is pulled, the paper clips move together linking to each other

What next?

1. Discuss with your students how the paper acts like a catalyst, lowering the activation energy while not being used up in the reaction.
2. Discuss any shortcomings this model may have.
3. Experiment with putting some elastic bands in between the paper clips. They will also be linked leading to a discussion about polymers and chains of molecules.

Chemistry

Make a detector for particulate matter

Ireland

Background

According to the EPA (Environmental protection agency), PM stands for particulate matter, a mixture of solid particles and droplets of liquid found in the air. Some particles can be seen with the naked eye while others are too small and can only be investigated using a microscope. PM are classified by size into PM10 & PM 2.5.

- PM10 : inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- PM2.5 : fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

Some PM are emitted from construction sites, unpaved roads, fields, or fires.

Most particles form in the atmosphere because of reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are often produced from power plants and automobiles.

Students get the opportunity to remove some PM from the environment.

You will need:

✓ Paper plates
✓ Vaseline
✓ Twine
✓ Hole punch

Follow these steps:

1. Punch one hole in the paper plate
2. Feed the twine through the hole and tie a knot
3. Generously cover the plate with Vaseline
4. Hang the plate in a position where it will catch lots of PM e.g. a gate beside a busy road.

So what happened?

Lots of PM was caught. There was various shapes and sizes and most were grey, black specks in the Vaseline.

What next?

Look at the PM under the microscope or use the cheap handy home made option outlined on page 19.

Capillary origami – blooming flowers

Slovakia

Background

Water moves through plants by means of capillary action.

We can show capillary action acting on a paper flower, causing the flower to “bloom”

You will need:

✓ Paper flowers
✓ A bowl of water

Follow these steps:

1. Draw a flower shape, colour it in and cut it out.
2. Fold the petals in to the middle of the flower and crease well.
3. Float each flower in the bowl of water, and observe.

So what happened?

Each paper flower absorbs the water from the bowl and then opens out to reveal a lovely flower. There are tiny gaps between the wood fibres that make up paper. These spaces allow liquid or air to pass through. Water molecules like to stay close together as well as adhere to other substances. When you place the paper flowers in the water, the water immediately adheres to the wall of the vessels and begins to travel to the rest of the paper. As the paper absorbs more and more water, the creases flatten out. As a result the flower petals unfold.

What next?

Try dying flowers (carnations, celery or daffodils) by placing them in water coloured with different coloured food dyes. This is a vivid example of a capillary action experiment.

Dynamics and Statics

Flight: Parachutes

Ireland:

Background

Gravity will pull a parachute down to Earth but parachutes are designed to fill with air and allow a person or heavy object attached to it to descend slowly when dropped from an aircraft. They are also used on landing as a brake. Investigate how to design and make the best parachute.

You will need:

- ✓ A variety of materials
- ✓ String
- ✓ Scissors
- ✓ Sticky tape
- ✓ LEGO people or other figurines
- ✓ Ruler

Things to think about:

1. Does having air around what is falling make a difference? What if there was no air? (Dropping things on Earth vs dropping things on the Moon)
2. What makes a difference to air resistance? Shape, type of material, speed.
3. What makes the best parachute?
4. Will a parachute work if there is a hole or many holes in it?

Follow these steps:

1. Predict which parachute will give the slowest fall to the figurine.
2. Consider which material to use, which shape parachute, with or without a hole/holes in the parachute, which size parachute?
3. In groups plan and conduct investigations to find out which is the best parachute.
4. Design and carry out a fair test.
5. Collect and organise data to show your results.
6. Interpret and discuss findings.
7. Present your findings and propose explanations and solutions based on the data.

So what happened?

When a parachute is released, the weight pulls down on the strings. The large surface area of the parachute material provides air resistance to slow the parachute down. The larger the surface area the more air resistance and the slower the parachute will drop.

What next?

- Change one thing only (for example: length of string, size of your parachute, shape of your parachute, weight of the figurine, material used etc.) and make a new parachute.
- Compare this parachute with your original parachute.
- How has the change affected how quickly the figurine will land?

Flight: Windmill kites

Ireland:

Background

What makes a good wind-mill?

You will need:

- ✓ Paper
- ✓ Scissors
- ✓ Hole punch
- ✓ String
- ✓ Pipe cleaners

Follow these steps:

1. Cut a sheet of paper into a square shape.
2. Fold the paper along the diagonal, then open it out and fold again, this time on the opposite diagonal. Open the paper out again.
3. Cut from one corner along the diagonal fold, stopping about 3cm from the centre. Repeat along the remain-ing folds.
4. Using a hole punch, punch a hole in the right (or left) corner of each of the four sides.
5. Fold four alternate corner sections down to the centre of the paper, join these together with a small cutting of pipe cleaner and run 60cm of string through the pipe cleaner. Tie a knot in the string.

So what happened?

The kite will fly in the air if pulled behind a student while she/he is running.

What next?

Here are some questions the students can discuss and answer for themselves:

- What makes a good windmill?
- Can you make some different windmills and decide which one is best? (Change the thick-ness of the paper, length of string etc.) What do we mean by best? Is it the one that spins the fastest?
- Can you make the windmill spin in the opposite direction? (by punching the hole in the other corner of each triangular section)
- Does the length of string affect the way the windmill kite flies?
- Does the length of string affect the speed of which the windmill turns?

Dynamics and Statics

Showing convection currents in air

Poland

Background

The convection current in air caused by a hot candle flame can be observed using the so-called shadow projection.

You will need:

- ✓ A projector
- ✓ A candle
- ✓ Matches

Follow these steps:

1. Direct the light from the projector onto the lit candle.

So what happened?

No smoke is visible over the candle. However, a plume of convection current appears on the screen because the air heated by the flame rises upwards.

Explanation:

The heated air above the candle has a lower density than the environment. A convection current plume is formed by the refraction of light as it passes through a non-homogeneous medium of low density.

Walking graphs for teaching kinematics

The Netherlands

Background:

This activity supports students in developing a strong conceptual understanding of movement through making connections between physical movement and graphical representation of this movement. After completing this activity students can:

- Use multiple representations (describe in words, diagrams and graphs) to explain an observed movement
- walk the graph, i.e., re-enact the movement represented on a graph.

You will need:

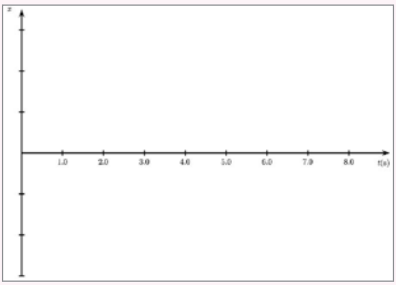
- ✓ A mini-whiteboard or laminated templates, with
- ✓ blank position-time and velocity time graphs
- ✓ examples of position-time and velocity time graphs

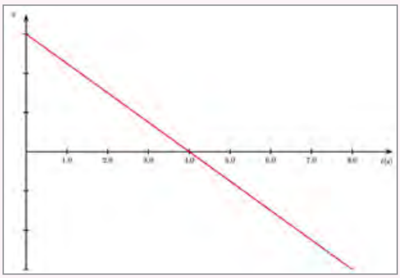
Follow these steps:

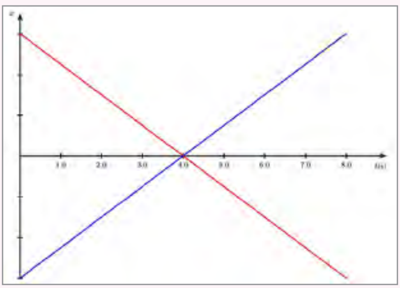
1. Set out some cones with set distances between them.
2. Ask a student to walk between two of the cones and other students are asked to graph the position-time to represent the observed motion on the blank templates.
3. Vary the starting position and speed of the walker and ask the other students to graph the motion as position-time and velocity time graphs.

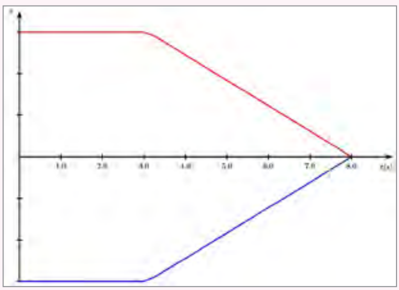
What next?

Using pre-prepared examples of position-time and velocity time graphs, ask students to 'walk the graph'. The graphs can represent one or two motions and students must discuss and decide starting positions, distance, time and speed of each individual motion.









Dynamics and Statics

Simple fire extinguisher

Slovakia

Background

Air from a bottle can be expelled at force extinguishing a flame.

You will need:

- ✓ An empty plastic bottle
- ✓ Disposable gloves
- ✓ Sticky tape

Follow these steps:

1. Cut the end of an empty plastic bottle.
2. Tape a disposable rubber or latex glove over the cut end of the bottle with sticky tape.
3. Light a candle.
4. Make a fire extinguisher by pulling on the rubber and aiming the mouth of the bottle at the flame.

So what happened?

What looks like an "empty" plastic bottle is in fact full of air. By pulling on the rubber the volume of air in the extinguisher expands. When you release the rubber it snaps back to its original shape expelling air under force. When this is aimed at a flame it easily extinguishes the flame.

What next?

Explore other kinds of fire extinguishers.

Energy Transforming Cars

Ireland

Background

According to the law of conservation of energy, energy cannot be destroyed but can only be transformed from one form to another.

In this activity students will build an energy transformation device to convert elastic potential energy into kinetic energy.

You will need:

- ✓ Car frame cut from card or scrap corriboard (advertising signs), 2 × 15 cm axles cut from 4 mm dowels or wooden knitting needles
- ✓ wheels cut from foam pool noodle or use bottle caps, jam jar lids etc.,
- ✓ mousetrap
- ✓ knitting needle for lever arm
- ✓ string
- ✓ tape.

Follow these steps:

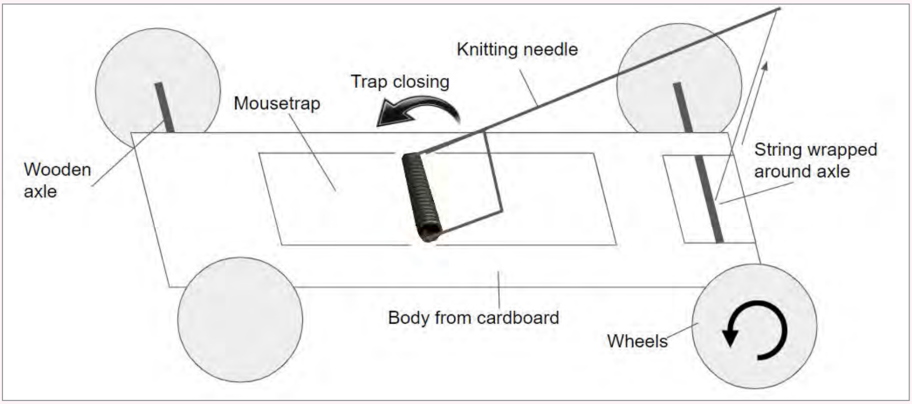
1. Cut a notch at one end of a 10 cm × 20 cm piece of corriboard to allow the string to easily wrap around the axle.
2. Slot the axles through the corrugated holes in the corriboard and attach the wheels.
3. Use tape or glue to make the wheels tight. Attach the mousetrap to the car body with tape so that the bar closes away from the notch.
4. Attach a knitting needle to the side of the hammer bar with tape as a lever arm and tie a string to the top.
5. To get the car ready, wind the string tightly around the back axle at the notch while at the same time opening the trap.

So what happened?

When the trap is allowed to close, the string pulls on the rear axle causing it to turn and drive the car forward.

What next?

Experiment with different lengths of lever arms to find the maximum distance the car is propelled.



Dynamics and Statics

Rubber band powered helicopter

Czechia

Background

This is a fun way students can both develop their engineering skills and investigate energy conversions.

You will need:

- ✓ Plastic drinking straws
- ✓ plastic bottle
- ✓ paper clips
- ✓ hot glue gun and tape
- ✓ rubber band
- ✓ plastic cotton buds or other narrow plastic tubing.

Follow these steps:

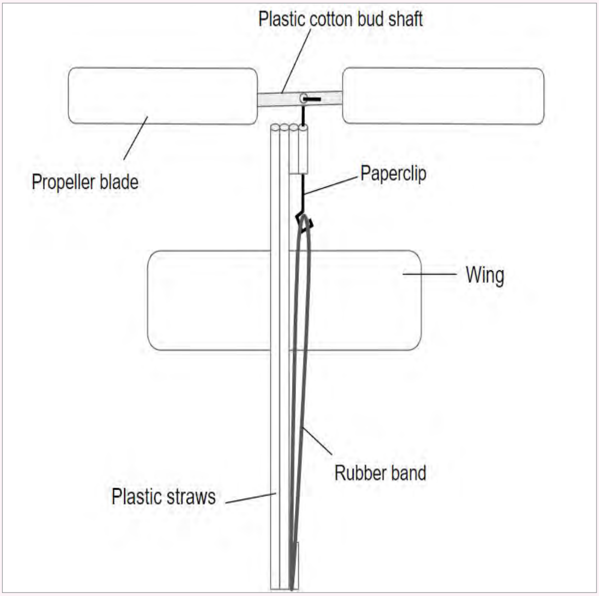
1. Cut two propeller blades from a plastic bottle and attach these to slits in the shaft of a cotton bud with tape.
2. Make a hooked axle from a paper clip and attach to the propeller as shown below.
3. Glue together two plastic straws for the main body of the helicopter.
4. Attach the propeller system to one end and stretch a rubber band from the hooked paper clip to the other end.
5. Attach a plastic wing to the body of the helicopter to minimise rotation of the body of the helicopter during flight.
6. Wind the propeller and launch!

So what happened?

The rubber band stores elastic potential energy which is quickly released to kinetic energy causing the helicopter to fly. The wing helps to stabilise the flight.

What next?

1. Rubber bands from model shops can be wound much tighter for longer flights.
2. Plastic cotton buds can be difficult to obtain but can be replaced with other narrow plastic tubes from old pens.
3. Students can investigate the effect of lubricating the propeller axle with washing up liquid and different sized wings on flight stability.



Walking Reindeer

Background

This is a fun activity that can be carried out close to Christmas.

Students can observe motion and take measurements of time, slope and speed as this cardboard reindeer wobbles its way down the slope.

You will need:

✓ Card,

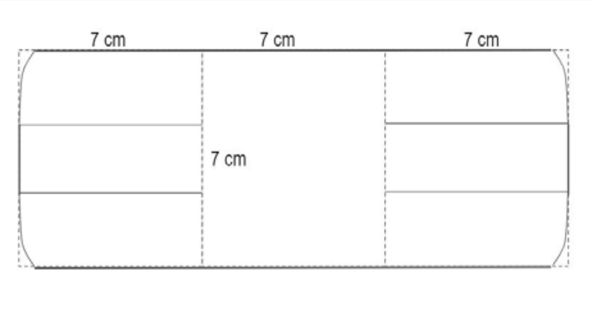
✓ scissors.

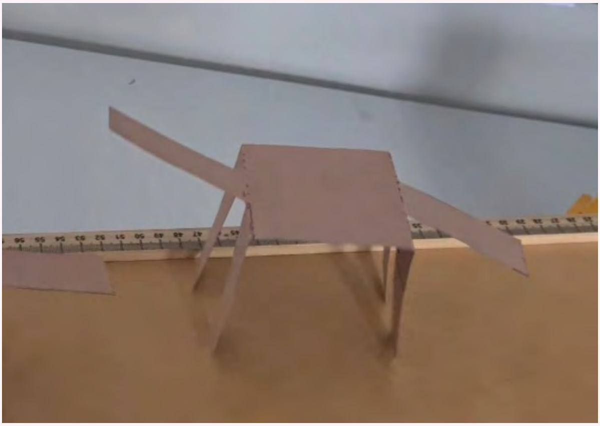
Follow these steps:

1. Cut a cardboard rectangle 21 cm × 7 cm and mark it into 3 zones of 7 cm × 7 cm.
2. Cut two slots in each end and fold down the outer pieces as legs.
3. Fold up the head and tail pieces.
4. Cut curves in each leg so that the reindeer wobbles.
5. Place the reindeer on a slope and give it a nudge to start it moving.

So what happened?

As the reindeer is unbalanced it starts to wobble over and back allowing the legs to alternately spring forward creating the illusion of walking down the slope.





What next?

1. Students can investigate with different leg lengths and materials to find the fastest walker.
2. Record time and distance for speed calculations.
3. Change the slope to see what effect it has on speed.

Dynamics and Statics

Energy-transforming wind turbine

Ireland:

Background

Wind turbines convert the kinetic energy in wind into useful energy.

In this activity students design and construct a wind turbine to lift weights from the ground generating potential energy.

You will need:

- ✓ Cork
- ✓ cocktail sticks
- ✓ card
- ✓ hot glue gun and glue
- ✓ straw
- ✓ wooden barbeque skewer
- ✓ string
- ✓ paper cup, wooden support.

Follow these steps:

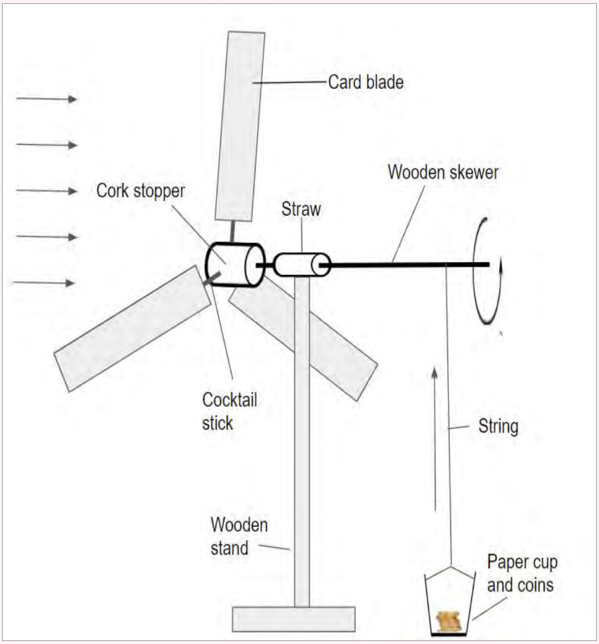
1. Cut 3 turbine blades from card and glue to them to cocktail sticks.
2. Insert the blades into a cork attached to a wooden skewer.
3. Allow the skewer to rotate inside a 3 cm section of plastic straw attached to a wooden support.
4. Attach a string and paper cup with some coins in it to the other end of the wooden skewer.
5. Hold a hair dryer of fan in front of the wind turbine.

So what happened?

As the wind turbine rotates the string wraps around the skewer and the cup is raised up converting kinetic energy into potential energy.

What next?

1. Experiment with different numbers of blades and different angles to the wind to find the most efficient set up.
2. Find the mass of the maximum number of coins lifted and calculate the potential energy generated using the formula : *P.E.* = *mgh*, where *m* is the mass in kilograms, *g* is the acceleration due to gravity (9.8 m / s²) and *h* is the height in metres.



Rubber band powered helicopter

Czechia

Background:

Lift is a force that occurs when an object pushes against the air, causing the object to rise upwards or slow its descent. It is needed to overcome the force due to gravity which pulls the object towards the ground.

Energy conversion in the helicopter: elastic potential energy → kinetic energy

You will need:

- ✓ rubber band
- ✓ propeller (plastic premade or a cotton bud, paper and wire)
- ✓ balsa wood
- ✓ adhesive tape
- ✓ scissor
- ✓ thin Styrofoam

Follow these steps:

1. Cut the balsa wood of length 25 cm.
2. Cut a small notch at the bottom of the wood. (<5 mm)
3. Assemble the propeller and attach to the wood. Ensure that there is a wire hooked onto the propeller and a second hook to attach the rubber band.
4. Cut the Styrofoam 25 cm by 1.5 cm. Attach the Styrofoam wing perpendicular to wood.
5. Attach the rubber band to the second hook and to the notch at the opposite end of the wood. If the rubber band is not tight, cut it and tie a knot on it.
6. Ensure that the propeller can spin. Rotate the propeller and as you do so the rubber band twists up creating elastic potential energy. Turn until the rubber band becomes significantly too difficult to wind.
7. Hold upright and with the propeller held in one hand and the bottom on the wood held with the other.
8. Release the propeller and watch it twist and rise.

So what happened?

Potential energy is stored in the rubber band by turning the propeller. When released this energy is converted to kinetic energy and causes the propeller to rotate, generating lift. Because of this rotational movement, for every action there is an equal and opposite reaction and therefore the body and wings of the helicopter rotate in the opposite direction also creating lift.

What next?

By changing one of the following variables, investigate what and how affects the lift of the helicopter: length of the wings, length of the wood, different materials mass, number of rotations of the propeller, different types of elastic bands.

Dynamics and Statics

Eggsperiments: raw versus hard boiled

Ireland

Background

Centre of gravity is where all the weight of an object appears to act.

Newton's first law states that if an object is at rest or moving at a constant velocity it will continue to do so unless an external force acts upon the object. This is also known as the law of inertia.

You will need:

✓ Two eggs in their shells, one raw and one hard boiled

Follow these steps:

1. Spin the two eggs and observe.
2. Now touch the eggs at their centre briefly and notice what happens.

So what happened?

The hard boiled egg spins smoothly as it is solid and has a fixed centre of gravity. The raw eggs spins with a wobble as the inside of the egg is liquid. As the liquid egg is also spinning inside the shell its centre of gravity moves hence the wobble.

When you touch the hard boiled egg it stops immediately as your finger is an external force. However, when you touch the raw egg the external force is applied to the shell not the liquid egg inside which is still spinning. As you remove your finger the raw egg still has inertia and therefore continues to spin for a while longer.

What next?

See the next eggsperiment.

Eggsperiments: Newton's First Law

Ireland

You will need:

✓ Cylinder
✓ Egg
✓ Paper plate
✓ Inside of toilet roll

Follow these steps:

1. Fill the cylinder with water.
2. Place the paper plate on top of the cylinder.
3. Place the inside of the toilet roll in the centre of the plate.
4. Place the egg standing up in the toilet roll.
5. Tap the edge of the plate in one quick smooth move.

So what happened?

The egg lands in the cylinder of water. This is because the external force is applied to the paper plate so by Newton's first law the egg remains at rest and hence falls directly into the cylinder below due to gravity.

What next?

Challenge: try increasing the number of eggs you can drop using a larger tray and a larger bucket of water!

Dynamics and Statics

Eggsperiments: spinning egg and Lenz's Law

Ireland

Background

In order for an object to spin you must apply an external torque to the object. The spinning object will then have angular momentum and only frictional forces will cause it to stop spinning.

An egg has two axis of rotation, a long axis and a short axis. This can be seen in the image below.

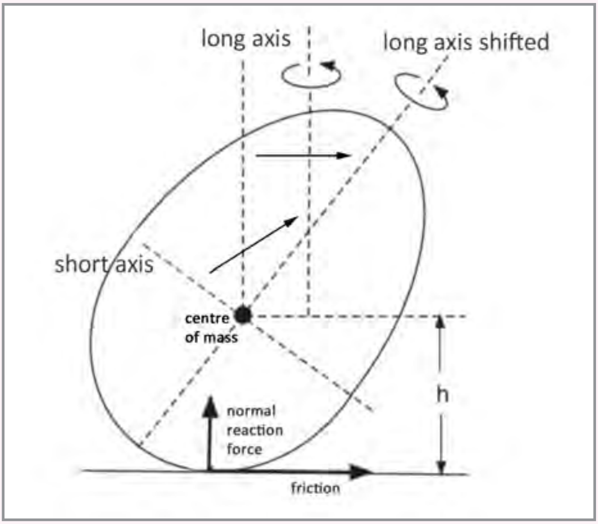


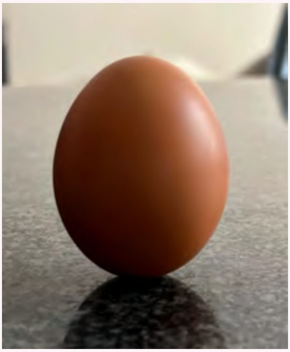
Image: Sciencealert.com Modified from *Analysis of a spinning egg*. Credit: Ross Cross. ©2018 European Physical Society

You will need:

- ✓ One hard boiled egg
- ✓ Phitop (can be bought online from suppliers such as Educational Innovations)
- ✓ Neodymium magnet

Follow these steps:

1. Place the egg flat on a smooth surface.
2. Use your left thumb and right index finger to spin the egg as fast as you can.
3. Observe the egg.
4. Now repeat with the Phitop.
5. Observe the Phitop.
6. Bring the neodymium magnet close to the Phitop without touching it.
7. Observe what happens.
8. Circle the neodymium magnet over the Phitop when it is at rest and observe what happens.



So what happened?

When the hard boiled egg is spun fast enough it changes its spinning axis from the short axis to long axis and ends up spinning upright due to frictional forces.

Objects usually spin around their centre of mass but the eggs centre of mass and the point of contact of the egg and the table are not the same point. This causes the egg to wobble slightly as it spins, tilting the angle of the short axis. This is due to the normal reaction between the egg and the table.

As it continues to spin now around its long axis the egg rises higher due to the force of sliding friction until it is completely upright. Eventually it will become unstable and topple over again and come to a stop.

The same happens with the Phitop, however the Phitop is made of aluminium. When the neodymium magnet is brought close to the Phitop it causes it to wobble and fall over and stop spinning. This is because of Lenz's law. The changing magnet field causing electromagnetic induction i.e. an e.m.f is induced causing a current to flow in the Phitop in a direction that will oppose the force. If the Phitop is at rest and the magnet is moved in circles just above it will begin to spin again for the same reason, similar to Arago's disc.

What next?

Try Lenz's law using a coke can as shown in *Science on Stage 2015,* p. 24.

Dynamics and Statics

The Kaye's effect

Poland

Background

The Kaye's effect is a phenomenon that occurs when a stream of liquid is poured onto a surface and then a jet of liquid leaps into the air. It was first described in 1963 by British engineer Alan Kaye.

The viscoelasticity of the liquid is crucial for this to happen. It commonly occurs with non-Newtonian liquids such as shampoos, dish soap and non-drip paints.

You will need:

- ✓ Non-Newtonian liquids such as shower gel, shampoo, dish soap, non-drip paint
- ✓ Smooth board
- ✓ High-speed camera or slow-motion video

Follow these steps:

1. Clamp your shower gel above the board.
2. Start your video in slow-motion mode.
3. Gently squeeze the bottle to get a thin stream of liquid flowing.
4. Observe any jets of liquid jumping off the board.
5. Now place a smooth board at an angle under the bottle of shower gel and repeat.
6. Change the angle of the board and repeat.
7. Change the liquids and repeat.

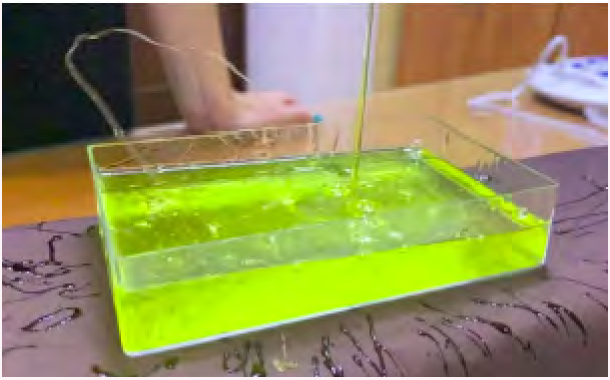
So what happened?

Non-Newtonian liquids behave differently to normal liquids. Some are shear thickening, apply a force and the viscosity increases and some are shear thinning, viscosity decreases with increased force. The liquids that work best for the Kaye's fluid are shear thinning.

There is no complete explanation for this effect to date but it is thought that as the liquid falls a layer of air exists between the heap of liquid on the board and the falling liquid which causes the liquid to slide. This sliding is a shear force.

The layer of liquid can create a small ramp that redirects the liquid's momentum and turns it into a jet. This works because the attractive forces between the molecules in the liquid jet are stronger than the forces trying to stick the stream to the surface.

Note: using slow motion video to record this effect works best as the effect is short and random.



What next?

Investigate the viscosity of the liquids as a comparison.

Investigate Bouguer's Law of light absorption in non-Newtonian liquids using a light sensor.

Make a boomerang

Czechia

Background

A boomerang is typically constructed as a flat object. It is designed to spin on its axis perpendicular to the direction of its flight. A boomerang is usually designed to return to the thrower. They are traditionally used in hunting or as a toy.

This experiment relates to many physical observables e.g. forces, energy conversions and has opportunity for student led inquiry.

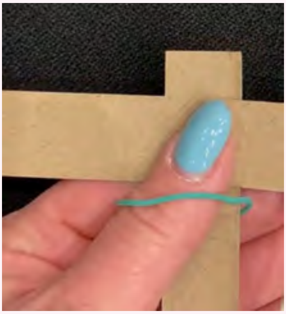
You will need:

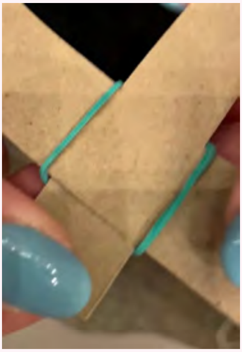
✓ Two long thin pieces of light cardboard (cereal box is perfect)

✓ One small thin elastic band

Follow these steps:

1. Place the two pieces of card one on top of another to make a T-shape; the card that makes top of the T (horizontal piece) should be on top of the other card (vertical part of the T-shape).
2. Slide the vertical piece of card up so that it is visible above the horizontal piece of card
3. Put the elastic band on your thumb
4. Place your thumb where the two pieces of card intersect and your other fingers under the cardboard to support it
5. Pull the elastic band from over your thumb to around the back of both pieces of card
6. Once secure, slide the card (on the bottom) out to make a cross shape
7. Gently curve all four sides of your boomerang downwards (towards to floor)
8. Now hold the boomerang by one of the ends and, in a wrist snapping motion, throw the boomerang from one hand and catch it in the other.





So what happened?

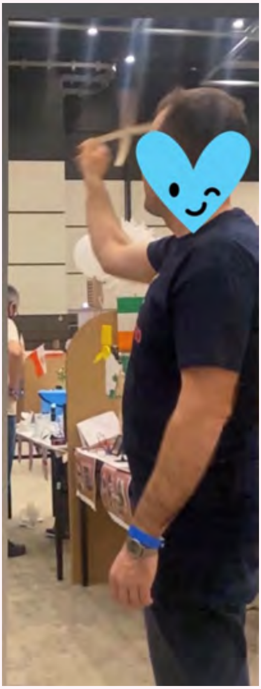
The Boomerang should fly from one hand to the other.

What next?

Investigate what happens if you bend the cardboard wings more or less.

Use different cardboard or other materials and see the effect on flight.

Does the speed change? What energy conversions are taking place? How could it be made more efficient?



Dynamics and Statics

A Strange Bottle of Water

Ireland

Background

Surface tension is the tendency of a still liquids surface to shrink into the minimum surface area possible. This invisible skin is what allows objects with a higher density than water such as paper clips and insects to float on a water without becoming even partly submerged.

Because of the relatively high attraction of water molecules to each other through hydrogen bonds, water has a higher surface tension than most other liquids (72.8 millinewtons (mN) per meter at 20 °C) .

This is a very visual demonstration of water's surface tension.

You will need:

- ✓ A PET (polyethylene terephthalate) plastic transparent bottle
- ✓ A clear top with hole in it
- ✓ Some pencils, toothpicks, matches etc.

Follow these steps:

1. Show the bottle of water which looks perfectly ordinary.
2. Invert the bottle a small amount of water falls out and then no more.
3. Careful place matchsticks and pencils through the hole into the bottle

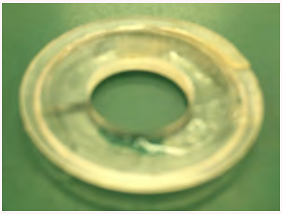
So what happened?

When the bottle is inverted the water's surface tension is sufficient to support the water in the bottle. When the pencil is inserted the surface tension is momentary broken and the pencil floats upwards.

What next?

The cap can be 3D printed or purchased from some magic shops.

A version can be made from a vinegar bottle that has a hole in the lid. Matchsticks or toothpicks can be inserted into the smaller hole. When inserted the pencil rapidly raises to the top. Ask students to devise a method for measuring this upthrust or buoyancy force.



Nutty nuts and bolts

Ireland:

Background

A simple demonstration of friction that can be used to stress the importance of observation.

You will need:

- ✓ A film cannister or other suitable container
- ✓ 3 nuts and bolts
- ✓ 3 different coloured tapes
- ✓ One willing volunteer

Follow these steps:

1. Place a piece of different coloured tape on each of the bolts
2. Ask the volunteer to choose one of the bolts and to place the nut in the middle of the tread
3. The scientist places all three nuts and bolts into the cannister
4. The scientist rotates the cannister
5. The contents are emptied out into the volunteer's hand

So what happened?

While the volunteer is distracted, two nuts and bolts are placed downwards in the canister. The chosen on is placed nut upwards. Friction causes the nut to loosen off.

What next?

Experiment by changing the direction of rotation and orientation of the nuts and bolts

Dynamics and Statics

The dry-erase dancers

Ireland

Background

Make figures appear to move and dance.

This a very visual demonstration of insolvent compounds and floatation.

You will need:

- ✓ some dry-erase white board markers
- ✓ a clean white bowl or plate or a piece of flat glass in a container
- ✓ a dropper
- ✓ some water

Follow these steps:

1. Draw your figures on the clean dry surface
2. Add drops of water to the figures. They will appear to float.
3. Rock the container to create movement.

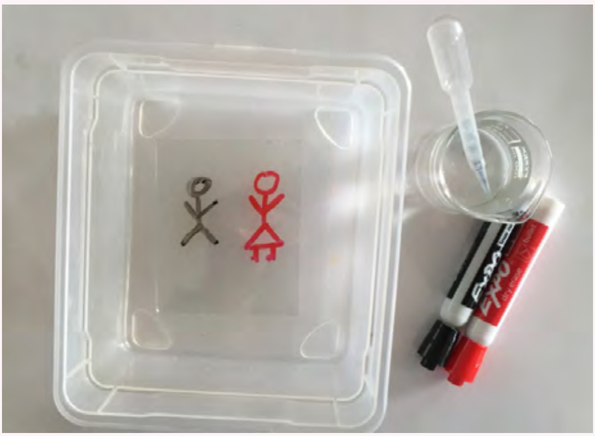
So what happened?

The surface is very smooth, and the marker ink loosens from the surface. Whiteboard markers usually contain a silicone polymer, an "oily" and hydrophobic molecule. Hydrophobic means "water-fearing," which means that the marker pigments can't mix with water. The marker pigments are also lighter than water. Therefore, the marker ink is buoyant and floats on top of the water.

What next?

Experiment with:

- Different marker brands and colours
- Different amounts of applied ink
- Different surfaces drawn on
- Different temperatures of water used



The elastic elevator

Ireland:

Background

On first viewing a paper clip appears to be moving up a piece of an elastic band. Is it ‘telekinesis or magic?

You will need:

✓ An elastic band

✓ A ring or paper clip

Follow these steps:

1. Break the elastic band.
2. Pass the band through the ring
3. Slope the band so that it is inclined
4. Magically the paper clip appears to move up the band.

So what happened?

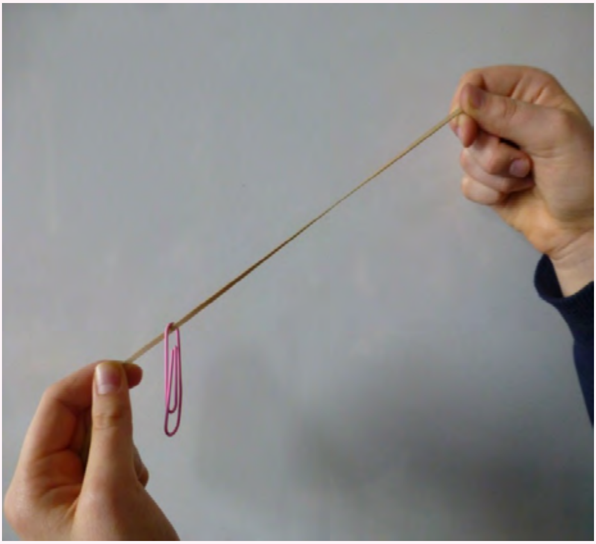
Secretly let the band slip through the finger and thumb at the lower end. It is the elastic that is moving rather than the paper clip.

This trick can be used to explain the scientific concepts of: elasticity, friction, forces and the conservation of energy.

What next?

Pose these question to your students:

- Will the paper clip climb to the top of the band? If not how far?
- Is there a maximum angle for the trick work?
- Ask students to draw a free body diagram indicating all the forces acting on the paper clip.



Dynamics and Statics

Spoon, fork and match trick

Ireland:

Background

How do you balance a spoon, fork and match on the rim on a glass?

What happens when the match is burnt?

You will need:

✓ A glass
✓ A spoon, fork and match
✓ A lighter

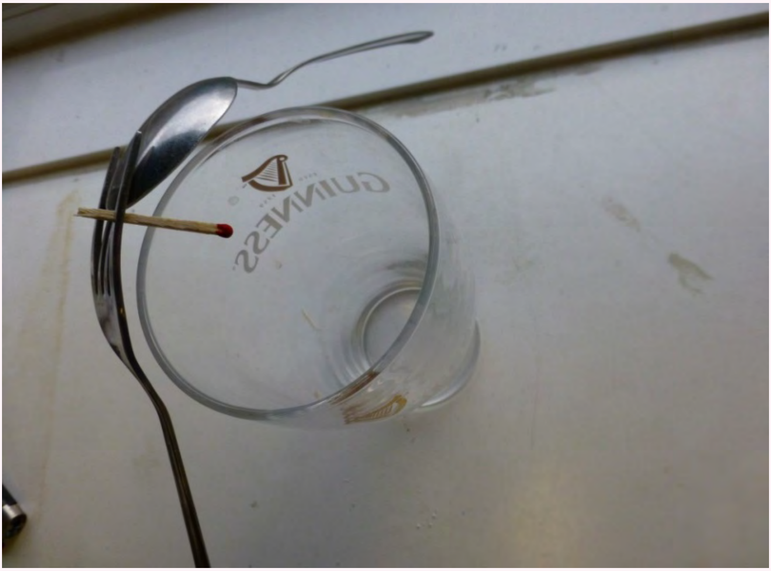
Follow these steps:

1. Balance the spoon, fork and match on the rim of the glass as shown in the photograph
2. Light the part of the match over the inside of the glass

So what happened?.

When the match is burnt the flame extinguishes when it reaches the glass. This is because the glass conducts the heat away and this is needed for fire.

The spoon, fork and match don't fall as the combined centre of mass is under the point of support on the rim.



Hurricane in a cup

Poland:

Background

Turbulence or turbulent flow is the violet, unsteady chaotic movement of the particles in a fluid like air, water or a cup of tea.

Turbulent thermal convection drives many natural and engineering flows, for example when hot air rises and cold air falls in the atmosphere and in a kettle.

You will need:

- ✓ Cup or tupperware
- ✓ Milk
- ✓ Coffee
- ✓ Syringe
- ✓ Mica powder
- ✓ Water
- ✓ Rotating disc
- ✓ Retort stand

Follow these steps:

1. Make a cup of hot coffee and place it on a rotating disc.
2. Place milk in a syringe and secure it above the cup using a retort clamp.

3. While rotating the cup, pour milk into the coffee.
4. Observe the patterns and convection currents.
5. By changing the following variables one at a time, different patterns and flows can be observed: temperature of the coffee, ratio of the volume of coffee to milk and direction or speed of rotation.

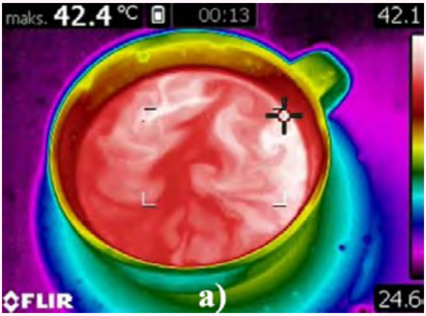
So what happened?

As the milk is being poured into the coffee, it meets the resistance of rotating coffee and gradually curls, forming spirals. This process disappears as the heat energy dissipates in the fluid.

What next?

(Change the the substance)

1. Mix mica powder with water. (Add 2 g of mica to 200 mL of water)
2. The movement of the mica particles reflects light in different directions allowing the observer to see fluid 'hurricanes'.



Pressure

Egg in a bottle – demonstrating air pressure

Czechia

Background

Air is heated and cooled to allow and change in air pressure to cause a hard-boiled egg to move through the neck of a bottle. Similarly, by blowing air into the up-side-down bottle containing egg, the egg is pushed out.

You will need:

- ✓ A hard-boiled egg, without the shell
- ✓ Suitable bottle
- ✓ Matches

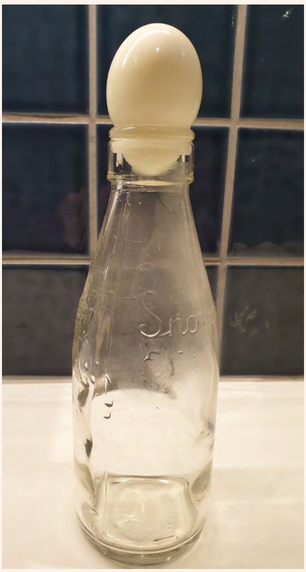
Follow these steps:

1. Place a glass or rigid plastic bottle with a wide mouth on the table. The mouth should be sufficiently smaller than the egg so that it cannot be pushed through the neck.
2. Light two matches at once and drop them into the bottle while lit.
3. Quickly place the egg onto the mouth of the bottle. The flame will go out and the egg will be drawn into the bottle.
4. Turn the bottle upside down. While the egg is sitting in the neck of the bottle, blow into the mouth of the bottle. The egg will be pushed back out.

So what happened?

The flame causes the air inside the bottle to expand when heated. The difference in air pressure inside and outside the bottle causes the egg to be pushed into the bottle, since the air pressure is larger outside the bottle. Note that the egg is not being 'pulled' into the bottle.

When air is blown into the upside-down bottle while the egg is inside, the egg acts as a valve, allowing air into the bottle, but not out. Now the air pressure inside the bottle is higher on the outside than the inside, so the egg is pushed out of the bottle.



What next?

An alternative approach to the first part of the demonstration is to carefully insert a birthday candle into the narrow end of the egg. Place the egg on a small pile of salt to keep it upright, then light the candle. Sing 'Happy Birthday' to the egg. Carefully place the opening of the upside-down bottle above the flame. Allow a few seconds for the air inside the bottle to heat up before lowering the mouth of the bottle over the candle.

The egg will squeeze through the neck of the bottle.

A common misconception is that the flame uses up the oxygen and that causes the difference in atmospheric pressure. A good way to demonstrate that this is not the case, is to use hot water instead.

Place a small amount of boiling water in the bottle, swirl it around and pour out the excess. Then quickly place the egg onto the mouth of the bottle. As the air in the bottle cools and contracts the pressure decreases. The egg is pushed into the bottle by the higher pressure outside.

(https://www.youtube.com/watch?v=6R215vLf29w)

Submarine demonstration

Ireland

Background:

A submarine is a vessel capable of diving with the possibility of controlled movement under the water's surface. Submarines have longitudinal cavities in the hull that can be fill with air or water. To submerge the submarine, these tanks are filled with water. A submarine driven by a propeller can also be stabilised underwater dynamically using depth rudders. The water is pushed out of the tanks with compressed air for the submarine to emerge.

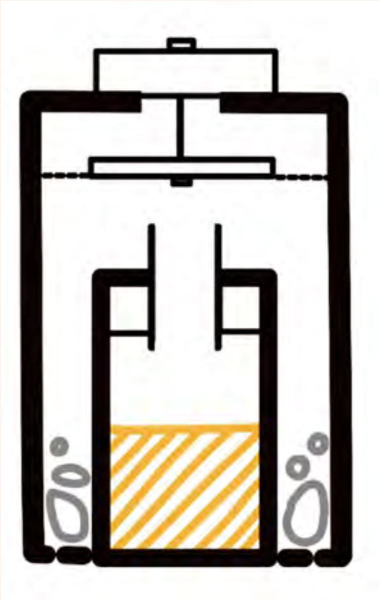
Follow these steps:

1. Glue a small tube to the centre of the large jar with a hot glue gun.
2. Make several holes around the perimeter of the bottom evenly with a nail. Make a hole in the lid of a small tube with a diameter of 0.5 cm.
3. Cut a circular hole of the same diameter as the base of the cork plugs into the lid of the jar. Then equip the gap with a float.
4. Build the float from a cork disc (1/3 of a cork wine plug), and put it on one end of the pin afterwards. At the other end, we attach a plastic disc.
5. Pour a mixture of soda and citric acid (1:1) into the inner tube so it's full to the brim, and close it with a lid.
6. Put a couple of fine pebbles on the bottom of the outer jar as a ballast. Proceed to close the jar using the lid with the float and put it in an aquarium with water.
7. The submarine gradually sinks to the bottom and begins to rise back to the surface after a while.

So what happened?

When we put the submarine in the basin, water enters through the holes in the bottom of the box and the jar sinks.

As soon as the water floods the inner bottle, citric acid dissolves and reacts with soda and carbon dioxide is formed, which accumulates in the submarine and displaces moisture. It cannot escape through the hole in the lid, as the cork disc, lightened with water, also lifts the paper flap that closes the valve. The submarine rises. When the cork disc reaches the surface, the valve opens automatically, and the gas escapes. Immediately, water rushes into the submarine, and the submarine sinks again. If properly built, the whole plot is repeated several times.



Electricity & Magnetism

Fidget Spinner Generator

Ireland

Background

An electric current is generated in a coil of wire when it passes through a magnetic field.

The size of the current produced is dependent on the strength of the magnetic field, the number of coils and on the speed the coil passes through the magnetic field.

You will need:

- ✓ Fidget spinner
- ✓ 3 neodymium magnets
- ✓ coil of insulated copper wire
- ✓ LED

Follow these steps:

1. Glue a magnet onto each arm of the fidget spinner. Ensure that the same pole of each magnet points downwards.
2. Attach the LED to the stripped ends of the coil of copper wire.
3. The coil of wire below has about 700 turns.
4. Spin the fidget spinner so that the magnets move quickly close to the coil.

So what happened?

As long as the coil and the magnets are in relative motion, a current is generated and the LED lights.

The direction of the current will depend on the direction of the spin so if the LED doesn't light at first, spin the spinner in the opposite direction.

What next?

More coils can be added and connected together in series around the fidget spinner to increase the current output.

Fidget Spinner Motor

Ireland

Background

A current passing through a coil of wire generates a magnetic field which can continuously repel permanent magnets to form a motor.

You will need:

- ✓ fidget spinner
- ✓ 3 neodymium magnets
- ✓ coil of insulated copper wire, about 700 turns,
- ✓ paper clips
- ✓ wooden board
- ✓ power supply

Follow these steps:

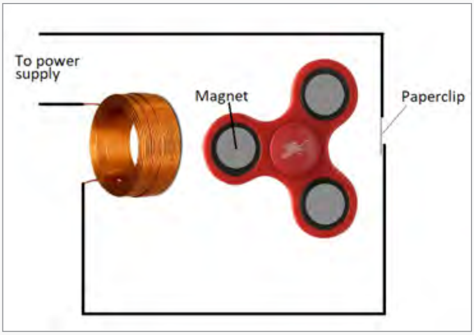
1. Glue a magnet onto each arm of a fidget spinner. Ensure the same pole of each magnet faces downwards.
2. Mount the spinner using a wooden rod onto a wooden board.
3. Place the coil underneath one of the magnets and connect it to the power supply.

So what happened?

The spinner is repelled by the magnetic field in the coil but comes to rest without rotating fully.

To keep the spinner rotating use metal paperclips to create a magnetic switch that breaks the circuit to the coil.

When the magnets pass over the switch the paper clip is attracted upwards, breaking the circuit and preventing the spinner from stopping.



Electricity & Magnetism

Make your own metal cutter

Ireland

Background

Using a couple of 9 volt batteries you can make a precision metal foil cutter. Concepts such as current flow, conductivity, etc. can easily be demonstrated.

You will need:

- ✓ At least four 9V batteries
- ✓ A container
- ✓ Some leads with crocodile clips
- ✓ Pencil graphite
- ✓ Aluminium kitchen foil
- ✓ An elastic band

Follow these steps:

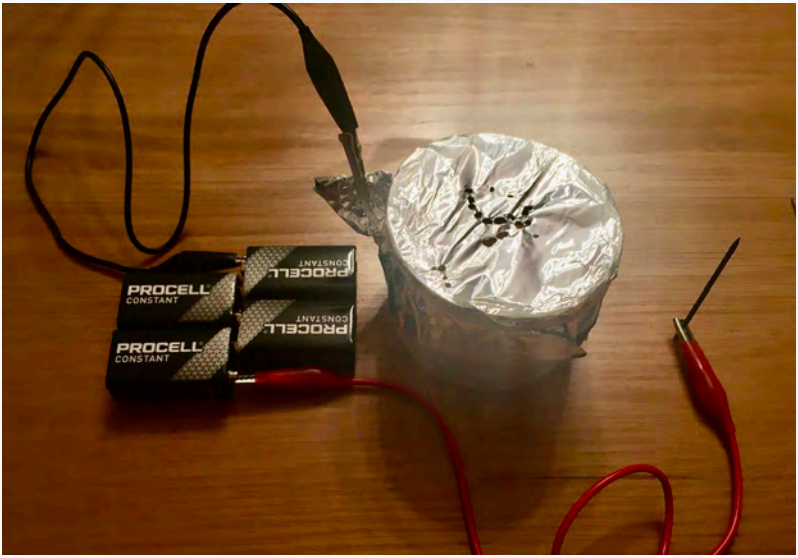
1. Connect then batteries in series
2. Connect the positive terminal to the pencil's graphite. Spread the foil on the top of the container and fix with an elastic band as shown
3. Connect the negative terminal to the foil.

So what happened?

When the graphite touches the foil, the electric circuit is completed. A large current flows vaporising the carbon and melting the metal and producing a fine cut or hole.

What next?

- Experiment with different thicknesses of pencil graphite.
- Get students to research commercial Plasma Cutters and Electrical Discharge Machines (EDM).
- Discuss any similarities and differences.



Generating electricity with a Peltier module

Background

The thermoelectric effect is the conversion of temperature differences to electric voltage with a thermocouple.

In its most basic form a thermocouple consists of two different alloy wires twisted together. When one end is heated and the other end cooled a potential difference is created between both ends due to the unequal energy gained by electrons in the alloys.

A Peltier module consists of an array of alternate p-type and n-type semiconductors sandwiched between two heat-conducting plates.

You will need:

- ✓ Peltier module – available from electronic suppliers
- ✓ wire support
- ✓ LED
- ✓ candle
- ✓ ice cube.

Follow these steps:

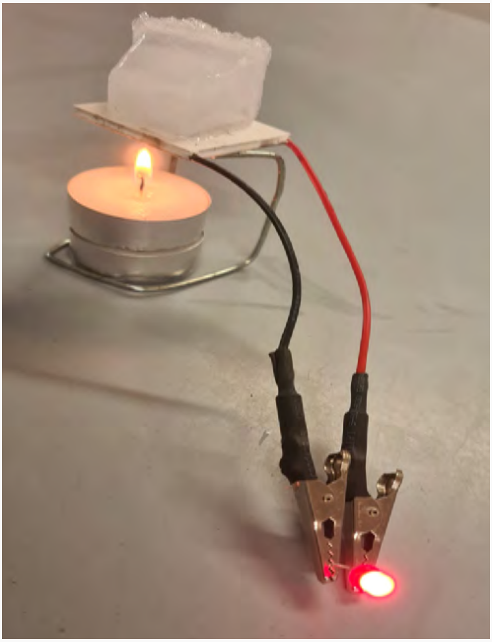
1. Attach an LED to the wires of the Peltier module.
2. Connect the positive long leg of the LED to the red anode wire of the module and the shorter negative leg to the black cathode of the module.
3. Place an ice cube onto the top of the module (with the printed text) and hold the module over a candle flame so that the lower surface is heated.

So what happened?

The temperature difference between the top and bottom plates creates a potential difference which generates enough current to light the LED

What next?

Connect a number of Peltier modules in series to create a battery of cells. Measure the potential difference obtained from known temperature differences to create a simple temperature scale.



Electric Catapult

Background

A current passing through a coil of wire generates a magnetic field.

You will need:

- ✓ coil of insulated copper wire about 700 turns
- ✓ neodymium magnet
- ✓ battery or power supply
- ✓ plastic food packaging
- ✓ spoon
- ✓ straws
- ✓ wooden skewers.

Follow these steps:

1. Assemble a simple catapult with a plastic spoon and other recyclable materials.
2. Glue a magnet to the bottom of the plastic spoon which is hinged at its handle using a straw and wooden skewer.
3. Place the coil of wire underneath the magnet and connect to the power supply.

So what happened?

The magnet is quickly repelled by the magnetic field from the coil of wire causing the spoon to flip and launch an object through the air.

What next?

Vary the potential difference across the coil of wire to change the repelling force and launch distance.

A candle and extra(ordinary) flame: electric wind

Poland

Background

An electric field is the area in which a force can be felt on a charged particle i.e. it is the force per unit charge. The direction of an electric field is the direction of the force that would be exerted on a positive charge. This can be seen in the image below.

An ion is a charged atom that has either lost or gained an electron. When you burn a candle, the heat of the flame ionises the air around the flame making the flame electrically conductive.

You will need:

- ✓ EHT supply (5 kV) or Van de Graaf generator or a Wimshurst machine
- ✓ Parallel plate capacitor
- ✓ Candle
- ✓ Screen
- ✓ Light source

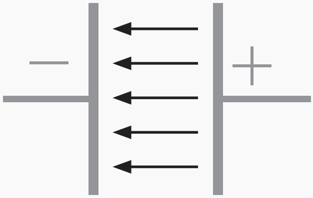
Follow these steps:

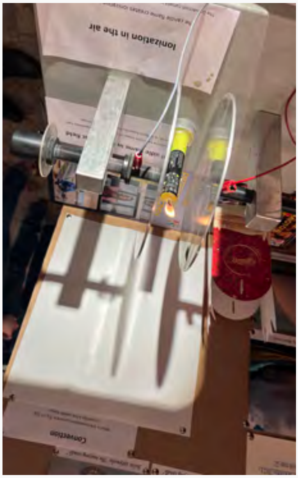
1. Fix the parallel plate capacitor approximately 10 cm apart and place the candle in the middle of the plates.
2. Light the candle so the flame is in the middle of the plates and note the shape of the flame.
3. Turn on the light source so that it casts a shadow of the flame onto the screen. Note: Both the screen and source should be a metre away from the candle on each side.
4. Connect one plate of the parallel plate capacitor to the negative and the other to the positive terminal of the EHT supply.
5. Switch on the EHT supply and slowly increase the voltage and observe what happens to the flame and its shadow.

So what happened?

As you increase the voltage you will see the flame get shorter and fatter and become non-symmetrical. As you continue to increase the voltage there will be a greater pull on the flame towards the negative plate. It appears that there is a wind blowing the flame hence the term electric wind.

The flame is made up of positive and negative ions. The negative ions are attracted to the positive plate and the positive ions are attracted to the negative plate, hence this causes the flame to be pulled in opposite directions. This can be seen nicely with the shadow on the screen.





What next?

The candle flame can also be used to show point discharge from a pointed object on top of a Van de Graaf generator.

Demonstrating induction

Background

Wireless phone chargers work by generating a fluctuating magnetic field which can create or induce an alternating electric current in a nearby coil.

You will need:

- ✓ Wireless charger
- ✓ coil of insulated copper wire about 700 turns
- ✓ LED

Follow these steps:

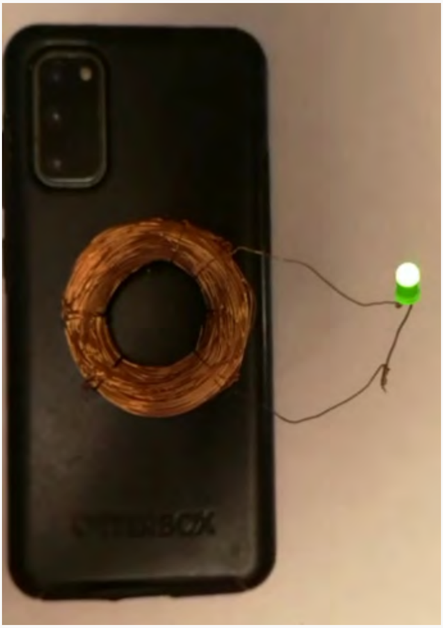
1. Connect the LED to the coil of wire and bring it close to the wireless charger.
2. The LED lights and flashes on and off.

So what happened?

An alternating current is induced in the coil of wire. The LED will light only when it is connected in forward bias so it turns on and off each time the alternating current changes direction. Many phones have a power sharing function where they can act as a wireless charger.

What next?

Create a simple bridge rectifier from diodes to convert the alternating current induced in the coil of wire to a direct current output.



A model of electron flow

Background

Students are assigned the role of ‘electron’ and create a moving model of the flow of electricity. Certain students may be given an additional role as the lesson progresses.

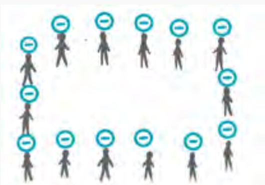
You will need:

- ✓ Labels for each circuit component.
- ✓ Props include classroom furniture, e.g., tables and chairs
- ✓ Large area to allow students to make a large circle and perform. (Open space in lab or gym).

Follow these steps:

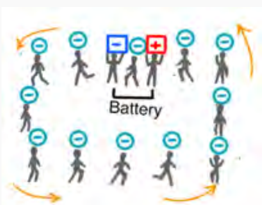
Scene 1: Making the conductor

Teacher asks students to demonstrate how they, as the electrons, may move in the wire.



Scene 2: Introducing voltage

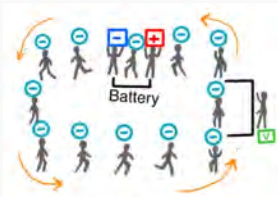
Assign two students the roles of the positive and negative terminal of the battery/fuel cell.



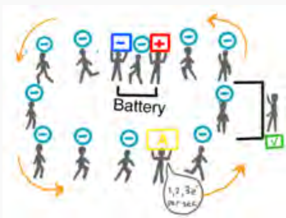
Scene 3: Introducing a voltmeter and ammeter:

How do we measure the voltage and current? Assign a student the role of voltmeter. They place their two arms either side of the wire, where their body is parallel to the circuit.

Assign a student the role of ammeter and discuss why they must be in series with the wire as the electrons must pass through them in order to be counted.



✓

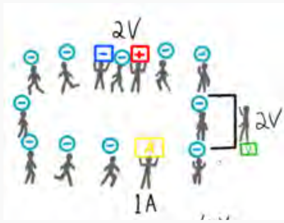


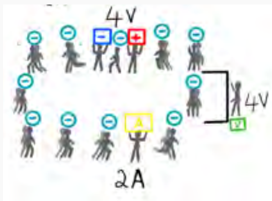
Scene 4: Relationship between voltage and current:

Students simulate what happens when the voltage is increased or decreased or doubled

So what happened?

By acting out the physical relationship between voltage and current, they learn about the concept of Ohm’s Law.





What next?

Resistance can be introduced by adding chairs that are resistors for the students to go around, i.e. slowing down the flow of electrons.

Parallel and series circuits can be made, showing the splitting of current at a junction.

Electricity & Magnetism

Solderless circuits

Source

Background

This is a simple way of connecting components for simple circuits using gel crimp connectors used for joining telephone wires.

You will need:

- ✓ Gel crimp connectors
- ✓ pliers
- ✓ battery and clip
- ✓ buzzer
- ✓ push switch.

Follow these steps:

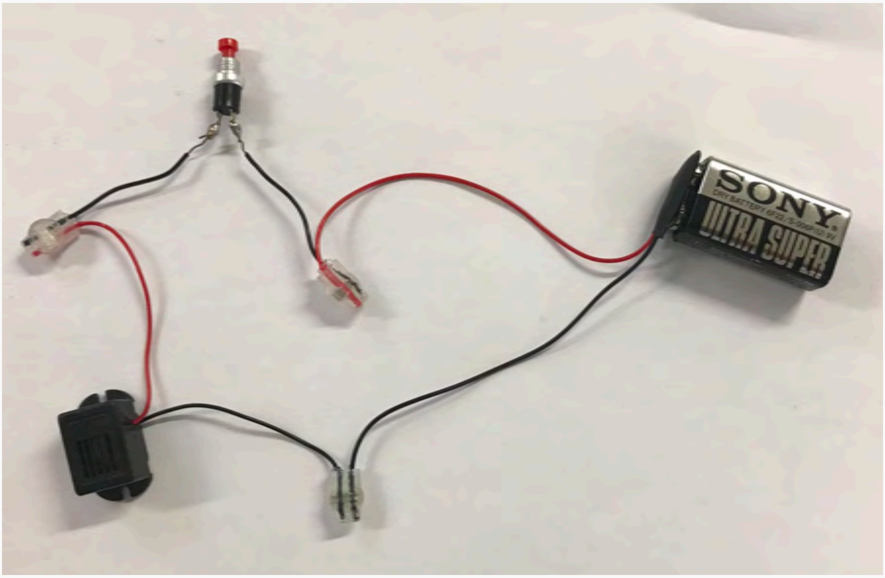
1. Place the wires directly into the connector and squeeze the connector with a pliers to make the connection.
2. There is no need to strip the plastic from the wire. The connector is filled with a gel to provide moisture resistance.

So what happened?

This is a permanent circuit and the connectors cannot be reused. Students can bring home the simple circuits made in school.

What next?

A selection of circuits can be made up and hot glued to a backing board for demonstrations.



LEDs and conductive ‘dough’

Czechia

You will need:

For the dough:

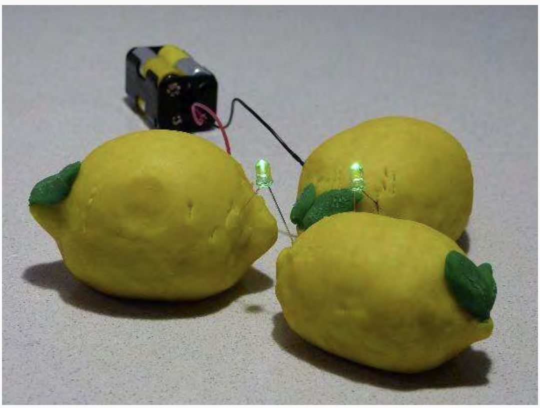
- ✓ a cup of flour (plain/all-purpose flour)
- ✓ a cup of water
- ✓ ¼ cup of salt
- ✓ 9 tablespoons of lemon juice
- ✓ 1 tablespoon of vegetable oil
- ✓ food colouring
- ✓ small pot,
- ✓ wooden spoon
- ✓ tablespoon
- ✓ cutting board
- ✓ cooker.

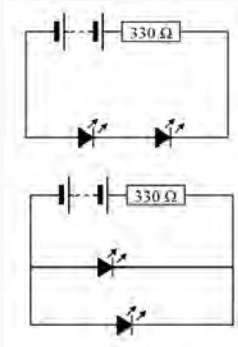
For the circuit:

- ✓ the conductive dough
- ✓ a 6 volt battery (or four AA cells in series’)
- ✓ 2 LED diodes.
- ✓ a 330 ohm resistor in series with the battery
- ✓ connecting wires

Recipe:

1. Put 1 cup of water, 1 cup of flour, ¼ cup of salt, 9 tablespoons of lemon juice, 1 tablespoon of vegetable oil and food colouring into a pot, preferably with a non-stick surface.
2. Start turning up the heat while stirring the mixture constantly.
3. Keep stirring, the mixture begins to thicken.
4. Stir until the mixture blends together and forms into a ball (it barely sticks to the sides).
5. Carefully transfer the mixture onto a floured cutting or baking board. Leave it to cool down (be careful, the dough is very hot at first).
6. Work about ½ cup of flour into the dough until it becomes non-sticky. Keep the dough in a sealed container.





Follow these steps:

1. Shape the dough into lemons. Prepare a power supply with wires and a LED diode.
2. Using the wires and the dough lemons, connect two LEDs in series.
3. Afterwards, you can connect the LED diodes in parallel.

So what happened?

Conductivity: Materials that conduct electricity - allow the flow or passage of electrical current - are called conductors.

They can be used to create circuits. Besides metal wire, more unusual things like fruit, potatoes or even dough can be used.

The conductive dough used here contains salt which increases the conductivity by breaking down into Na^+ and Cl^- ions.

Resistance is also important because it reduces the electric current. The conductive dough has more resistance than the copper wires.

Light

DIY UV lamp

United Kingdom

Background

A homemade DIY UV lamp (black light or long wave ultra violet light) can easily be made using common stationary items.

You will need:

- ✓ A mobile phone with a flashlight (LED) function
- ✓ A blue felt-tip marker
- ✓ A purple felt-tip marker
- ✓ A yellow highlighter pen or marker
- ✓ Clear sticky tape (transparent)

Follow these steps:

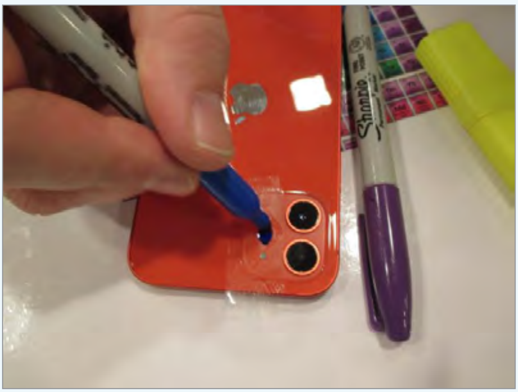
1. Cover the flashlight on the mobile phone with a strip of sticky tape. (This will also work on tablets with built-in flashes.)
2. Paint on top of the tape with blue marker so that it covers the flash.
3. Place another piece of tape over the top of the flash, and colour on top of it with blue marker as well.
4. Place a third and final piece of tape over the flash, but this time colour over the flash with the purple marker.
5. Draw on paper with the yellow highlighter pen. Now use your DIY UV light in a darkened room to see what you have written.

So what happened?

The light from your phone now acts as a UV light.

What next?

Use your UV light to look for safety marks on bank notes.



A candle and extra(ordinary) flame: candle spectra

Poland

Background

The spectrum of white light can be seen using a CD. When light hits the CD it passes through a clear plastic which causes the light to be refracted first before hitting the mirror surface. This separates the different wavelengths of light.

Different wavelengths are reflected off the mirror surface at different angles as the light hits the pits in the CD. The spacing of the pits is approximately 1.6 micro meters, which is slightly bigger than the wavelength of visible light (400 – 700 nm). Diffraction and constructive interference then create the spectrum or rainbow visible on the CD face.

You will need:

- ✓ CD
- ✓ Different types of candles e.g. beeswax, paraffin, soy, citronella

Follow these steps:

1. Light the candle.
2. Place CD behind flame as in picture.
3. Observe spectra.

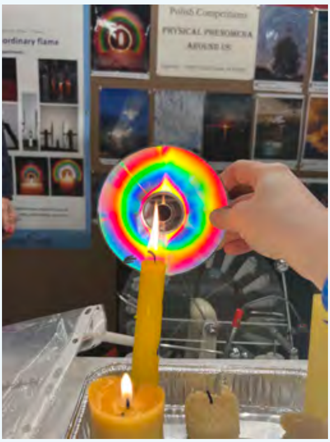
So what happened?

Each candle wax is composed of different chemical compounds which gives slightly different spectra depending on which elements are mainly found in the candle.

What next?

Try the interactive CD at https://javalab.org/en/light_interference_on_cd_surface_en/ .

Make your own spectroscope to view absorption lines and get students to identify the elements present in different light sources.



Light

Polarising Light Using Corn Syrup

Scotland

Background

Birefringence is the optical property of a material that has a refractive index that depends on the polarisation and propagation direction of light. Birefringence occurs in substances that have physical properties that give it more than one refractive index.

Unpolarised light is where light is vibrating in more than one plane. Plane polarised light is where light vibrates in one plane only.

You will need:

- ✓ Two polarisers
- ✓ Light source (LED torch works well)
- ✓ Corn syrup or agave syrup
- ✓ Stand

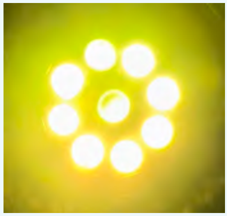
Follow these steps:

1. Place torch in stand and switch on.
2. Place one polariser on top of the torch.
3. Place beaker of corn syrup on top.
4. Place second polariser on top of the beaker.
5. Slowly rotate the top polariser and observe the light from directly above.

So what happened?

As the top polariser is rotated different wavelengths of light can be seen (see images below).

Corn syrup is optically active meaning when light that is polarised passes through the syrup the orientation of polarisation rotates. This is because the corn syrup is made of helical sugar molecules which allows it to exhibit birefringent properties. The rate of rotation of polarisation is frequency dependent and so we see different wavelengths as the polariser is rotated.



What next?

Try different syrups.

Physics meets art: refraction

Czechia

Background

The project was carried out by students of Církevní gymnázium in Plzeň, where they combined physics and photography to make art.

Refraction is the bending of light as it passes from a transparent medium of one refractive index to another transparent medium with a different refractive index.

If an object is placed in front of a lens the image produced can be magnified or diminished, upright or inverted depending on the type of lens used.

The art in this investigation is created using converging lenses (convex). These converging lenses can be found in the lab or can be made using different types of glasses and water or different liquids.

If an object is placed outside the focal point the image produced is real and inverted.

You will need:

✓ Different shaped glasses
✓ solid glass ball
✓ Water

Follow these steps:

1. Create different backgrounds, as can be seen in the images, and print.
2. Place different shaped glasses in front of the images and fill the glasses with water.
3. Observe and take photos.

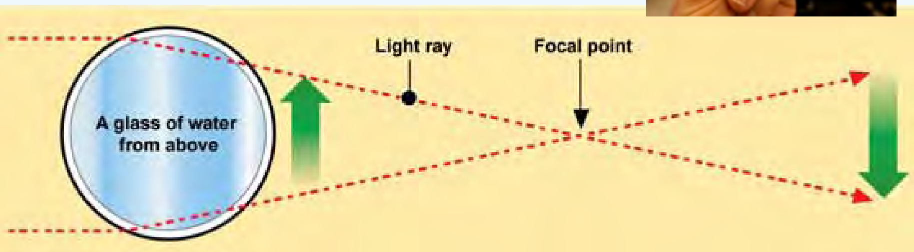
So what happened?

The lines bend and colours invert due to the refraction of light.

What next?

Explore the photography of the teacher and students for more inspiration: https://eu.zonerama.com/KaterinaLipertova/878474

Image: www.physicscentral.com



Light

Mobile phone microscope

France

Background

The camera on a mobile phone can be used to make a versatile microscope.

You will need:

- ✓ a camera-equipped mobile device (phone, tablet, etc.)
- ✓ lens (search online for acrylic collimating lenses; they are widely available to bulk buy)
- ✓ cardboard
- ✓ elastic bands
- ✓ scissors
- ✓ Optional: hole-punch, graph paper, clear tape

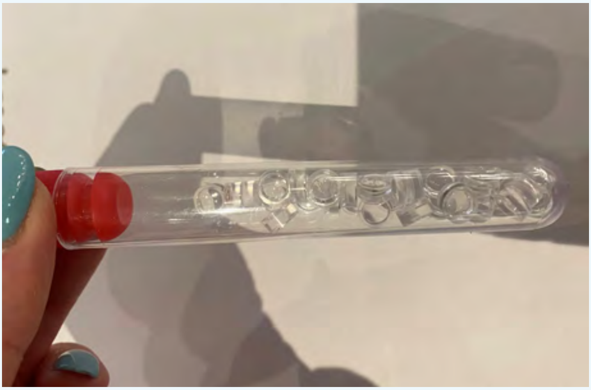


Photo: tube with several acrylic lenses

Follow these steps:

1. Cut cardboard to the size of your device and mark the location of the camera.
2. Make a hole and drop-fit the lens. (A hole-punch works well to remove some cardboard, yet leave a tight fit to hold the lens in place, but a pen, pencil will work.
3. Place your camera over the lens. Secure in place with elastic bands. (This may take some adjustment and may need to be redone occasionally during use.)
4. Your device is now ready to use as a microscope probe.
5. Find the distance that works for best imaging, e.g. 0.5 cm to 2 cm away.
6. Start observing surfaces, rocks, leaves on plants, food, computer and phone screens.

So what happened?

Objects are magnified, and more detail can be seen than is possible with the naked eye.

What next?

Keep magnifying and comparing e.g. animal -v- plant surfaces.

Thanks to Michael Gregory for his idea here.

What can we do to protect ourselves from UV radiation?

Spain

You will need:

- ✓ UV colour changing beads – widely available to buy online
- ✓ UV torch.
- ✓ Various sun creams.
- ✓ Various sun glasses.
- ✓ Various sun hats.
- ✓ Various cloths.
- ✓ Cling film or acetate page

Follow these steps:

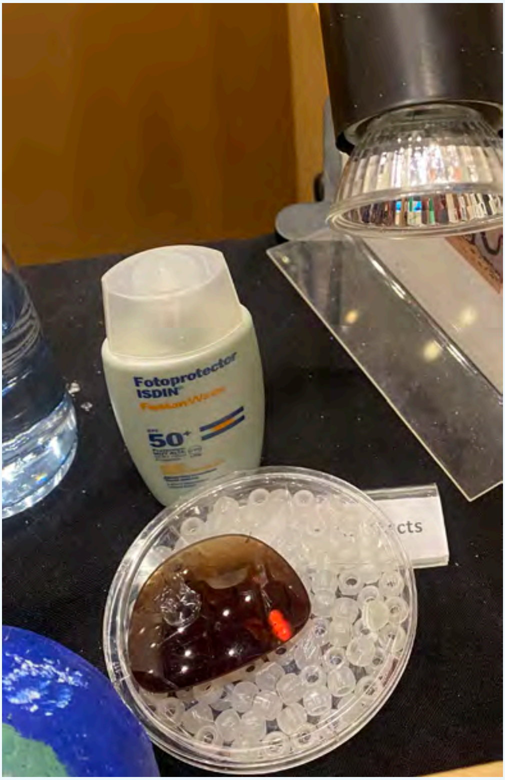
1. As a control expose your beads to UV light using the torch.
2. Make a slow-motion video of the UV beads changing colour.
   Pause the video when you see the colour change.
   Get a screen grab of each colour. This will allow you to make a 1–10 colour chart of the colour change so that you can rate the effect of sun creams, etc.
3. Now cover the beads with various cloths e.g., T-shirts and expose to UV torch light for 1 minute
4. Use your colour chart to rate the colour of the beads after each cloth.
5. Now cover the beads with various sunglasses and expose to UV torch light for 1 minute
6. Use your colour chart to rate the colour of the beads after each one.
7. Now rub some sun cream on some cling film/acetate, cover the beads and expose to UV torch light for 1 minute.
8. Use your colour chart to rate the colour of the beads after each one.

So what happened?

The UV beads will change to a deeper pink/purple when they receive more UV radiation. They turn a lighter pink/purple when they are exposed to less UV light. They are colourless when they get little or no UV light.

What next?

Students could investigate new and innovative ways to protect a living thing from UV radiation on other planets as an extension.



Earth and Space

Learning about light through space

Georgia & Sweden

Background

It is possible to combine the themes of light and space in order to make models of the Earth and moon in space.

You will need:

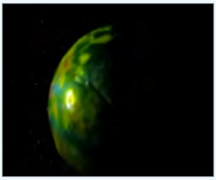
- ✓ Cardboard shoe boxes
- ✓ Polystyrene spheres
- ✓ Torch or flashlight
- ✓ Skewers

Follow these steps:

1. Paint a polystyrene ball to look like the Earth, and another smaller polystyrene ball to look like the moon.
2. In a cardboard box, cut out a rectangular viewing window at the side of the box and a circle from the top of the box.
3. Place a skewer through the circle and into the Earth sphere.
4. Put another skewer into the moon sphere and hold this in place next to the cut out circle.
5. In the side of the box cut out a circle large enough to insert a torch or flashlight.
6. While the light is shining, hold the skewer that is connected to the moon and have the moon circle the Earth. It is possible to replicate a solar eclipse and a lunar eclipse by observing the light and shadow caused by the placing of the Earth and moon in relation to the sun (or to the torch or flashlight in our case).

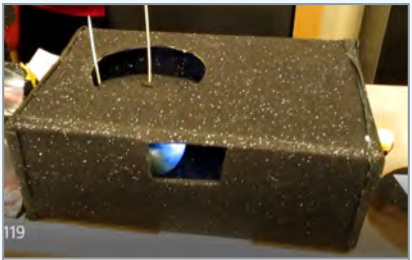
So what happened?

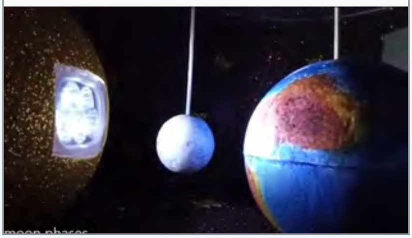
This model clearly demonstrates what happens during a solar eclipse and a lunar eclipse.



What next?

- Build another space box, this time with a hole cut out for a torch/flashlight on the side of the box and a rectangular viewing hole on the side of the box.
- Paint a polystyrene ball as a model of the Earth.
- Insert the Earth into the box. Push a skewer into the Earth and extend this skewer through the top of the box.
- While twirling the skewer observe the light that falls on the model of the Earth.
- This model shows why our planet has day and night at different times in different countries and places on Earth.



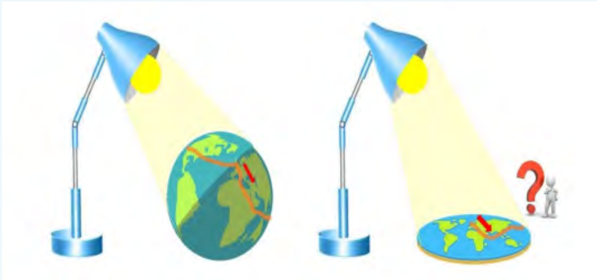


Showing that the earth is not flat

Greece

Background

A number of ancient cultures believed that the Earth is flat. Here is one very simple demonstration to show that the Earth must indeed be spherical in shape.



You will need:

- ✓ A globe of the Earth and a 2D representation of the Earth (a map)
- ✓ Two lamps

Follow these steps:

1. Shine a lamp on the globe. You can easily see that some areas of the Earth are in (artificial) daylight while other parts of the globe remain in darkness.
2. If the Earth was flat, then when the light shines on the 2D version of the globe it will be obvious that all countries would be in daylight at the same time.

So what happened?

We know that different parts of the Earth have different time zones and that while it is day time in some parts of the Earth, it is night time in other places. This happens because the Earth is spherical in shape. It would not be the case if the Earth was flat.

Earth and Space

Expansion of the Universe

Poland

Background

Introducing students to the expansion of the universe and 'The big bang theory' can be challenging. This balloon activity can be a visual aid to help with understanding.

You will need:

- ✓ 2 balloons
- ✓ 1 marker to write on the balloons

Follow these steps:

1. Show students the deflated balloons.
2. Place random marks/dots on the both balloons, as seen in image.
3. Explain that each mark on the balloon represents galaxies in the universe.
4. Ask students to watch what happens each mark on the balloon when it is blown up.
5. Slowly blow balloon up 1 balloon only
6. The second balloon to be left deflated so it can be used as a comparison in discussions
7. Hold the inflated balloon up and discuss with students the distances between the marks now that the balloon is inflated.
8. Describe to students the expansion of the universe using the marks on the balloon.

So what happened?

'The Big Bang' is a theory we use to explain the start of the expansion of our universe. It was not an explosion where everything gets scattered from a single point. 'The Big Bang' was the creation of matter and space, and it is this space that is expanding.

The marks on the balloon are not moving as the balloon is inflated, the spaces between the marks are. So inflating the balloon is modelling what is happening in our universe. The marks represent everything that exists in the universe. So as it is expanding so to are the spaces between the marks.

This balloon activity is only a model that helps students visualise some aspects of what is happening in our real universe

What next?

Research the work by Edwin Hubble in 1929 who discovered that the further away a galaxy is from us the faster it was receding from us.

Radio Astronomy in Schools

Ireland and Portugal

Introduction

The activities featured on the following pages can be used as a TY module or embedded along with the Leaving Certificate physics syllabus.

The full activities and background information can be accessed the project Padlet by scanning the QR code or by using the following link:

https://padlet.com/maireduffy13/lil41e7zi0uccajc

SCAN ME

1. Building an astronomical telescope
2. Radio frequency interference detectives
3. Observing radio waves with an SDR
4. Using Pictor Telescope to detect the 21 cm hydrogen line
5. Itty Bitty Radio Telescope

6. Constructing a horn antenna: https://padlet.com/maireduffy13/lil41e7zi0uccajc/wish/2076007778

Further information may be found here on the Padlet site.

Earth and Space

1. Building an Astronomical Telescope

Ireland and Portugal

Background

An astronomical telescope is used to observe distinct images of heavenly bodies.

It is a refracting telescope which consists of 2 lenses, the objective lens O of large focal length (f_o) and large aperture and the eyepiece E which has a small focal length (f_e) and small aperture.

In this activity you will make a Keplerian telescope which consists of two converging lenses (bi-convex) as this gives you a wider field of view when looking at the moon for example.

You will need:

- ✓ 2 bi-convex lenses with different focal lengths
- ✓ Two mailing tubes/ strong card
- ✓ Scissors
- ✓ Duct tape

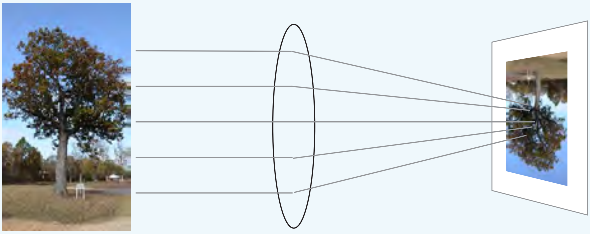
Find Approximate Focal Length:

Measure the approximate focal length of the lens by focusing a distant object onto a screen and measuring the distance from the lens to the screen using the metre stick.

Repeat for the second lens and record both focal lengths.

Focal length 1 = _____ cm

Focal length 2 = _____ cm



Magnification:

The eyepiece lens will be the shorter focal length (f_e).

The objective lens will be the longer focal length (f_o).

The magnification (M) of your telescope can be calculated using the formula:

$$M = \frac{f_o}{f_e}$$

Optics Ray Diagram:

Draw a ray diagram showing what you expect to happen as the light passes through the objective lens and then the eyepiece lens into your eye.

Check your work and calculations using the simulation:

https://www.walter-fendt.de/html5/phen/refractor_en.htm

Method:

1. Check your smaller tube slides neatly into the larger tube (or create tubes using stiff card).
2. The length of each tube should be longer than the focal length of each lens and the diameter should be slightly bigger than the lenses.
3. The smaller tube will be the eyepiece and the longer tube will be the objective.
4. Decorate your tubes by covering them in duct tape or paint.
5. Cut a small circle of card the same diameter as the end of the smaller tube.
6. Draw another circle on this card and then cut it out to create a circular frame for the lens.
7. Attach the shorter focal length lens (fe) with tape to this circular frame and then attach the frame to the end of the tube with tape.

8. Repeat for the longer tube using the longer focal length (f_o).
9. Slide the shorter tube inside the longer tube and your Keplerian telescope is ready for use.
10. Locate a distant object outside the window of the class and adjust your telescope by sliding the tubes until the object comes into focus.
11. Try using it at night to look at the moon and the night sky. Locate what you want to view and then point your telescope at the moon/star/satellite and adjust until they come into focus. You will need to hold your telescope very steady.

What Next?

Use the link below to look at some celestial bodies. Try changing the focal length and see how that changes the object being viewed.

https://www.stelvision.com/en/telescope-simulator/

Use the link below to look at some more celestial bodies. Use the search bar to search for various nebula or planets e.g. Orion nebula, Crab nebula, Butterfly nebula etc.

https://telescopius.com/telescope-simulator

Earth and Space

2. Radio frequency interference detectives

Ireland and Portugal

Background

Astronomers use the entire electromagnetic spectrum to observe a variety of things. Radio waves and microwaves – the longest wavelengths and lowest energies of light – are used to peer inside dense interstellar clouds and track the motion of cold, dark gas. Radio telescopes have been used to map the structure of our galaxy while microwave telescopes are sensitive to the remnant glow of the Big Bang. Most of the radio part of the EM spectrum falls in the range from about 1 cm to 1 km, which is 30 gigahertz (GHz) to 300 kilohertz (kHz) in frequencies. The radio is a very broad part of the EM spectrum.

In 1836 Michael Faraday invented the Faraday cage. In Faraday's studies and experiments regarding charge, magnetism, and their interaction, he found that charge on a conductor only resided on the outer surface. This phenomenon produces an interesting result: any and all noise with an electronic component that exists outside the cage is completely cancelled within that space. This is also a two-way street: any noise created inside the cage is prevented from escaping to the outside world. Keep in mind that breaks in the cage cause gaps that allow for penetration by outside electromagnetic (EM) fields. For a wire mesh, the penetration of EM radiation is limited to oscillations that have wavelengths shorter than twice the diameter of the opening. So a 1 cm opening allows 2 cm and shorter wavelengths, which correspond to 150+ GHz noise, hence radio waves and microwaves would be blocked.

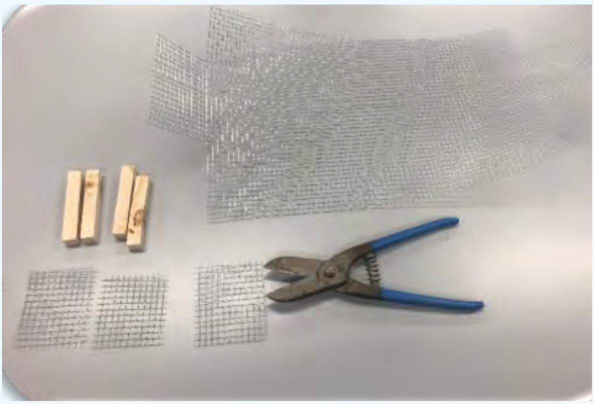
There are international frequency designations which are designed to prevent one type of station from interfering with another for example TV stations and police radio frequencies. A number of frequency bands are allocated to radio astronomy as they work with extremely sensitive equipment. Transmitters in orbiting Earth satellites, are located overhead, precisely where radio astronomers must aim their telescopes to study the Universe and therefore can cause problems.

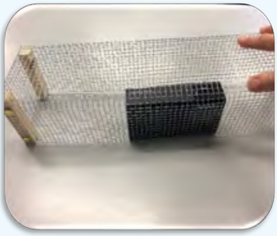
Equipment:

- ✓ Wire mesh
- ✓ Wire cutters
- ✓ Wood
- ✓ Staple gun
- ✓ AM/FM radio or electrosmog detector (can be bought online)
- ✓ Battery
- ✓ Bare wire
- ✓ Electronic devices to test e.g. remote controls, power tools, mobile phone

Faraday Cage:

1. Measure out 32 cm × 62 cm (approximately) of rectangle metal mesh.
2. Cut out the rectangle with heavy duty scissors/wire cutter.
3. Cut four lengths of wood strips, approximately 8 cm.





4. Fold the mesh to form a rectangular box and cut the excess away.
5. Begin stapling the metal mesh to wood strips to form an open rectangular box.

Note: These are approximate dimensions used to enclose a small AM/FM radio and any size box open or closed will work.

Method:

1. Turn on your radio.
2. Choose "AM," and tune it to a frequency low on the dial where there are no stations.
3. Note what you hear.
4. Record the dial setting: _________ kHz
5. Tape one end of the wire to the positive end of the battery (the wire should be bare). Tape the other bare end of the wire to the negative end, but only briefly. Do this close to the radio.
6. Note what you hear.

Dial Setting (kHz)	Interference Level (Range of 1 to 5, quiet to loud)

7. Change the dial on the radio, and repeat the battery experiment.
8. Does the interference get louder or quieter?
9. You will now try to look for interference in the lab. What do you think might cause interference?

So What happened?

When electrical items such as the phone, remote controls and the batteries are brought near the radio you will hear a noise or static caused by the electrical interference. This happens more clearly with AM and not FM. This is because information transmitted in an FM signal is through varying frequency and not the amplitude as in an AM signal. If the frequency of these other waves from the electrical sources overlap with the intended channel in the radio, the AM receiver can pick them up as changes in amplitude, resulting in noise or static.

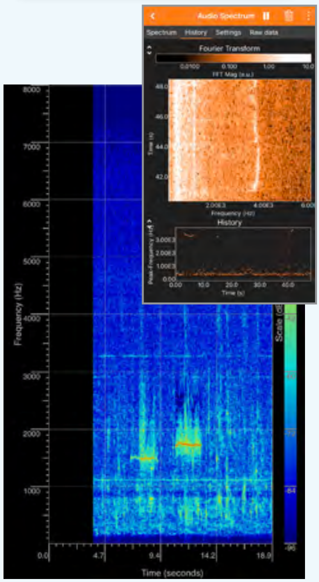
When you place the Faraday cage over the radio the signal drops as it gets blocked out.

What next?

Download any spectrum analyser and use it to record/ take a picture of the interference e.g. Phyphox or Spectrum view (Oxford wave research)

Investigate how a transmitter and receiver work using the PhET simulation:

https://phet.colorado.edu/en/simulation/radio-waves



Earth and Space

3. Observing Radio Waves with an SDR

Ireland and Portugal

Background:

SDR is a software defined radio that can be used as a cheap radio telescope for radio astronomy to detect the Hydrogen line, meteor scatter, sudden disturbances in the ionosphere (SIDs) and Pulsar observing.

It is generally used in conjunction with an appropriate antenna (length and type depends on what you want to detect), a low noise amplifier (LNA) or low noise block down converter (LNB) and software such as GNU radio or Ubuntu to integrate the signal and display in graph form.

In this activity we will be investigating radio waves emitted from car key fobs using an RTL-SDR dongle.

Car key fobs work by using a built-in radio frequency identification system (RFID). It uses an electromagnetic field to locate or identify stored information called tags. The tag provides the information to the remote device using radio frequencies. It contains a microchip that has an assigned frequency that communicates with the reader in the car. Each car key fob carries a unique code.

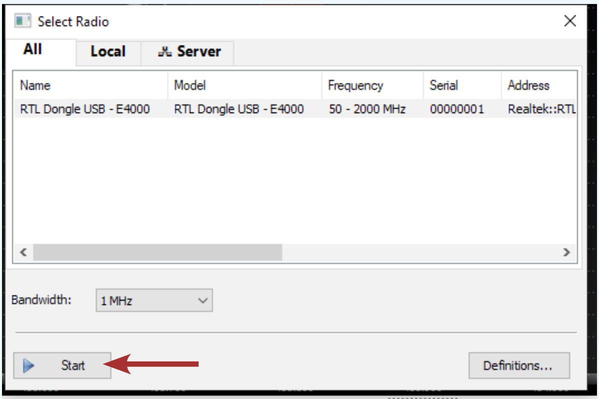
European cars operate at a frequency of **433.92 MHz** and American and Japanese cars operate at a frequency of 315 MHz.

Equipment:

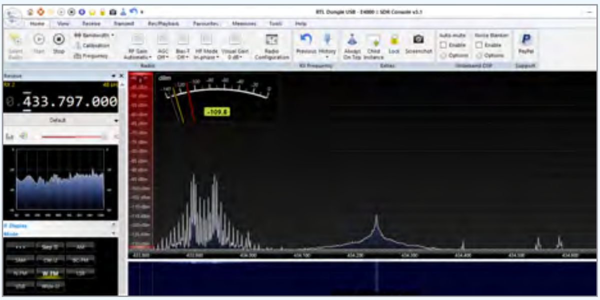
- ✓ RTL-SDR (e.g. https://www.nooelec.com/store/nesdr-smart-xtr-sdr.html US 39.95 dollars)
- ✓ Copper wire for antenna or antenna kit bundle (e.g. https://www.nooelec.com/store/sdr/sdr-receivers/nesdr-smartee-xtr.html US 49.95 dollars)
- ✓ Car keys (with wireless remote control fob)
- ✓ Laptop (connect SDR to download recommended software that comes with it.)

Method:

1. Connect RTL-SDR to laptop.
2. Open up the SDR software.
3. Select RTL dongle.



4. Press start.
5. You will hear noise and see the corresponding graph displaying the signal.
6. Change the frequency you wish to detect to **433.797 MHz** to detect the signal from your car key by clicking on the number in the r**eceive box.**
7. Press your car key and note the frequency detected. Take a screenshot / picture.
8. Repeat for different car keys.



So what happened?

Different brands of cars had a unique frequency peak which could clearly be seen in the graph.

What next?

Try various other items that transmit radio waves such as a remote controls for toy cars.

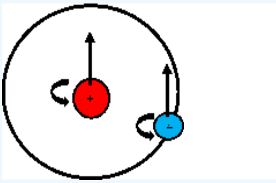
Earth and Space

4 Using Pictor telescope to detect the 21 centimetre hydrogen line

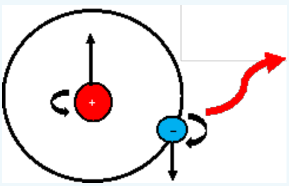
Ireland and Portugal

Background:

The hydrogen atom is composed of a positively charged particle, the proton, and a negatively charged particle, the electron. These particles have some angular momentum called spin in quantum mechanics. When the spins of the two particles are antiparallel, then the atom is in its lowest energy state (ground state). When the spins are parallel, the atom has a tiny amount of extra energy (excited state).



Excited State (proton and electron spins are parallel)



Ground State (proton and electron spins are anti-parallel)

Hydrogen atoms in space are in their ground state. If there are collisions between particles then these hydrogen atoms can move to an excited state. According to the rules of quantum mechanics, such atoms radiate their acquired energy in the form of low-energy photons that correspond to a wavelength of 21 cm, or a frequency of 1,420 megahertz ($c = f\lambda$). 1,420 MHz is in the radio wave range. This is know as spin-flip transition.

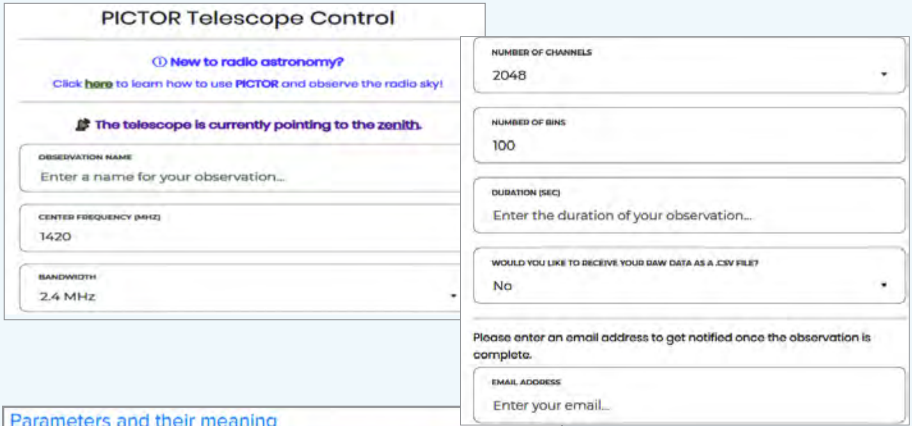
This radio radiation was theoretically predicted by the Dutch astronomer H.C. van de Hulst in 1944 and was experimentally detected by American physicists Harold Ewen and Edward Purcell at Harvard University in 1951. There is so much hydrogen in the Milky Way Galaxy that 21-centimetre hydrogen emission is easily observable. The 21-centimetre radiation readily penetrates the clouds of interstellar dust particles that obstruct optical observations deep into the galactic centre and thus allows the mapping of the galaxy's spiral structure. This spin-flip transition is also used in MRI (magnetic resonance imaging).

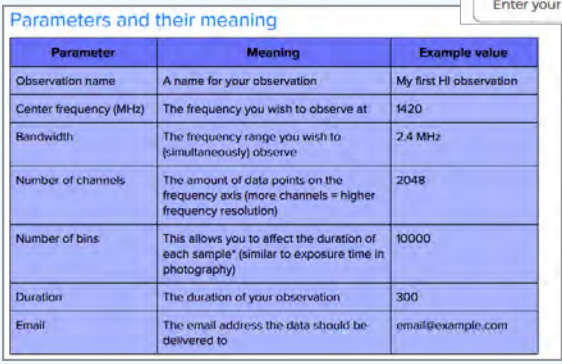
Method:

1. Go to https://pictortelescope.com/
2. Click on 'observe'.
3. You will get the screen shown top facing page.
4. Enter observation name as: Student name, School name, observation number.
5. Set duration of observation to 300 seconds (maximum time).
6. Enter email address and submit.

Note: Image from: https://pictortelescope.com/Observing_the_radio_sky_with_PICTOR.pdf

7. Go to https://stellarium-web.org/ or download the Stellarium app. Search Athens, Greece where Pictor is located.
8. Select **azimuthal grid** and **constellations** and drag the screen to view the zenith, sky directly above.





Parameters and their meaning

Parameter	Meaning	Example value
Observation name	A name for your observation	My first HI observation
Center frequency (MHz)	The frequency you wish to observe at	1420
Bandwidth	The frequency range you wish to (simultaneously) observe	2.4 MHz
Number of channels	The amount of data points on the frequency axis (more channels = higher frequency resolution)	2048
Number of bins	This allows you to affect the duration of each sample* (similar to exposure time in photography)	10000
Duration	The duration of your observation	300
Email	The email address the data should be delivered to	email@example.com

From: https://pictortelescope.com/Observing_the_radio_sky_with_PICTOR.pdf

9. Take a screenshot so you can record what the Pictor telescope was pointing at during the 300 seconds.
10. After 300 seconds check your email for the data collected from Pictor telescope.
11. Repeat several times over the course of the next few weeks, entering screenshots of the night sky and graphs emailed to you in a PowerPoint presentation.

Note the time and date taken on each slide and any observations.

12. Compare the frequency of the Hydrogen line to the reference line and identify if it is blue or red shifted.

Earth and Space

13. Calculate the relative velocity of the telescope and hydrogen cloud using the Doppler equation:

$$v = c\left(\frac{f_e - f_o}{f_o}\right)$$

Where;

v = relative velocity

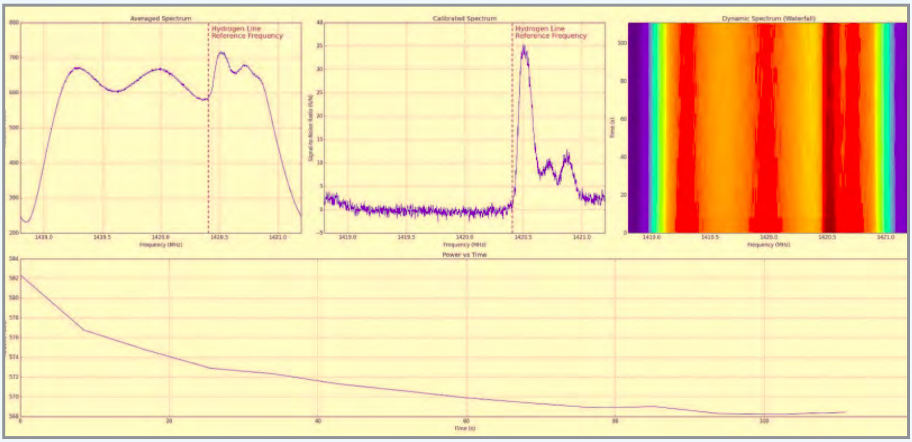
c = speed of light (3×10^8 m s^{-1})

f_e = emitted frequency (1420.4 MHz)

f_o = observed frequency (peak from your graph)

Sample Data Collected

The image below is the result of a 2-minute observation with PICTOR (when the galactic plane is in the beam):



Top left: Averaged Spectrum, top centre: Calibrated Spectrum, top right: Dynamic Spectrum (Waterfall), bottom: Time series (Power vs Time plot).

The top left plot is the averaged spectrum, showing the average power (intensity) for every frequency. The top centre plot is the calibrated spectrum, which is identical to the averaged spectrum, with the effects of the receiver removed (so the noise floor becomes flat and the peaks become more distinct). The top right plot shows the dynamic spectrum (waterfall) (a Power vs Frequency vs Time graph displayed as a 2D plot with a colour map indicating Power) and the bottom plot shows the average power vs time plot.

We see three curvy bumps in the averaged spectrum. This is due to the receiver's bandpass shape (different sensitivity at each frequency) and should not be mistaken for radio emissions.

As you can see, there are three distinct peaks on the calibrated spectrum at around 1420.5, 1420.7 and 1420.85 MHz. This is the hydrogen line, and it's blue-shifted (frequency > 1420.4 MHz), meaning the source is approaching us! We've just detected 3 unique spiral arms of our own galaxy, and by conducting another observation (i.e. when the other side of the Milky Way is in the beam), we should expect to see differently Doppler-shifted line(s), potentially indicating more spiral arms, Doppler-shifted (red-shifted or blue-shifted) to a different degree. This proves that beyond any doubt, we do indeed live in a spiral galaxy!

Remember

The Doppler effect is the apparent change in frequency due to the motion of the object relative to the observer. In astronomy if a star, for example, is moving away from the observer it is red shifted but if it is moving towards the observer, it is blue shifted.

What next?

Use the following link to measure the velocity of various different galaxies using the hydrogen alpha line.

https://depts.washington.edu/astroed/HubbleLaw/measurements.html#redshift

5. Itty Bitty Radio Telescope

Ireland and Portugal

Background:

Radio telescopes look toward the heavens to view planets, comets, giant clouds of gas and dust, stars, and galaxies. By studying the radio waves originating from these sources, astronomers can learn about their composition, structure, and motion. Radio astronomy has the advantage that sunlight, clouds, and rain do not affect observations.

Since radio waves are longer than optical waves, radio telescopes are made differently than the telescopes used for visible light. Radio telescopes must be physically larger than an optical telescopes in order to make images of comparable resolution. But they can be made lighter with millions of small holes cut through the dish since the long radio waves are too big to "see" them.

The satellite dish is a 12,000 MHz Itty Bitty Radio Telescope with a range of 12,220 MHz to 12,700 MHz. Note the radio spectrum ranges from 3 kHz to 300 GHz.

We will use the satellite dish to:

1. Detect the sun.
2. Detect blackbody radiation such as 300 K trees, buildings, people, when viewed against blank sky.

It must be used outside or through a large window. The dish itself acts like a concave mirror where it collects the radio waves and focuses them onto the LNB (low noise block down converter) which in turn amplifies the signal and filters out the noise.

Note: The Itty Bitty Telescope was designed by Society of Amateur Radio Astronomy Members Kerry Smith and Chuck Forster. It has been incorporated into the NRAO Navigators Program—an outreach program to promote radio astronomy.

Equipment:

- ✓ T.V. satellite dish with LNB attached preferably (can be obtained from zero waste sites).

- ✓ Two coaxial cables (Some satellite dishes may have their coaxial cable still attached; in that case only one would be needed)
- ✓ Satellite finder e.g. https://www.satellitetv.ie/satellite-finder-meter-ireland

- ✓ 12 V AA battery holder i.e. holds 8 AA batteries (can be bought online.)

- ✓ Soldering iron and solder (electrical duct tape can be used either)
- ✓ Wire stripper

Building your Simple Radio Telescope:

Connect the coaxial cable from the LNB of your satellite dish to the satellite finder on the side labelled LNB/ Satellite.

Connect the second coaxial cable to the satellite finder on the side labelled Receiver/ Power.

Take the end of this second coaxial cable and use the wire stripper to reveal the metal core and the braided copper shield.

Solder the metal wire core to the positive wire of the battery pack and solder the woven copper shield to the negative wire of the battery pack. If you choose not to solder then twist the wires from the battery pack tightly around the core and the braided shield, separately, and use electrical duct tape to hold them in place.

Insert eight AA batteries into the battery pack.

Your simple radio telescope is now ready to use.

Method:

Turn the satellite dish to the blank sky (3 K) and adjust the gain of the satellite finder to zero. Listen to the speaker or look at the meter. Now turn it towards the ground (300 K) and see/hear the difference.

Reading on satellite finder =
__________ dB~

Now turn the satellite dish towards the Sun.

Reading on satellite finder =
_________ dB

Find the tree line and gaps between trees.

Reading on satellite finder pointing at tree =
_________ dB

Reading when pointing at gap between trees =
__________ dB

Close your eyes and try to find trees or buildings by listening to the satellite finder.

As long as the dish is not obstructed, nearly anything can be detected with a radio telescope. Having a temperature of 300 K, your reading will be similar to the ground if you fill the beam.

Note the effect of walking in front of the satellite dish or waving your hand in front of it.

So what happened?

The satellite finder will make a noise when switched on and give a reading of around 2 or 3 dB but when it is pointed to the sun there will be an increase in the signal even if it is hidden by clouds.

This could also be used in conjunction with an SDR to give a graph reading.

What next?

Many geo-stationary satellites are in orbit above the Earth and many transmit radio signals. Much of this might be regarded as radio noise or radio pollution.

Note: the Sun is a broadband transmitter whereas a satellite is a very narrow beam transmitter, so all its energy is given off in a very narrow band.

See if you can locate any satellites in the sky.

Use https://in-the-sky.org/satmap_worldmap.php# to identify any possible passing satellites.

Exploring the formation of craters

Spain

Background

A crater is a large bowl-shaped hole in the ground or on a celestial object. They are usually caused by an explosion or the impact of a meteorite.

You will need:

- ✓ Cardboard box lid
- ✓ Flour
- ✓ Brown sugar
- ✓ Sprinkles
- ✓ Hot chocolate powder
- ✓ Stones, rocks or balls of various size, shape, mass
- ✓ Ruler
- ✓ Newspaper (to contain any mess)

Follow these steps:

1. Fill your box with 2 cm of flour (the flour represents the planet's or moon's surface. It is likely to blast out upon impact.
2. Sprinkle brown sugar or 'sugar sprinkles' to represent minerals and rocks in the Earth's surface
3. Level the surface with a ruler
4. Dust the surface with hot chocolate powder to represent the surface of the planet/moon
5. Drop the balls from different heights
6. Record the height and the size of craters
7. Record if 'minerals' from the surface were ejected
8. Note if the crater had objects from under the surface ejected by the impact and if there was a pattern
9. Compare the results

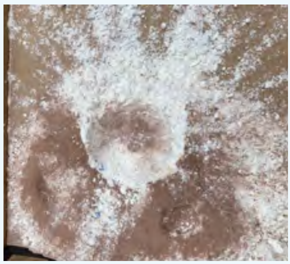
So what happened?

- Craters of various size are formed.
- Craters of various depth are formed.

- Some craters cause objects to be ejected from under the surface.
- Some larger, deeper craters form ray patterns (see photo).

What next?

1. Try using sand under water to investigate the pattern of crater formation when the surface is under water. This might hint at the previous possible presence of water on a planet where there are fewer craters present.
2. Students could compare their findings to pictures of craters on the Moon or on Mars.



Earth and Space

EO Browser

Ireland

Background:

During Covid 19 lockdown in Ireland, we had a unique opportunity to measure air pollution levels when people could not and did not move around and drive this car longer than 5 km.

Prior learning included:

- weather and climate,
- greenhouse gases and air pollution.

We used real world satellite data from EQ Browser and https://aqicn.org/map/europe/ or https://www.epa.ie/environment-and-you/air/ to gather data and analyse trends and pattern in air pollutant levels and link the trends to human behaviour.

You will need:

✓ class of 24 students

✓ one to one device/tablet (or a device per pair)

✓ Wi-Fi or access to Internet

Follow these steps:

1. Divide the class into four groups of 6 who are each going to investigate the changes in one air pollutant:

- Groups 1 & 2 - NO_2
- Groups 3 & 4 - SO_2
- Each of the students will use EQ Browser to look at satellite data for the same day and month in 2019, 2020 and 2021.

So, student X in group 1 measures NO_2 on odd days in January and February 2019, 2020 and 2021 (if available).
Student Y in group 2 measures NO_2 on even days in January & February 2019, 2020 and 2021 (if available).

2. Ideally between group 1 & 2 all days and months of the year are analysed.

- Students then get average levels of NO_2 or SO_2 for each day and month (if possible)

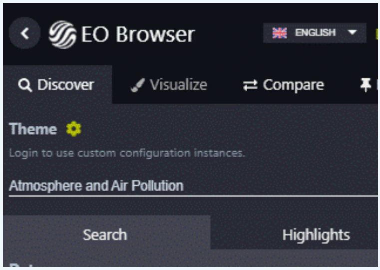
3. Trends and patterns between the years 2019,2020 and 2021 are compared.

How to use EQ Browser

Visit EQ Browser – Sentinel Hub EQ Browser (sentinel-hub.com)

1. Select education mode
2. Type in **Dublin**, Ireland (or your own location)

3. Select the theme of **Atmosphere and Air Pollution**



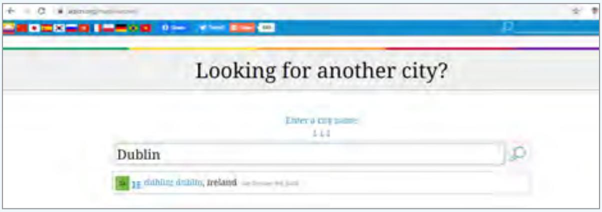
4. Select **Sentinel-5P** as the satellite you want data from
5. Then click which **pollutant** you are measuring : (Nitrogen dioxide or Sulfur dioxide) from the list:

- AER AI (Aerosol Index)
- CH_4 (Methane)
- Cloud
- CO (Carbon monoxide)
- HCHO (Formaldehyde)
- NO_2 (Nitrogen dioxide)
- O_3 (Ozone)

- SO_2 (Sulfur dioxide)

6. Select the **date** you want data from and click **search**
7. Students can pin data to compare or save as a picture for comparison later.

Now compare the data found with EQ Browser to the summary



and overview on https://aqicn.org/map/europe/

Note: The daily AQI is based on the 24 hours average of hourly readings.

1. Type in your city on the website here:
2. Look at historical data for your city

Note: Cities vary for what data is available and for how far back historical data goes. For example, Prague currently has 43 months available and the data available includes NO_2 and SO_2. Some stations only record particulate matter (PM 2.5 and PM 10).

3. Compare your averages to the averages for each month and year here.

So, what happened?

Students learned to handle real world data.

EQ Browser is time consuming. Measuring daily averages is important to avoid daily blips. Using daily data figures on their own is not sufficient. Averages for days and months are needed.
The air quality index allowed students to compare their averages to real pre calculated averages (below and next page).

SO_2 daily averages in Dublin 2019, 2020 & 2021

NO_2 daily averages in Dublin 2019, 2020 & 2021

Sample student results and conclusion:

NO_2 levels

NO_2 is a highly reactive gas. Fuel is the main cause of this pollutant circulating in the air. High levels of Nitrogen dioxide can have damaging effects on vegetation, restricting crops from growing. It can also affect humans by harming the lungs. From our research we can see that the levels of NO_2 were higher in 2019 compared to 2020. We believe this is because people were less active in 2020 due to the COVID-19 Pandemic. For example, people were using vehicles less, because of the restrictions and vehicles pollute the air with NO_2.

SO_2 levels

There were fewer days with high levels of SO_2 from March to July 2020 than there was during the same months in 2019. SO_2 is emitted by the burning of fossil fuels — coal, oil, and diesel — or other materials that contain sulfur. Sulfur dioxide is also a natural by-product of volcanic activity. However, there is no volcanic activity in Ireland so the reduction we see is likely to be related to the lockdown period due to COVID 19.

What next?

Action:

Students can look at ways they can use this data to encourage people to change their habits. They can identify obstacles and barriers to walking and cycling and take action to remove these barriers e.g., lobby your local county council to improve cycle lanes so that less students drive to school, look at decreasing the mass of school bags so that students could walk to school.

Fairytales where problems are solved with physics experiments

Prague

Background

Jack needs to get up the beanstalk. Students have to devise a way of getting safely up to the Giant's castle using only paper, straws and a string!

You will need:

- ✓ thick printing paper (160 g)
- ✓ markers,
- ✓ string, straw,
- ✓ beads
- ✓ duct tape
- ✓ scissors

Follow these steps:

1. Draw Jack on cardboard and colour and cut out or cut out as shown below.
2. Cut about 1 m of string or thick thread.
3. Cut two equal pieces of straw, about 3-4 cm long
4. Turn the climber's bottom side up and glue the two pieces of straw about halfway up the body using duct tape.
5. Push the string through one straw upwards and then through the other straw downwards. A bend is created at the top.
6. Tie beads or make loops on both ends of the string.
7. Hang the string in the middle on a window or door handle.
8. To make the climber climb, pull down on one side releasing the other, then pull down on that other side releasing the first side… and continue alternating.
9. Once the climber has climbed up to the doorknob, release both ends of the string

So what happened?

Each time the string is pulled in one straw, the string tightens, and the friction holds it against the straw. Friction is created because the string is pushing against the inside of the straw.

The other side is slack, and the toy rotates sliding up the loose string.

When this side is then tightened the string grips again, the toy rotates in the opposite direction, and thus begins its climb.

As soon as the strings are released, they stop pushing against the straws, so the friction is less and the climber slides down. And we can climb again.

If we turn the climber inside out, we can see how this process works..

What nest

Adding a pivot makes the model more versatile. See: https://sciencetoymaker.org/the-climbing-creature/make-climbing-creature/

General

Butterfly's journey

Czechia

Background

This project focuses on cooperation between children of different ages and interests and students with special needs. The project includes a wide variety of activities and is integrated into different school subjects. This topic is divided into different fundamental educational areas and checkpoints which take place outdoors in the garden, park or forest.

You will need:

- ✓ Caterpillars
- ✓ Butterfly garden or caterpillarium
- ✓ Craft materials: paper, card, glue, laminator, filter paper, markers, scissors, pipe cleaners, straws, tissue, laminated pictures of butterflies cut into halves, squared paper, glass of water, paper clips, toothpicks, sticky tape
- ✓ Short plumbing pipe with a stopper for both ends, cork or styrofoam, small magnet, paper clip

Growing butterflies

Follow these steps:

1. Find caterpillars on nettles or cabbages.
2. Place them in the butterfly garden or caterpillarium.
3. Feed them cabbage leaves or nettles. Keep these leaves moist and change regularly.
4. Observe and record as the caterpillars become chrysalises and emerge as butterflies. Record the daily temperatures as the butterflies emerge.
5. Release into the wild.

Ordering lifecycle phases

Follow these steps:

1. Laminate two nettle leaves, a picture of a cocoon, a butterfly and some arrows.
2. Students will put these into the correct sequence to illustrate the lifecycle of a butterfly.

Art: Making paper models of caterpillars.

Follow these steps:

1. Cut out a leaf shape. Roll a rectangle of paper into a straw shape and another into the shape of a semi-circular bridge. Roll a length of tissue into the shape of a caterpillar. Glue one end of the caterpillar to the bridge and the other end to the straw shape. The caterpillar can be moved by pushing the straw shape through the bridge shape, on the leaf.
2. Make a caterpillar as shown above by folding and cutting out a caterpillar from a rectangular piece of paper. Move the caterpillar by blowing it with a straw.

Mathematics: Practising axial symmetry and logical reasoning.

Follow these steps:

1. Have students match two parts of a butterfly by comparing the patterns of both halves. Can the students identify each butterfly?
2. Given a drawing of half a butterfly on squared paper, can the students complete the other half of the picture?

Using chromatography to make colourful butterflies.

Follow these steps:

1. Cut out two circles with a diameter of approximately 15cm from filter paper.
2. In the middle of each circle draw a thick line in black, green or brown marker.
3. Fold the circles into a cone shape and place them into a glass filled with approximately 2cm of water so that the dark line doesn't get wet.

4. The water that is absorbed by the filter paper divides the colour of the marker into individual components and colours.
5. Dry the paper.
6. From the dried paper circle, fold butterflies wings.
7. Use pipe cleaners to make the bodies and antennae of the butterflies.

Flying Butterfly.

Follow these steps:

1. Close one end of a short plumbing pipe with a stopper. Into the pipe put a piece of cork or styrofoam that has been attached to a small magnet. Fill the pipe with water and use a stopper to close the other end of the pipe.

2. Draw and cut out a paper butterfly.
3. Attach a paper clip.
4. Now the butterfly can fly up and down the plumbing pipe as the cork or styrofoam inside floats on the water in the pipe. When you flip the pipe upside down, the cork/styrofoam and magnet will float on the water as it rises in the pipe.

Butterfly paper weight

Follow these steps:

1. Draw and cut out a paper butterfly. You can laminate it if you like.
2. Attach a paper clip to both of the wings.
3. Stick a toothpick to the underside of the butterfly with sticky tape.
4. Balance the butterfly on your finger or on a toothpick.

General

Graphing stories

Sweden

Background

A graphing story is a classroom routine that can be used to develop secondary school student's knowledge of graphs, relationships and mathematical models.

It was pioneered by the American math teacher Dan Meyer. Students see short films of everyday events, and then use graphs to describe them. In the ensuing discussion, there is a natural need to introduce mathematical concepts such as linear relationship, proportionality, exponential function and derivatives.

The idea is simple. Students are shown a short film of an everyday event, such as a glass filled with water. The students are then prompted to sketch a graph that describes the event, e.g. how they think the water's height, the salmon's temperature or the speed of the swing changes over time. The students' sketches become the starting point for a classroom discussion, which ends with the correct graph being displayed.

You will need:

- ✓ Graph Paper
- ✓ Graphing paper: Water-filling glass water
- ✓ iPads (optional)

Follow these steps:

1. Show the first part of the film to the students. Pause after the coordinate system has been displayed and explain to the students that they are going to draw a graph that describes the event. Tell them that they don't have all the information needed to draw the graph. That means that they will have to make some assumptions and estimates. In the graphing story above, for instance, the students need to estimate the height of the water.
2. Distribute graph paper or have students draw a coordinate system in their notebooks.
3. Start the film again, so that the students can see the event once more, and give the students time to draw the graph.

So what happened?

Walk around the classroom and follow the students' work. Select some graphs that you want to compare in the classroom discussion.

Discuss some of the students' graphs. This can be done by letting students describe their graphs orally, while you draw them on the board or by letting the students draw their graphs on the board or take pictures on iPads.

Compare students 'graphs and help them formulate the graphs' similarities and differences. At the same time, it introduces important mathematical concepts.

Restart the video and display the correct graph. Discuss similarities and differences between the correct graph and the students' suggestions.

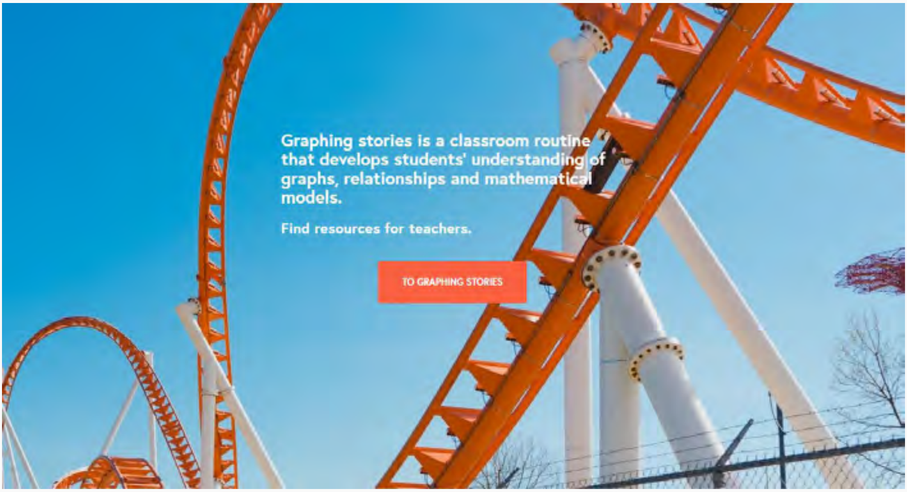
What next?

1. There are lots of ways to vary the work with graphing stories. For example, instead of drawing the graph that describes the event, students can choose between four graphs and justify their choice. That approach can make common misconceptions visible. In the description of most of the graphing stories, there are suggestions for such graphs
2. You can also follow up the graphing stories with questions. In the example of water being poured into a glass, some such questions could be:

   What is the equation of the line?

   How does the graph change if…

- the water is poured faster
- the water is paused for a few seconds
- the glass is higher
- the glass has a larger diameter



3. Working with the same graphing story in different year groups is also possible. In lower secondary school, for example, students can describe how the speed of a swing changes over time when it is in motion. In upper secondary school, in contrast, students can be given the task of finding the expression of the trigonometric function that describes speed as a function of time.
4. The work with a graphing story can have different focuses. Sometimes you can be interested in the students sketching the graph without caring about grading on the axis. Alternatively, you can distribute coordinate systems with a suitable scale on the axis or let the students set out a suitable scale themselves.

Why use graphing stories?

There are several reasons to work with graphing stories.

By working with graphing stories, students experience how graphs describe everyday phenomena. It connects mathematics to students' reality and allows them to see the usefulness of mathematics.

The classroom discussion of the students' graphs creates a need to formulate what the students have drawn. That provides an opportunity to introduce important concepts, such as slope, linear, constant, growing, decreasing, etc. In upper secondary school, you can use graphing stories to discuss more advanced concepts, such as derivatives, inflexion points and maximum.

After working with several different graphing stories, a natural step is to compare the graphs and categorise them. This makes graphing stories an excellent tool for introducing and naming different types of relationships, e.g. linear, quadratic, periodic and exponential.

In lower secondary schools in Sweden, it is common to work mainly with linear relationships. With the help of graphing stories, you can let students experience that there are other types of relationships whose graphs are not straight lines.

Sketch graphs of everyday events is a common task in many textbooks. Letting students see a film of the event makes it more concrete, making it easier for students to draw the graph. In addition, the connection between the event and the graph becomes stronger.

Find out more:

Read more and access resources at

www.matemagi.com

General

Making coloured paints

Finland

Warnings:

Do not store ready paints or paintings in direct sunlight or even in a sunny place.

Always mix the colours well before using.

The colours are at their best when fresh, so it is advisable to use them as soon as possible.

You will need:

- ✓ Electric kettle / hot plate / microwave oven
- ✓ Water
- ✓ Turmeric powder
- ✓ Gum Arabic powder
- ✓ Baking soda (for orange colours)
- ✓ Decilitre (dL) cup
- ✓ Teaspoon
- ✓ Tablespoon
- ✓ Filtering fabric and a sift

Yellow

- 1 dL water (i.e, 100 cm^3)
- 4 teaspoons turmeric powder
- 4 teaspoons gum Arabic powder

Red

- 1 dL yellow colour
- 0,5 teaspoons of baking soda

Follow these steps:

Yellow

1. Boil the water.
2. Mix turmeric and gum Arabic well in a heat resistant container.
3. Add hot water little by little mixing all the while.
4. Let the solution cool down.
5. Filter and squeeze colour through fabric
6. Colour is also an indicator. Acidic solution is bright, while alkaline is darker.

Orange

1. You can also prepare orange by mixing yellow let it cool down. from turmeric and red from beetroot.
2. Prepare the yellow according to the instructions above. Mix baking soda in and boil the result in a microwave oven. Beware of boiling over! Mix and let it cool down.

Making snowflakes

Czechia

Background

This experiment helps students create their own snowflakes in the class-room!

You will need:

- ✓ A 500 mL empty water bottle
- ✓ Sewing pins
- ✓ Sponge
- ✓ Paperclips
- ✓ Length of cotton
- ✓ Salt and ice
- ✓ 1 litre jug (or styrofoam cups)
- ✓ Hot water
- ✓ Scissors
- ✓ Sellotape

Follow these steps:

1. Remove the label and cut the bottom off the bottle carefully about 2 cm from the bottom.
2. Put a small hole through the middle of the bottom of the bottle vertically (carefully).
3. Cut a length of cotton to fit inside the bottom of the bottle with a small hole in the middle.
4. Cut the sponge to fit inside the bottom of the bottle with a small hole in the middle.
5. Secure the sponge into the bottom of the bottle with sewing pins.
6. Thread the cotton through the sponge and lid hole so the paper clip would hang about 5-7 cm from the bottom lid. Secure with sellotape.
7. Place a mixture of crushed ice and plenty of table salt into the jug, stir well and secure the upturned bottle in the middle.
8. Soak the sponge in recently boiled water - (not dripping).
9. Secure the bottom of the bottle to the rest with sellotape. Make sure the thread and paperclip are not touching the sides/ bottom.

So what happened?

Watch and wait! (10-15 mins). The crystals will form in the bottom third of the bottle and can be visualised by the eye or with a microscope app on a mobile phone.

What next?

This experiment can be localised to the Irish curriculum under the strand energy and forces and strand units heat, materials and change.

For more details, contact Dr Samantha Ireland/ Dr Andy McConkey - QEGS Penrith UK

Emails:

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General

Paper helicopters

Czechia

Background:

Part 1: Paper helicopters

How do paper whirlpools work?

Although we call them paper helicopters, the following toys are in reality, whirligigs.

A whirligig is held in the air by rotating blades that are not actively spun by a power unit but are spun by the airflow.

We launch our paper helicopters from a height. They fall to the ground because of the force of gravity. There's a resistance of air against this motion. This drag force pushes on the angled parts of the vortices (like propellers) and makes the vortices spin.

You will need the following:

- ✓ template no. 1
- ✓ thick printing paper (160 g)
- ✓ paper clips
- ✓ scissors

Follow these steps:

How to make:

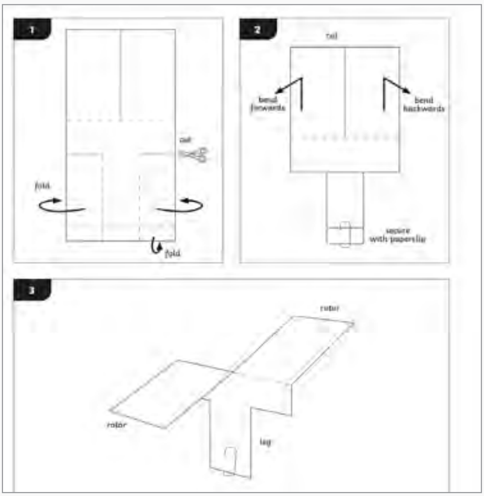
1. Print the template or draw it on thick paper.
2. Then cut along the solid lines and bend along the dashed lines.
3. Create the body of the swirl by folding the outermost rectangles over the middle rectangle and secure it with a paper clip, which also serves as a weight.
4. Fold the top ears propellers to one side each.
5. Grasp the helicopter with the propellers (they should be at an acute angle) and release it from the height.

So what happened?

The vortex falls and rotates.

We can increase the load, i.e. the number of paper clips, and observe the changes in movement. (At a certain number of paper clips, the whirligig stops rotating and falls down in free fall.)

If we change the propeller-ear bend, the whirligig rotates to the other side.



Secret message with lemon juice

Czechia

Background:

This experiment will allow students to play detective and make secret messages with DIY invisible ink made from lemon juice

They will be able to write messages or draw pictures in secret ink and then make them appear to see what they say!

You will need:

- ✓ Half a lemon
- ✓ Water
- ✓ Spoon
- ✓ Bowl
- ✓ Cotton bud
- ✓ White paper
- ✓ Hair dryer

Follow these steps:

1. Squeeze the lemon into a bowl. Add just 2 or 3 drops of water to dilute. This is just to make it clearer on the paper! Your invisible ink is now ready.
2. Take your invisible pen (your cotton bud) and dip it into the ink. Write or draw your message.
3. Leave to dry.
4. When you want to reveal your message, you need to apply a heat source. Either hold it near a lamp, iron it or place it in the oven. (I found the oven worked best). You do need to watch it carefully to ensure the paper does not scorch.

What happened?

Lemon juice oxidises (which means it reacts with oxygen) and turns brown when heated.

Diluting the lemon juice in water makes it harder to notice the invisible message on the paper.

General

Tricks with lemons - Experiment 1

Czechia

You will need:

- ✓ A conical flask
- ✓ a yellow balloon
- ✓ a teaspoon
- ✓ baking soda
- ✓ citric acid

Follow these steps:

1. Put two teaspoons of baking soda into the balloon.
2. Then pour 50 mL of the citric acid into a conical flask.
3. Thread the balloon on the neck of the flask and carefully pour the baking soda into the balloon.

So what happened?

The reaction of baking soda with citric acid produces carbon dioxide, which inflates the balloon. The reaction does not consume all baking soda and soda residue makes the solution in the flask alkaline.

Tricks with lemons - Experiment 2

Czechia

Background:

This experiment will mix food dye, baking soda and dish-washing liquid with lemons to create different coloured ‘volcanic eruptions’..

You will need the following:

- ✓ Knife
- ✓ Spoon
- ✓ Green Food dye
- ✓ Yellow food dye
- ✓ Red food dye
- ✓ Baking soda
- ✓ Dishwashing liquid (detergent)
- ✓ 3 lemons

Follow these steps:

1. Using a knife, cut off one nib of the lemon. This will create a flat surface to sit still.
2. Then cut the top off the other end of the lemon.
3. Using the knife, mash up the insides of the lemon.
4. Then add a tablespoon of food dye, a tablespoon of washing-up liquid and a tablespoon of baking soda.

So what happened?

Mixing all the ingredients will react together to create a colourful volcano. If you are having trouble, continue to mix all ingredients in the lem-on together with the knife.

General

Cooking the perfect spaghetti

Italy

Background:

Students are asked to design and carry out an investigation to cook the perfect spaghetti. Students are asked to consider what factors will affect the cooking of the spaghetti, and what variables they should measure and record. Students must discuss and agree how they will determine when they have cooked the perfect spaghetti.

You will need:

- ✓ Packet of spaghetti,
- ✓ water,
- ✓ salt
- ✓ oil
- ✓ vernier callipers, ruler
- ✓ kitchen (weighing) scales,
- ✓ thermometer/ temperature probe,
- ✓ hob or hot plate.

Follow these steps:

1. In planning their investigation, students consider the following questions:
2. What you see (observe) happening to spaghetti when it is cooked?
3. What is your method for cooking the perfect spaghetti?
4. What changes to the spaghetti are you going to record or measure & how?
5. What factors do you think could affect the spaghetti during cooking?

So what happened?

Students share and discuss their plans with each other and identify several variables that will change during the cooking process, such as: the mass, length, diameter, volume, density of a single spaghetti strand. They discuss the effect of the type of spaghetti used, volume and temperature of the water used, addition of salt or oil, lid/no lid on cooking vessel and time allowed for cooking. Students carry out their investigation and compare their results. They reflect on their plans and how they have controlled and measured variables.

Money from A-Z

Czechia

Background

All countries issue banknotes with many security features to prevent money being forged. With the use of a small class digital microscope and a UV light students can investigate and compare security features of notes from many different countries.

You will need:

✓ Use of all your senses
✓ A digital microscope
✓ An ultraviolet light or pen

Follow these steps:

1. Using your sense of touch feel the texture of the banknotes. Does this vary from country to country? Special printing processes give banknotes their unique feel. Banknotes often have **raised print** on the note rather than the smooth texture of regular paper.
2. Hold the banknote to the light and inspect the portrait **window**, the **watermark** and the **security thread**.
3. While tilting the banknote, look for a **silvery stripe** which in Euro notes reveals a portrait of Europa in a transparent window and for **holographic** colours showing the amount of the note and the picture on the front of the note.
4. Using your microscope look for **micro prints** hidden in the design of the banknote.
5. Using a **UV light** look for areas of the banknote that become illuminated.
6. Compare banknotes from different countries.

What next?

Investigating Euro notes

- On Euro currency can you identify the initials of the European Central Bank in the nine linguistic variants of countries of the European Union?
- Can you find Euro written in the Cyrillic alphabet-Bulgaria (EBPO), in Latin (EURO) and in the Greek (EYPΩ) alphabets?
- Can you find the map of Europe on the back of the bank notes? (including Malta and Cyprus)
- Can you find a signature of a former president of the European Central Bank on the banknote?
- Can you find the serial numbers on the bank notes? In which colour are they printed? Are both numbers the same?
- Find out about the countries shown on the map on each bank note. Learn about the language, culture and people of these countries.

FROM TEACHERS FOR TEACHERS

JOINT PROJECTS

Jane Shimizu, Scoil Chaitriona Junior, Galway, IRELAND
Audrey Boyd, St. Mary's Primary School, Fivemiletown, NORTHERN IRELAND, UK

Our joint Irish-Northern Irish project used the theme of "flight" to engage primary school students in STEM education.

We encouraged active learning by
- Questioning
- Observing
- Decision-making
- Designing
- Making and researching
- Showing enthusiasm

FLIGHT...UP, UP AND AWAY!

Using flight as a topic to encourage students to take an active interest in STEM and STEAM subjects.

FLIGHT: * Hovercrafts * Kites * Helicopters * Balloons * Parachutes * Aeroplanes

Focus on ▪ curiosity ▪ collaboration ▪ creativity ▪ critical thinking ▪ communication ▪ inquiry-based learning

Active Learning is FUN!

DCU SCIENCE ON STAGE 2022 PRAGUE · SCIENCE ON STAGE IRELAND · SCIENCE ON STAGE UNITED KINGDOM · CASTeL · SCIENCE ON STAGE EUROPE

FROM TEACHERS FOR TEACHERS

JOINT PROJECTS

SCIENCE ON STAGE NETHERLANDS · SCIENCE ON STAGE IRELAND

Declan Cathcart, Temple Carrig School, Greystones, Ireland
Andrea van Bruggen- van der Lugt, Willem van Oranje College, Waalwijk, The Netherlands

The Good, the Bad and the Complex

Food and Biotechnology

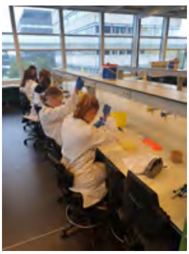
A series of activities have been designed and developed for secondary school laboratories and classrooms. The aim of the project is to improve students conceptual understanding and investigative laboratory skills by framing these activities in an inquiry-based, structured problem-solving approach in the context of food and microbes.

Part 1 – The Good – Lactic Acid Bacteria

Investigation of 'probiotic' lactic acid bacteria in fermented food.

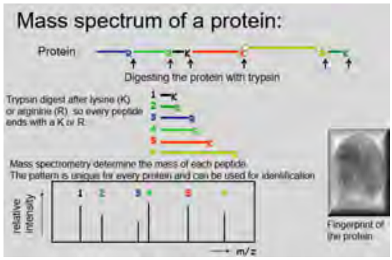
Part 2: The Bad – Shiga Toxin-producing *E.coli* (STEC)

Lab activity with PCR-based diagnostics for the detection of Shiga toxin-producing *E.coli* (STEC) strains.



Part 3: The Complex – Shiga Toxin proteins

3D -visualization of Shiga Toxin proteins (PyMOL). Detecting Shiga Toxins from STEC using mass spectrometry data of trypsin-digest of the protein.



Future development of the project

Investigation of the survival of 'probiotic' strains in gut models.

Epidemiology of an *E. coli* outbreak – a case study/ role play.

LabXchange – pre- and post virtual lab activities.

Acknowledgment

Support is gratefully received from:

Amgen Biotech Experience

U-Talent – Utrecht University

AMGEN Biotech Experience — Scientific Discovery for the Classroom · U-TALENT

Conclusion: We have developed a series of inquiry-based activities for students to learn some of the important concepts and techniques of food biotechnology.

FROM TEACHERS FOR TEACHERS

Sustainable Development Goals in Education

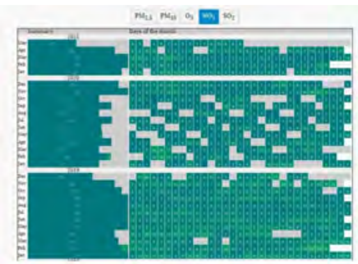
Jennifer Egan | Goatstown Educate Together Secondary School | Dublin | Ireland

Air pollution, evidence from satellite data & human habits

During Covid 19 Lockdown in Ireland, students had a unique opportunity to **measure air pollution levels** when people could not and did not move around and drive their car longer than 5km.

They used real world satellite data from EO browser and https://aqicn.org/map/europe/ and https://www.epa.ie/environment-and-you/air/ to gather data, analyse trends and pattern in air pollutant levels and link the trends to human behaviour.

For example, students found that the levels of NO2 were higher in 2019 compared to 2020.



Students made **pollution catchers**, using paper plates and Vaseline, to find and remove particulate matter from the air outside our school.

Students looked at **plants** and their ability to remove carbon dioxide from the atmosphere using our **CO2 monitors** that are in our classrooms to measure ventilation during the COVID-19 pandemic.

Students then measured the **greenhouse effect** of carbon dioxide using beakers, clingfilm, vinegar and bicarb, a lamp and a thermometer.

Despite the endothermic reaction between vinegar and bicarb, the carbon dioxide generated trapped the heat from the lamp.

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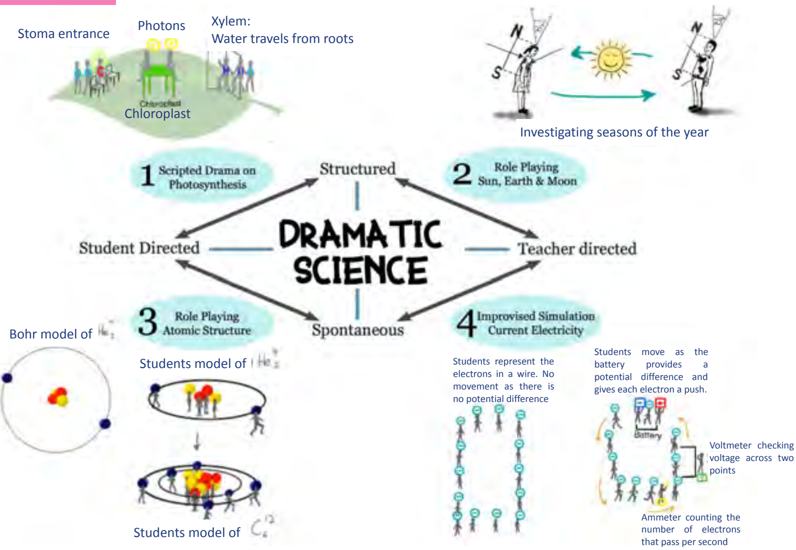
FROM TEACHERS FOR TEACHERS

STEM WITH ARTS

Julia Dolan | Clonkeen College | Dublin | Ireland

Dramatic Science

'Play is the greatest form of Research' Albert Einstein



Description

This project consists of a sample of science lessons which use specific drama-based pedagogies (DBP) as seen in the image above. The need for methodologies that optimise students' authority, engagement and interest in the scientific subjects has been a key goal as the traditional classroom fails to meet the needs of students today. The drama used in this project has been seen to provide a model for learning, allowing students to communicate the nature of science, advance social interaction and debating. The aim is to attract more students into the world of science, captivating their imagination and creativity.

Results

Observations of these lessons show the positive effects of drama on students' conceptual understanding of the scientific concepts.

1. Students developed models leading to a deeper understanding.
2. Students had much learner agency and took ownership for their own learning.
3. Lessons provided structure and control and improved students' social behaviour.

Conclusion: The use of drama in a well-considered manner, guided by reflective science teachers, may provide empowering learning environments for students

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FROM TEACHERS FOR TEACHERS

TECHNOLOGIES IN STEM EDUCATION

PROJECTS INVOLVING CODING, ICT, BIG DATA, AI, VR, NETWORK SECURITY

Karen Marry | Cannistown Scoil Bhríde National School | Navan, County Meath | Ireland

UNLOCKING IMAGINATIONS AND DEVELOPING COMPUTATIONAL THINKING SKILLS THROUGH PRIMARY SCIENCE!

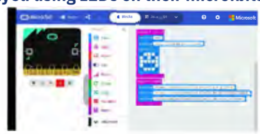
To prepare students for the future, educators must design science lessons that embed digital technologies in new and innovative ways. This project used Bee-Bots, ScratchJr, LegoWeDo and BBC Micro: bits to create collaborative STEM learning experiences for students from junior infants to sixth class (6 - 13 years old). Lessons in this project can be localised into different curricula throughout the world.

The first stage of this project incorporated Bee-Bots into science lessons with infant classes (4 - 6 years old). This project demonstrated how primary science can be enhanced by introducing concepts of computational thinking through the context of play.

The second stage integrated ScratchJr into science lessons with 1st/2nd class (6 - 9 years old). Students created streets based on their local town and programmed pathways on their iPads.

The third stage of this project integrates LegoWeDo into science lessons wiith 3rd/4th class (6 - 9 years old). Students created and programmed cars with motors and lego using the engineering design process.

The fourth stage explored the use of Micro: bit in science lessons with 5th/6th class (10 - 13 years olds). Using this beginner-friendly code editor, pupils designed and created programmes which were then displayed using LEDs on their micro:bits.



Through the meaningful use of digital tools, primary schools have the power to support and enhance children's computational thinking while fostering a lifelong passion for STEM education.

DCU | SCIENCE ON STAGE IRELAND | ELIXÍR DO ŠKOL | SCIENCE ON STAGE 2022 PRAGUE | CASTeL

FROM TEACHERS FOR TEACHERS

SCIENCE ON STAGE FESTIVAL 2022

JOINT PROJECTS

Máire Duffy | Clonkeen College| Dublin| Ireland
Nelson Correia | Escola Secundária Maria Lamas| Torres Novas| Portugal

Radio Astronomy in Schools

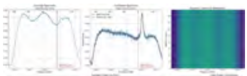
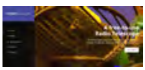
Radio Astronomy at School is a project that aims to promote students' interest in astronomy and physics in the area of radio waves emitted by celestial bodies.

Students were involved in building three different types of radio telescopes.

1. An Itty Bitty Telescope using a t.v. Satellite dish and a signal finder to detect radio waves from the sun.
2. A horn antenna to detect the 21 cm hydrogen line from our milky way.
3. A 2.5 m parabolic dish radio telescope in Portugal. The dish itself was donated from AMRAD.

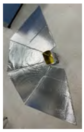
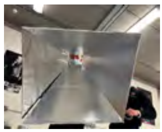
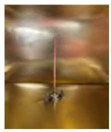




Conclusion: This project allowed students to apply their physics knowledge to real world applications and brought radio waves to life!



Students also investigated RFI (radio frequency interference) in the lab from electrical appliances, the effect of a Faraday cage on radiowaves, detected radiowaves using a Software Defined Radio (SDR) and a RTL-SDR dongle, made simple astronomical telescopes as a comparison to radio telescopes and investigated the night sky for the 21cm hydrogen line using Pictor telescope and Stellarium online. Students from both countries collaborated on a map of radio telescopes around the world using Padlet, which allowed them to see the best place to locate a telescope with the least amount of radio interference. Thanks to all the advice from both AMRAD, Portugal and I-LOFAR, Ireland.

FROM TEACHERS FOR TEACHERS

Sustainable Development Goals in Education

Michael Kavanagh| St Augustine's College| Dungarvan, Co Waterford | Ireland

Toys, Science, Mars and SDGs!

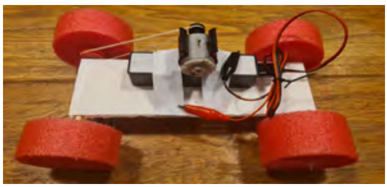
Could you survive on Mars ?

The purpose of this project is to use a Mars theme to excite students about design and engineering and to help them appreciate the importance of renewable energy in a world of limited resources. Students were challenged to produce their own energy from wind, to grow food crops using only a limited water supply and to build and test electric vehicles. Future Martians will need engineering skills to maximise limited resources!

Activity 1 : Students designed **wind turbines** that converted the K.E. of wind to P.E and then developed their designs to generate enough electricity to charge power supplies essential for life support and transport.

Activity 2: Students built **hydroponic systems** to produce a supply of food within 6 weeks with a limited water supply. Students learned about seed germination, nutrients, and the oxygen and light requirements of plants.

Activity 3: Students built an EPV or electric powered Martian vehicle to explore the red planet. Students investigated how solar energy could be used to charge their EPV and investigated the suitability of different tyres to navigate slopes and difficult terrain



Through these activities student developed both their engineering and design skills and also developed a deeper appreciation of the importance of the limited resources we enjoy here on Earth.

DCU Ollscoil Chathair Bhaile Átha Cliath Dublin City University

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Air pollution, evidence from satellite data & human habits
LINKS


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