SCIENCE ON STAGE
TURKU 2024

Demonstrations and teaching ideas selected by the Irish team

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SCIENCE ON STAGE EUROPE

Science on Stage 2024
Demonstrations and teaching ideas
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One never notices what has been done; one can only see what remains to be done.

Marie Curie

It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong.

Richard P. Feynman

Science and everyday life cannot and should not be separated.

Rosalind Franklin

The most beautiful thing we can experience is the mysterious. It is the source of all true art and science.

Albert Einstein

Disclaimer

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

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

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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 13th European Science on Stage festival took place from 12-15 August 2024 in Turku, Finland. At the largest European educational fair for STEM teachers around 450 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.

Every two years a Science on Stage Festival is held in a different country and Turku in Finland had the pleasure of being the host of #SonS2024 under the theme of Sustainability in STEM Education. Following the principle "from teachers for teachers" the Science on Stage festival is 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 2024 contributors: Alan Casey, Declan Cathcart, Denis McCarthy, Eilish McLoughlin, Jane Shimuzu, Máire Duffy, Paul Nugent, Sean Kelleher, Sinead Kelly, Stephen Gammell, Tracey Mason and Veronica Ward. 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 2024 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 SonS2024 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 Oide - the support service for teachers and school leaders in Ireland.

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

SonS 2024 TEAM AND CONTRIBUTORS

A team of eleven delegates represented Ireland at the European Science Teaching Festival, 12-15 August 2024 in Turku, Finland. The team consisted of:

- Alan Casey, Coláiste an Chroí Naofa, Cork.
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Irish Science on Stage team 2024 –

Denis McCarthy, Eilish McLoughlin, Declan Cathcart, Máire Duffy, Tracey Mason, Jane Shimizu, Sean Kelleher, Stephen Gammell, Veronica Ward, Alan Casey, Sinéad Kelly and Paul Nugent.

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Posters by the Irish Team

The effect of forest fires the soil organisms

Spain

Background:

Life on Land is Sustainable Development Goal 15. This goal focuses on sustainable forest management, combating desertification, halting and reversing land degradation, and preventing biodiversity loss.

Natural environments are under increasing pressure from human activities and natural disasters.

In this activity, students examine the effects of forest fires on a soil sample.

This small-scale investigation helps students understand the larger environmental impact of forest fires at the national and global levels.

You will need:

- ✓ 2 petri dishes
- ✓ Soil sample 30 g (2 x 15 g) to fit petri dishes as in image.
- ✓ 1 dropper
- ✓ Graduated cylinder
- ✓ 6 ml of hydrogen peroxide (2 x 3 mL)
- ✓ Mass balance
- ✓ Weight boat
- ✓ Spatula
- ✓ Bunsen burner, wire gauze, tripod, evaporating dish

Follow these steps:

1. Use a balance and a weighing boat to measure 15g of soil.
2. Transfer the soil to an evaporating dish, evenly distribute the soil in the dish.
3. Place the evaporating dish on wire gauze over a tripod.
4. Heat the soil over a Bunsen burner for 5 minutes.
5. Leave the soil in the dish for an additional 10 minutes. The dish and soil will remain hot. Allow the soil sample to cool completely.
6. Place an equal amount of heated and unheated soil into a separate petri dishes
7. Pour 3 mL of hydrogen peroxide onto the unheated soil.
8. Pour another 3 mL of hydrogen peroxide onto the cooled, heated soil.
9. Observe the reaction in both samples

Observations

The unheated soil produces visible effervescence (bubbling) (see image A). This indicates the presence of organic matter.

The heated soil produces little or no effervescence (see image B). This suggests that the organic matter was destroyed during heating.

So what happened?

Forest fires destroy soil structure and the living organic matter that lives within it. While also decreasing nutrient availability, infiltration rate and increasing surface runoff and erosion. We can check if the soil has presence of organic matter by adding hydrogen peroxide; the result being the observation of effervescence; bubbles /fizzy appearance, and if no living organic matter the result is no effervescence only a wet appearance.

To replicate the forest fire we burn soil using a Bunsen burner and evaporating dish. Unburned soil sample has a greater presence of organic matter. The image shows the observations between the untreated/not burned soil and treated / burned soil.

What next?

Use these observations as classroom discussions for the effect of human activity or climate change and natural disasters on our Earths resources. What will the effect of more fires be on the soil in the further? What resources could be directly and indirectly affected.

Biology

How varying temperature & llight can affect chlorophyll

Czechia

Background

Chorophyll is a green pigment used by plants to trap light energy from the sun so it can be available for the reaction photosynthesis, the correct temperature is alo needed for the enzymes involved in the reaction to work. Chlorophyll is found inside chloroplasts, organelles in the leaves of plants. We investigated how the chloropyll of a pond moss ball would vary in cold temperatures and the lack of light.

We compared 3 different environment room temperature; 19-21 °C, fridge; 3–5 °C and freezer; -18 °C or colder. We realise that plants need light to photosynthesise; placing plants in a dark environment can eventually stop photosynthesis from occurring so we only left them 2 days. Water freezes in the freezer! so we used glycerine as it prevents ice crystal formation and damage to tissues, allowing us to see the chlorophyll.

You will need

- ✓ Light microscope
- ✓ Microscope slide & cover slip
- ✓ Forceps × 2
- ✓ Glycerine / glycerol
- ✓ Small jar as in image 2.
- ✓ Pond moss ball. Bought in a aquarium / pet shop.
- ✓ The aquarium water that the moss ball came in.
- ✓ A dish for the moss ball and aquarium water ensuring the moss ball is submerged.
- ✓ Dropper
- ✓ Camera phone
- ✓ Freezer

Image 1

Follow these steps:

1. Leave the moss ball in a dish submerged in aquarium water at room temperature.
2. After two days pull a few strands of green from the moss ball. (Use two forceps, it is easier.)
3. Place the strands on a glass slide as in image 2. Only a small amount is needed.
4. Place a coverslip over the sample.
5. View under a micrscope at 10x.
6. Take images with a smartphone.
7. Take a small amount of aquarium water and using forceps take a few strands and place them in a jar as in image 2.
8. Place the sample into a fridge for 2 days. Remove and view under 10x, image 4.
9. Using forceps take a few strands and place them in a jar as in image 2. Cover the strands completely in glycerine. Place them in a freezer for two days.
10. Remove the samples and view under 10x, image 5.

So what happened?

At room temperature the plants have light and a suitable temperature, so chlorophyll is not destroyed as in image 3.

In the fridge it is dark and the temperature is reduced — conditions not suitable for many plants to survive. They are unable to produce the energy needed to survive. The chlorophyll in the cholorplasts is destroyed, as in image 4.

In the freezer the glycerol prevents ice crystal formation and allows us to see that again with the lack of light and the colder temperatures that there is a large amount of damage to the chorophyll and cholorplasts. This makes the concepts that we are teaching the students visual.

Fridges and freezers are also dry and can dehydrate the plant. The temperature in the freezer causes the cells to rupture as seen in image 5. The glycerine has prevents ice crystals forming allowing us to see the damage to the moss ball fragments.

What next?

1. Leave the moss ball in the fridge for longer with no glycerine and compare the results.
2. Take strands off the moss ball at room temperature and view the moss ecosystem under a microscope.
3. Research adaptations of plants in different ecosystems and make comparsions.

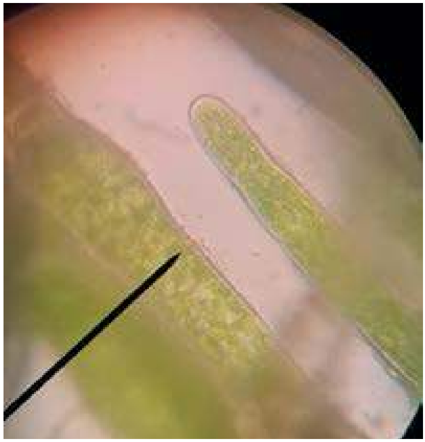


Image 3

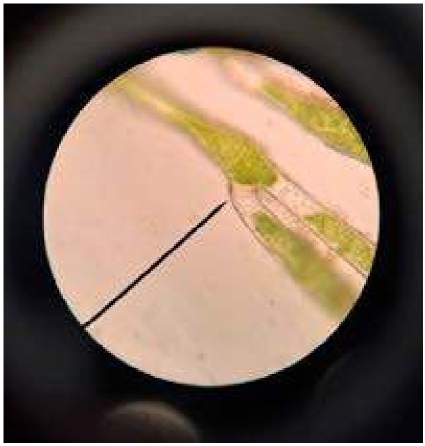


Image 4

Image 5

Biology

Ecosystem in a Jar

Netherlands

Background

Ecosystems are areas where living organisms interact with their environment. An terrestrial ecosystem in a jar is also known as a terrarium. Plants carry out the chemical process of photo-synthesis; the leaves absorb the light energy and using water and carbon dioxide they produce food and oxygen. In respiration oxygen and food are used by plants (and animals) to produce energy, releasing carbon dioxide and water. Using a terrarium you can demonstrate that plants can survive on their own if they have the necessaryresources .
We monitored the pH of the environment.

You will need:

- ✓ A large jar with lid
- ✓ Potting soil
- ✓ A small indoor plant here we used a fern
- ✓ Drill hole in lid to fit your pH monitor

Note: you need the pH monitor to fit snuggly into opening, if the opening is too large carbon dioxide and oxygen will leave the jar and you won;'t have a terrarium.

Follow these steps:

1. Place potting soil in the jar ,a quarter way up.
2. Using the tablespoon to move a small amount of the soil; place the plant into soil.
3. Water the soil.
4. Drill a hole in the lid of the jar, ensuring that the pH monitor fits snuggly leaving no gaps.
5. Leave the terrarium in a well lit area but not in direct sunlight.
6. Allow the plant 24 hours to adjust to new environment before placing the lid on and closing.
7. Insert the pH probe into the lid of the jar.

So what happened?

You have created a mini ecosystem. So how does it survive in the jar without opening the lid? The products of photosynthesis are used by the plant to allow the respiration to occur and the products of respiration allow photosynthesis to occur. The cycle continues allowing a balance in the systems for the plant to grow. Images from table of the reading of the monitor show the pH has increased steadily due to the plant growth waste, this may come from the reaction photosynthesis as hydroxide ions are produced. Plants take in the carbon dioxide during photosynthesis, carbon dioxide is acidic so the environment therefore becomes more alkaline. As the ecosystem develops over time there will be an eventual balance in systems and the pH environment will become ideal.

5.4	5.5	5.6	5.8	5.9	6.0	6.1	6.3	6.4

What next?

1. Continue to monitor your ecosystem over a few months or leave the pH monitor in the jar and allow your ecosystem to develop over the months. The pH monitor can be removed and opening area sealed or replaced with a second lid! The pH if monitored should become less alkaline as the days continue, balancing out the systems.
2. Draw graphs from the results.
3. Measure oxygen or carbon dioxide levels over a 2 week period and discuss results.
4. Discuss the impact of human activities has on ecosystems.
5. Create ecosystems with different plants and compare pH or oxygen and carbon dioxide levels between the different plants.
6. Study biotic and abiotic factors of ecosystems.
7. Discuss the Earth as an imperfect terrarium due to human waste and solar energy.

The secret life of screens: a pixel investigation

Greece

Background:

Modern smartphone screens use millions of tiny light-emitting elements arranged in a precise pattern to create the images we see. Each pixel is typically made up of three sub-pixels: red, green and blue (RGB). Our eyes blend these colours together to perceive the full spectrum of colours on the screen. By using a simple microscope, students can observe these individual sub-pixels directly, revealing the hidden structure behind everyday technology. This practical demonstrates how additive colour mixing works and provides a tangible link between physics concepts and real-world applications.

You will need:

- ✓ A smartphone (iPhone or Android – works with most modern devices)
- ✓ A digital optical microscope (100× magnification)
- ✓ Coloured phone wallpaper (red, green, blue, black) to show different pixels illuminated

Follow these steps:

1. Position the microscope objective lens directly over the screen surface
2. Adjust the focus carefully until you can see sharp details
3. Change the wallpaper to see which sub-pixels are activated

So what happened?

When you looked at the white screen under magnification, you saw separate red, green and blue sub-pixels rather than white light. This is because white light on the screen is created by illuminating all three colours simultaneously at full brightness. Your eyes, viewing from a normal distance, cannot resolve these tiny individual elements, so your brain blends them together into white. The microscope allows you to see beyond this limitation and observe the true structure. When you displayed different colours, you likely noticed that only certain sub-pixels lit up – red screens activate only red sub-pixels, and so on.

What Next

1. Link to the eye: Discuss how cone cells in our retinas work similarly, with three types sensitive to different wavelengths
2. Research how cathode ray tube (CRT) televisions used phosphor dots in a similar RGB arrangement

Biology

Why are surgical scrubs teal?

Greece

Background

The teal/blue-green colour of surgical scrubs is not arbitrary - it's based on visual physiology and the physics of colour perception. When our eyes focus on a particular colour for an extended period, the photoreceptors become fatigued. When we then look at a neutral surface, we see the complementary colour as an after image. This demonstration shows how surgical scrubs are designed to reduce eye fatigue during operations where surgeons are constantly looking at red blood.

You will need:

- ✓ PowerPoint presentation with:
- ◆ Slide 1: Bright red background with a small black dot in the centre
- ◆ Slide 2: Plain white background
- ◆ Slide 3: Image of medical professionals in an operating room wearing teal scrubs
- ✓ Timer or clock with second hand
- ✓ Projection screen or large monitor
- ✓ Colour wheel showing complementary colours

Follow these steps:

1. Display the first slide with the bright red background and black dot.
2. Time 30 seconds while students focus on the black dot.
3. Without warning, quickly switch to the white slide (Slide 2).
4. Immediately ask: "What do you see on the white screen?" (Students should report seeing a teal/blue-green afterimage)
5. Allow 15-20 seconds for the afterimage effect to fade.
6. Display Slide 3 showing medical professionals in teal scrubs.
7. Ask students to consider why this particular colour might be chosen for surgical environments.

So what happened?

Staring at the red background, the photoreceptors in the retina that respond to red light became fatigued. Looking at the white screen (which contains all colours of light), these fatigued receptors respond less strongly to the red component in the white light. This creates an imbalance, with the appearance of the complementary colour—teal / blue-green

What next?

Try the experiment with different colours. For example, use a bright green background and observe the magenta/purple afterimage.

Little Cardiologists – embodied learning activities for teaching about the circulatory system

Cyprus

Background:

This lesson introduces students to the circulatory system through embodied learning an approach that emphasizes the connection between the body, movement and cognitive understanding. Learning through movement and body interaction fosters inclusivity, deeper understanding and long-term memory. As part of this activity students will describe how blood circulates through the body. They will identify habits that promote a healthy circulatory system (diet, exercise, avoiding smoking).

You will need:

- ✓ Large open classroom or hall space for movement activities.
- ✓ Station cards labelled Station 1–4.
- ✓ Diagrams of the human heart and circulatory system.
- ✓ Red and blue ribbons to represent oxygenated and deoxygenated blood.
- ✓ Plastic balls or beanbags to symbolize oxygen/ nutrients.
- ✓ Stopwatch timer.
- ✓ Chart paper, markers and worksheets for reflection.

Follow these steps:

Station Activities (about 10 minutes per station)

1. Station 1 – The Heartbeat

- Students mimic the pumping action of the heart using clapping or bouncing movements.
- One student plays the role of the heart, others represent the blood.
- Demonstrate how blood is pumped to the lungs and the rest of the body.
- Discuss how the heart never stops working and why regular exercise helps strengthen it.

2. Station 2 – Oxygen Journey

- Use red and blue ribbons to represent oxygenated and deoxygenated blood.
- Students move around the room carrying "oxygen" (beanbags), transferring them from the lungs (oxygen station) to body parts (muscles, brain, etc.).
- Discuss what happens when blood lacks oxygen and why breathing is essential.

3. Station 3 – Circulation Pathways

- Students form a large human model of the circulatory system, linking arms as "vessels."
- A "blood cell" travels through the system, moving from heart to lungs to body and back.
- Students observe the direction and flow, learning the difference between arteries and veins.

4. Station 4 – Healthy Habits Clinic

- Students act as "little cardiologists."
- Discuss and record healthy lifestyle choices: nutritious foods, exercise, avoiding smoking, adequate rest.

So what happened?

Students experienced how the circulatory system functions by physically modelling it. They demonstrate understanding of blood circulation pathways, identified healthy and unhealthy behaviours affecting the heart.

What next?

This activity could be extended by having students build a 3D model of the circulatory system using craft materials. Students can also conduct a simple heart rate experiment: measure pulse before and after exercise.

Biology

Cricket Lab

Germany

Background:

Crickets offer many advantages for teaching biology. The used cricket species *Gryllus bimaculatus* (two spotted cricket or Mediterranean field cricket), *Gryllus assimilis* (Jamaican field cricket or silent cricket) and *Acheata domesticus* (house cricket) are cost-effective as well as easy to procure and maintain in species-appropriate manner and will not be harmed. Various cricket species can be used for the cricket-lab. In all the species presented, adult females and males can be easily distinguished by the presence of an ovipositor. Juveniles can be recognized by their smaller size as well as by their missing or incompletely developed wings. Small terrariums or fauna boxes are suitable for husbandry. The latter can also be used for transportation. are adequate fillings, while egg cartons and hollow branches provide hiding places. House crickets can be kept together in larger numbers, whereas Mediterranean and Jamaican field crickets require more space (group size 20 - 40 animals depending on the size of the terrarium). If the crickets are supposed to be bred, a small bowl with sand that is always kept moist must be added for laying eggs. To prevent the eggs from being eaten, the sand container must be covered with gauze. Small cups with lids, such as urine cups, are perfect for keeping animals individually. These must be provided with holes for ventilation. Oat flakes are suitable as food and aqua pearls from the pet shop have proved to be the best option for supplying water, as mold does not form so quickly if there is sufficient ventilation

Analyze the dependence of the level of aggression occurring during the cricket fight based on the selection of the size of animals.

You will need:

- ✓ arena with slider
- ✓ six male crickets in separate boxes
- ✓ four males with similar body mass / same weight class
- ✓ a male with a lower body mass / smaller weight class
- ✓ a male with a higher body mass / larger weight class

Follow these steps:

1. Take a look at the crickets available and plan a procedure for a tournament to complete the task.
2. Place two crickets separately in the arena for a fight. If necessary, activate the crickets by carefully touching the antennae with a brush.
3. Open the partition and let the crickets fight with each other. Don't stop the fight until there is a clear winner and loser.
4. Wait for one minute and let the same two crickets fight again.
5. Document the level of aggression reached, the duration of the fight and the winner and loser. Also make a note of any other observations that occur.
6. Following, carry out the other fights according to your tournament plan

cricket no.	mass / weight class	cricket	mass / weight class

fight no.	cricket 1	cricket 2	level of agression	duration	winner	loser

So what happened?

In crickets, such as *Gryllus assimilis* (Fabricius, 1775), *Gryllus bimaculatus* (De Geer, 1773) or *Gryllus locorojo* (Weissman & Gray, 2012), only males are fighting. Recurring levels of aggression occur. However, not all aggression levels have to be passed through.

What next?

1. Explain proximate and ultimate causes of fighting behavior in male crickets.
2. If losers are allowed to fly briefly, for example by throwing them into the air, they return to the fight as if they had never lost. Formulate a hypothesis to explain this behavior.

Biology

Magnificent moss

UK

Background

Moss is a small, non-vascular plant that grows in damp, shady environments such as forests, rocks, and tree trunks. Unlike most plants, moss does not have roots; instead, it absorbs water and nutrients directly through its leaves. Because of this, moss is very sensitive to moisture and light conditions. A moss terrarium is a simple ecosystem that demonstrates the water cycle, plant growth, and how living things interact with their environment. By creating an indoor moss terrarium, we can observe condensation, evaporation, and precipitation on a small scale.

You will need:

For the Indoor Moss Terrarium

- ✓ Glass jar
- ✓ Plastic Wrap
- ✓ Rubber Band
- ✓ Charcoal (optional/best results)
- ✓ Small pebbles
- ✓ cloth or mesh (window screening, landscape fabric, cheesecloth, gauze or sock material will do)
- ✓ Soil (collected with moss or potting compost)
- ✓ Moss
- ✓ Water (squirt bottle works best)
- ✓ Toys or rocks to decorate the ecosystem (optional)

Follow these steps:

Collect moss from outside. Moss can be found on the ground and on rocks and trees, even in urban areas. Look for the plant growing in shady and moist areas. You may choose to gather one type of moss or several types. Once you have collected the plants, store in a plastic bag and spray with water to keep wet. You can observe the moss under a light microscope.

Indoor Moss Terrarium

1. Wash your jar using a dishwasher or with dish soap and warm water. Allow to dry thoroughly.
2. Trace the bottom of the terrarium jar on the cloth or mesh and cut out. Set aside.
3. Place a layer of pebbles at the bottom ¼ of the jar.
4. Sprinkle a layer of charcoal over the pebbles. Charcoal helps eliminate odours, absorbs toxins, and prevents the buildup of bad bacteria in your terrarium.
5. Place the cut out cloth or mesh on top of the charcoal and pebble layer. Trim cloth if necessary.
6. Spray one squirt of water onto the netting to prevent soil from falling through to the rock layer.
7. Spread a thin layer of soil on top of the cloth.
8. Add moss to the jar. The jar should now be 1/3 filled and 2/3 space.
9. Add rocks or toys for decoration.
10. Spray one to two squirts of water into your jar.
11. Cover jar with plastic wrap and secure with a rubber band. Poke holes into the plastic wrap for sufficient air flow.
12. Place terrarium in indirect sunlight and water as needed.

So what happened?

Examine your terrarium for signs of the water system at work. Note where you see water in your jar.

After the terrarium was assembled and placed in indirect sunlight, moisture began to collect on the inside of the jar. Water droplets formed on the sides and top of the plastic wrap due to evaporation and condensation. The soil and moss remained moist, and the moss stayed green and healthy. Over time, the water droplets fell back down into the soil, showing a miniature water cycle occurring inside the jar. CO_2 levels will decrease in the terrarium during the day due to photosynthesis and increase at night due to respiration.

What next?

- Continue to observe the terrarium over the next several days or weeks. Check for changes in moss colour, growth, or moisture levels. To further investigate the terrarium ecosystem, you can measure carbon dioxide (CO_2) levels inside the jar. CO_2 is produced by organisms during respiration and used by plants during photosynthesis.
- One simple way to measure CO_2 is by using a CO_2 sensor or probe, if available, and briefly inserting it into the jar through a small opening. Record the CO_2 level and compare it to the CO_2 level in the surrounding air.
- If a sensor is not available, an indirect method can be used. Place a small cup of clear limewater (calcium hydroxide solution) inside the jar. Over time, if CO_2 is present, the limewater will turn cloudy, indicating carbon dioxide in the terrarium.
- Take measurements at different times of the day and observe how light exposure affects CO_2 levels. This helps demonstrate the balance between photosynthesis and respiration in the closed ecosystem.

Biology

Power of Lichens and Moss

Ireland

Background:

Mosses and lichens serve as highly effective, natural bioindicators and filters for air quality due to their lack of roots, obtaining nutrients directly from the atmosphere. They accumulate heavy metals, nitrogen, and sulfur dioxide, allowing for accurate monitoring of pollution levels. A lack of lichen diversity indicates high pollution, while their presence signals cleaner air. This lesson will prepare students to lead a local lichen ecology study. Students will learn the skills they need to identify a selection of lichens. They will learn the differences between lichen that are nitrogen loving, nitrogen-sensitive and intermediate. Students will describe and measure their study area and will finish with making their own pollution catcher to use at school.

You will need:

- ✓ Site image, site characteristics sheet,
- ✓ pencils,
- ✓ tape measures
- ✓ lichen twig samples,
- ✓ lichen identification guide, lichen images Group A and Group B,
- ✓ magnifying lens,
- ✓ marker pens, paper plates,
- ✓ string, hole punch,
- ✓ Vaseline.

Follow these steps:

Part 1:

Lichen Identification

1. Working in pairs focus on the lichens between 50-150cm above ground level.
2. We will focus on looking for only nine different types of lichens as there are hundreds of species.
3. Using the lichen identification guide label the nine images in Group A.
4. Using the identification guide try to identify the different types of lichen you can see in the Group B images, and count the number of different lichens found.
5. Give each group a twig with lichen on it and ask them to try and identify any of the nine lichens they have been looking at.

Part 2:

Make a Pollution Catcher

6. Identify where air pollution can be worst and identify the causes.
7. Using the paper plates, punch a hole at the top and bottom
8. Thread a long length of string through the holes at the top and bottom
9. When ready to hang up and start the investigation – colour in the centre of the paper plate with petroleum jelly or Vaseline.
10. Hang up catchers and leave up ideally between 2-3 weeks.
11. Take down and analyse the results using a magnifying lens.

So what happened?

You should find there is a difference between catchers placed in heavy traffic areas compared to low traffic areas/indoors. You should also be able to identify a higher concentration of Nitrogen-tolerant lichens by their yellow colouring in heavy traffic areas.

What next?

1. After all groups are done recording data, have them discuss their findings. Which areas had the highest pollution? Are they surprised by any of the sample cards (more or less pollution than expected?) Does the pollution outdoors look different than the pollution indoors? What are some similarities between the indoor and outdoor cards?
2. Additional activities: Measure how much traffic is entering your school grounds and/or travelling by your school on adjacent roads. This will provide you with traffic data that will help you when interpreting your results.
3. Place monitoring tubes to measure nitrogen dioxide outside in 3 location at your school. To gather chemical data on air quality. The air quality map can also be used to monitor air quality in Ireland https://airquality.ie/

Liver cells under the Microscope

Ireland

Background:

In this investigation, students observe an animal cell as an alternative to a cheek cell.

Liver cells from a lamb were used. Liver tissue allows many cells to be observed at the same time. Methylene blue stain was applied to the sample. The stain clearly shows the nucleus and cytoplasm.

Students also develop skills in using a microscope during this activity.

You will need:

- ✓ Lambs liver from butcher or supermarket.
- ✓ Glycerol (this one is supermarket bought)
- ✓ Spatula
- ✓ Cocktail stick
- ✓ Chopping board
- ✓ Methylene Blue
- ✓ Microscope
- ✓ Microscope slide
- ✓ Cover slip
- ✓ Dropper x 2
- ✓ Camera phone

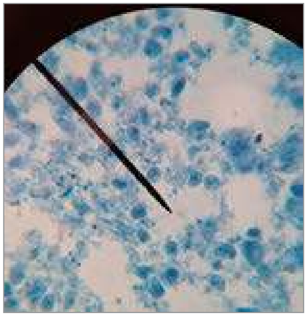
Follow these steps:

1. Place the liver on a chopping board.
2. Using the end of a spatula, gently scrape the surface of the liver in one direction.
3. Transfer a small amount of the collected cells onto a microscope slide.
4. Use a pointed stick or cotton swab to gently spread the cells evenly across the slide.
5. Add one drop of glycerol to the sample.
6. Add one drop of methylene blue stain to the sample.
7. Carefully lower a coverslip over the sample using a dropper.
8. Place the slide on the stage of the microscope.
9. Observe the sample using the lowest magnification. Increase the magnification to observe greater detail.

Notes

If the coverslip is lowered too quickly air bubbles may appear,

If the sample contains too many tissue fragments, the liver may have been scraped too firmly or scraped repeatedly. This can damage the cells.



So what happened?

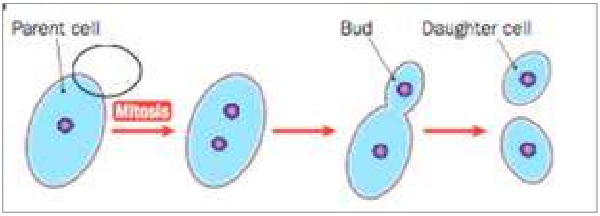
A drop of glycerol was added to the cell sample on the slide. Glycerol improves image clarity and contrast. This makes the cells more visible under the microscope.
Glycerol also helps maintain cell structure. It prevents the cells from drying out or shrinking. For this reason, glycerol is commonly used as a mounting medium for microscope slides.
The liver sample allows many animal cells to be observed at the same time. This helps students study cell structure more effectively.

What next?

1. Investigate our cheek cells and the lambs liver cells at the same time to show that the are the same.
2. Investigate other meats to see if the cells are visible under the mircoscope.

Observing yeast budding under the microscope

Switzerland



Background:

Bakers / bread yeast is a eukaryotic cell. Yeast when added to a glucose solution will grow and reproduce. The yeast to grow will respire or ferment the glucose which is a simple sugar. Reproduction of yeast cells will then occur, this is called budding. It is asexual reproduction; the nuclei will a make copy of itself; a division called mitosis, the nucleus then moves into a new cell that forms from the parent cell (forms a bud). When the nuclei moves into to new cell it will separate and move away from the parent but at times the new cell does not move away and stays attached to the parent cell forming a chain of buds, known as a colony.

You will need:

- ✓ 100 mL beaker
- ✓ Mass balance
- ✓ Bread yeast 1 g
- ✓ Weight boat
- ✓ Spatula
- ✓ 10 mL of warm water
- ✓ Graduated cylinder
- ✓ 1 g of glucose
- ✓ Microscope
- ✓ Microscope slide
- ✓ Cover slip
- ✓ Dropper
- ✓ Camera phone

Follow these steps:

After the solutions are made it will only take about 10 minutes to see yeast budding under the microscope.

1. Using a mass balance and a weight boat measure 1g of yeast.
2. Using graduate cylinder measure 10ml of warm water.
3. Suspend/mix 1g of yeast with the warm water in the beaker, stirring gently with spatula.
4. Add 1g of glucose to yeast solution, mixing gently with spatula.
5. Leave solution to rest for 5 mins.

Carry out the next steps over the next 10 – 20 mins.

6. Using a dropper, place a drop of the solution onto the microscope slide.
7. Gently lower the cover slip at angle over the solution.
8. Starting at a low magnification bring the yeast cells into focus and sharpen with fine focus.
9. Increase the magnification and view cells.
10. Use the camera to take photos.

Note: Leaving the solution too long or over 20 min in the beaker before looking under microscope will lead to grainy looking substance rather than clear images.

So what happened?

Yeast cells will ferment the glucose at a faster rate as it is a simple sugar. This has allowed us to see more budding occur than respiration. The enzyme in the yeast cells ferments the glucose quickly. The yeast cells start to reproduce and budding can be seen.

What next?

No colony was found when completing this activity, but you could be in luck and find one!! If you do please share with the science on stage Ireland team.

Observing respiration of yeast cells

Switzerland

Background:

Yeast is a eukaryotic organism. During respiration, yeast cells break down glucose to release energy. In this investigation, sucrose is used as a substrate. Sucrose is broken down into glucose and fructose. The glucose is then used in respiration.

Observing yeast cells under the microscope provides a clear visual example of respiration in eukaryotic cells. This helps students understand that respiration also occurs in their own cells.

You will need:

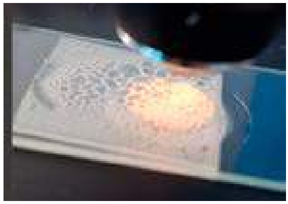
(See previous investigation)

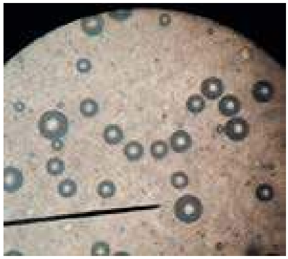
Follow these steps:

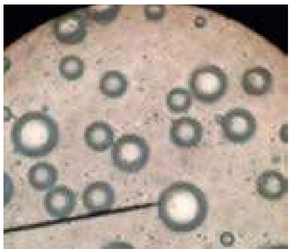
1. Measure 1g of yeast and 1g of sucrose.
2. Put10 mL of warm water in a beaker and add the yeast. Stir gently and then leave the solution to rest for 5 minutes.
3. Use a dropper to place one drop of the solution onto a microscope slide. Gently lower a coverslip onto the sample at an angle.
4. Observe the sample under the microscope at 10X.
5. Bring the yeast cells into focus using the fine focus adjustment.
6. Select one yeast cell located near the centre of the slide.
7. Keep the slide stationary.
8. Observe and capture an image of the selected cell every 5 minutes.
9. Continue this process for 15 to 20 minutes.

So what happened?

Sucrose is a disaccharide. It is a carbohydrate composed of two simple sugars.
Sucrose is broken down by a process called hydrolysis.
Yeast cells release enzymes that break sucrose into glucose and fructose. Glucose and fructose are monosaccharides, carbohydrates with one sugar unit.
The yeast cell absorbs the glucose. The absorbed glucose is then used in respiration.
During respiration, carbon dioxide gas is produced.
Carbon dioxide bubbles can be observed under the microscope (see image 1). In images 2 to 6, carbon dioxide gas can be seen accumulating under the coverslip. The gas bubbles increase in size and may cause visible expansion around the yeast cells.







Seed Germination

Latvia

Examining the conditions required for seed germination & how light affects growth

Background:

Seeds require certain conditions in order to germinate and grow into healthy plants. The main requirements for seed germination are water, oxygen, and a suitable temperature. Water activates the seed and allows enzymes to begin working, while oxygen is needed for respiration. Temperature affects the rate of chemical reactions inside the seed. Light is not always required for germination, but it plays an important role in how seedlings grow after they sprout. This investigation explores how different conditions, especially light and water, affect seed germination and early plant growth.

You will need:

- ✓ Seeds
- ✓ Containers for seed germination
- ✓ Paper towels or cotton wool (to place seeds on)
- ✓ Water

Follow these steps:

1. Place folder paper towels or napkins, or cotton wool in the containers and spread the seeds on them.
2. Choose different conditions and locations (at least 3) to place the containers for seed soaking.
3. For example, in one container, add a small amount of water and place it in light and warmth.
4. In another container, fully submerge the seeds in water, and so on.
5. After a few days, you should observe sprouts in some of the containers.
6. Record your observations for each container
7. Take photographs of the results

So what happened?

After a few days, seeds placed in moist but not flooded conditions began to germinate. Small roots and shoots appeared in containers that had enough water and warmth. Seeds that were fully submerged in water germinated poorly or not at all because they lacked oxygen. Seeds placed in light and warmth produced green, healthy shoots, while seeds grown in darker conditions often had pale, weak, or elongated stems. These results show that while light is not essential for germination, it strongly affects how seedlings grow.

What next?

To extend this investigation, you could measure how fast the seedlings grow under different light conditions by recording their height each day. You could also test different temperatures, types of seeds, or light colors to see how they affect growth. Another next step would be to transfer the seedlings into soil and observe how continued light exposure affects long-term plant development.

Chemistry & Materials

Making the invisible visible

Sweden

Background

These experiments immerses students in understanding everyday chemical reactions. Oxidation will be investigated at three levels; Macro, submicro and symbolic. Physical models of chemical bonding encourage students to investigate bonding responsible for oxidisation.

You will need:

- ✓ zinc
- ✓ copper sulfate,
- ✓ ping-pong balls
- ✓ velcro

Follow these steps:

1. Students search outdoors for examples of oxidisation
2. An experiment to investigate the reaction of zinc and copper sulfate is carried out in the lab
3. Devise a chemical equation for the reaction between zinc and sulfur
4. Bonding is modelled with reference to the periodic table

So what happened?

Students observe examples of oxidisation, discussing variables responsible for chemical reaction.

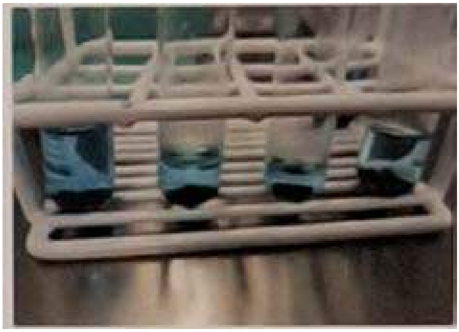
By carrying out the investigation, students can choose variables they want to investigate with regard to oxidisation.

A very simple physical model of chemical bonding can generate predictions and discussion between pairs of students.

An awareness of the link between a costly real life problem and a chemical reaction in the laboratory is emphasised.

What next?

Investigate inks between types of chemical reactions and everyday chemicals or situations.



Reaction of zinc and cop-

Modelling chemical reactions

Developing Photos using coffee

Germany

Background

Traditional film developers use chemicals such as hydroquinone as the reducing agent. Here there is a substitution of the hydroquinone-developer for an inexpensive and non-hazardous household chemicals. The prime candidate is to use instant coffee as the developer to create *Caffenol*.

You will need

- ✓ Instant coffee (not decaffeinated)
- ✓ Sodium carbonate
- ✓ Ascorbic Acid (Vitamin C powder)
- ✓ Distilled water.

Follow these steps

1. Add 40 g of instant coffee to 1 L of warm water.
2. Stir until coffee is totally dissolved.
3. Add 16 g ascorbic acid and stir until it is dissolved.
4. Add 56 g sodium carbonate and stir until it is dissolved.
5. Pour the caffenol into a storage bottle and use.

Note: (Caffenol degrades overtime, so use it immediately).

So what happened?

Adding the coffee to the water caused the release of caffeic acid which is the main reducing agent in the developer. The ascorbic acid is another reducing agent that speeds up the developing process and the Sodium carbonate creates a solution that has the correct pH level to allow the reactions to occur.

What next?

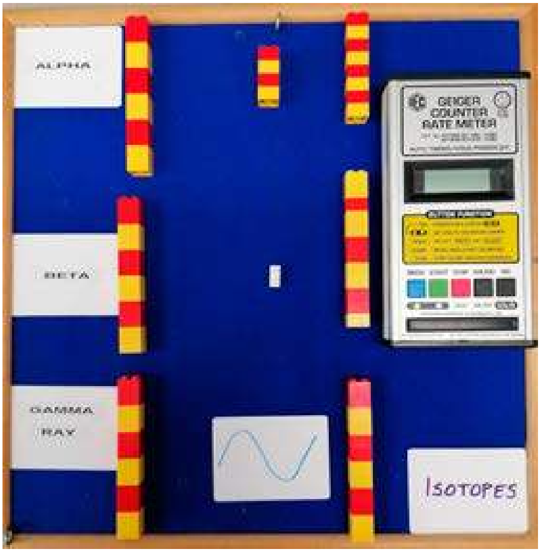
Investigate other natural substances that can be used as a replacement for hydroquinone such as Red Wine, Tea, and Beetroot juice for example.

Radioactive replay

Ireland

Background

The lack of relevant practical work in atomic, particle physics sections of the leaving cert course encouraged the use of models, matching exercises.



You will need:

- ✓ Building bricks
- ✓ Information cards
- ✓ Keyword hexagons

Follow these steps:

1. Model concept e.g. Isotopes of hydrogen using building blocks with help of information cards
2. Write down chemical symbols, formula associated with model
3. Reinforce understanding of idea using keyword cards or matching exercise

So what happened?

Explain concepts in the form of a narrative. Explain connections using a worksheet.

What next?

Use similar approach to investigate other concepts on physics course

Homemade ozone detector

Croatia

Background

One of the earliest methods for measuring ozone was developed by Christian Schönbein, the discoverer of ozone. This method involved using strips of paper coated with a mixture of potassium iodide (KI) and a starch solution. The paper would react with the ozone in the air, changing colour based on the amount of ozone present. The paper would be left in the open air (away from direct sunlight) for 8 hours, then dipped in water to develop the colour. The shade of purple that appeared would be compared to a reference scale, known as a Schönbein number, to determine the concentration of ozone.

You will need:

- ✓ Potassium iodide
- ✓ Cornflour (i.e. Starch)
- ✓ Distilled water
- ✓ Filter paper
- ✓ Air tight container.

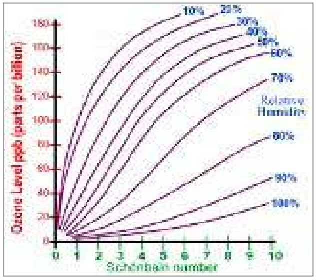
Follow these steps:

1. Measure 100ml of distilled water into a Beaker.
2. Add 10g of cornflour
3. Heat mixture while stirring until it thickens and clears. (note: do not allow mixture to boil).
4. Remove mixture from heat and while stirring, add 1g of Potassium Iodide.
5. Allow mixture to cool and thicken to a paste.
6. Using a brush, paint both sides of filter paper.

7. Place paper in microwave for 1 min to dry paper.
8. Cut the filter paper into 1x10 cm strips and place in airtight container.
9. Store the container in a dark environment until use.

How to measure Ozone.

1. Take a strip and place it in a shaded place for 8 hours.
2. Ensure it is not exposed to rain.
3. Note the relative humidity.
4. After 8 hours, wet the strip with distilled water.
5. The strip will turn from white to a purple colour.
6. Compare the colour against the Schönbein number chart and note the number.
7. Record the number and the relative humidity.
8. Repeat each day for a week to improve accuracy.
9. Calculate the mean value of relative humidity and Schönbein number.
10. Use these values to determine the Ozone level by reading the graph below.



So what happened?

Exposed to open air, the Potassium Iodide on the strip reacted with a) the Ozone and b) the humidity existing in the environment. When the strip was dipped into distilled water, the strip turned a shade of purple as a function of the concentration of Ozone present. The intensity of the purple colour is proportional to the amount of iodine produced, which in turn reflects the ozone concentration in the air. By comparing the colour against a given scale, a Schönbein number was obtained and linked to an existing Ozone concentration in the environment.

What next?

1. Compare ozone levels at different times of day (morning, midday, evening)
2. Investigate how air quality monitoring has evolved since the 19th century.

Reading the colour of the strips is subjective and can lead to inaccuracies.

It is possible to use software (O3METER) to read the colour change and output the number.

This software can be accessed here on Github. https://github.com/EPhysLab-UVigo/O3METER

What's in your bin? Testing everyday materials for static charge

Ireland

Background

Many items encountered at home – sweet wrappers, sandwich bags, cereal boxes, plastic bottles – are made from materials with different positions in the triboelectric series. In this investigation, you will use the gold leaf electroscope to test common household materials and determine where they fit in the triboelectric series.

By rubbing different combinations of recyclable materials together and measuring the charge on each using the electroscope, you'll discover that the triboelectric series isn't just a scientific concept, but a property of the objects you handle every day

You will need:

- ✓ Gold leaf electroscope
- ✓ Reference materials: Wool and PVC
- ✓ Household recyclable materials such as:
- ✓ Sweet wrappers (various types)
- ✓ IKEA sandwich bags
- ✓ Cereal boxes (cardboard)
- ✓ Matchsticks (wood)
- ✓ Crisp packets
- ✓ Plastic bottles
- ✓ Newspapers
- ✓ Cling film

Follow these steps:

1. Ensure the electroscope is discharged (gold leaf hanging vertically)
2. Select one household material to test
3. Rub the household material against the wool reference with consistent strokes (e.g., 10 strokes in the same direction)
4. Touch the household material to the metal cap of the electroscope
5. Observe and record the deflection angle (descriptive terms or estimate the angle)
6. Discharge the electroscope
7. Repeat steps 3-6 two more times for consistency
8. Rub the same household material against the PVC/ Teflon reference and repeat the measurement process

So what happened?

When household materials were rubbed against reference materials (wool and PVC), electrons transferred from one to the other, creating static charges.

Materials further apart in the triboelectric series transfer more electrons and create stronger charges, producing larger electroscope deflections.

By comparing deflections with different references, each material's position was determined:

Larger deflection with wool material sits below wool (negative end)

Larger deflection with PVC material sits above PVC (positive end)

Everyday recyclable items all have distinct positions in the triboelectric series – it's not just a scientific concept, but a property of objects handled every day.

What next?

Create a triboelectric series diagram showing where each household material sits relative to wool and PVC.

Explain why clothes cling together from the dryer, or why you sometimes get shocked by car doors.

Sample Data Collection Table

Material Tested	Reference Material	Trial 1	Trial 2	Trial 3	Average Deflection	Notes
Sweet wrapper (plastic)	Wool	Medium	Medium / Large	Medium	Medium	charged well
Sandwich bag (polyethene)	Wool	Large	Large	Very large	Large	Strong static
Cereal box (cardboard)	PVC	Medium	Medium	Medium-Large	Medium	charged well

Build a Triboelectric Generator to power an LED

Ireland

Background

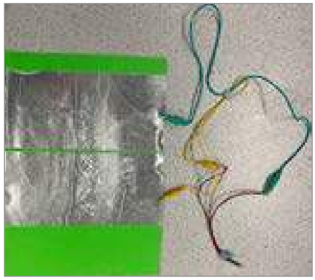
Triboelectric nanogenerators (TENGs) convert mechanical energy into electrical energy using two principles: the triboelectric effect (charge separation when materials contact) and electrostatic induction (induced current from changing electric fields). Materials further apart on the triboelectric series produce greater charge separation. This practical uses PVC (negative) and paper (positive) to generate enough voltage to light and LED.

You will need:

- ✓ PVC card,
- ✓ A4 paper
- ✓ Aluminium foil tape,
- ✓ 2× LEDs
- ✓ connecting wires
- ✓ crocodile clips

Follow these steps:

1. On the back of the paper, attach aluminium foil tape covering one-third of the area going from side to side
2. Attach second aluminium strip with a 1-2mm gap between electrodes; **these must not touch**
3. Connect LEDs in anti-parallel: twist one long leg with one short leg; twist remaining legs together
4. Attach one twisted pair to each aluminium electrode using crocodile clips
5. Flip paper over (electrodes face-down, paper face-up)
6. Place PVC card on paper and slide it rapidly back and forth

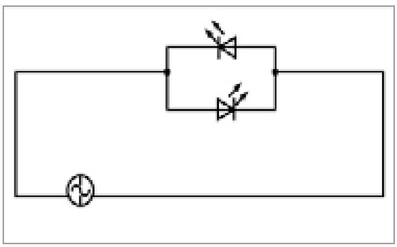


So what happened?

SSliding the PVC across the paper, the triboelectric effect transfers electrons, creating opposite charges on each surface. As the charged PVC moves across the gap between the electrodes underneath, the changing electric field forces electrons to flow through the circuit - they can't jump the gap, so they must travel through the LEDs instead. The sliding motion creates alternating current (AC): electrons flow one direction when sliding forward, lighting one LED, then reverse when sliding backward, lighting the other LED.

What next?

1. Test different material pairs from the triboelectric series
2. Vary the sliding speed.
3. Add a small capacitor for charge storage



Build a Triboelectric Generator (sliding)

Ireland

Background

Triboelectric generators convert mechanical energy into electrical energy using the triboelectric effect (charge separation when materials contact). This investigation demonstrates the freestanding triboelectric mode. When a charged insulating material is slid across a gap between two electrodes, voltage is generated as it moves.

You will need:

- ✓ One sheet of A4 paper
- ✓ Aluminium foil
- ✓ Various insulators (PVC , polystyrene, etc)
- ✓ Voltmeter with connecting wires

Follow these steps:

1. Attach to paper the aluminium foil so it is covering one half of the paper.
2. On the same side of the paper, leave approximately 2mm gap and attach the remaining aluminium foil
3. The paper now has two pieces of aluminium foil separated by 2mm gap that will act as electrodes.
4. Connect these to the voltmeter using crocodile clips
5. Turn the paper over, so that side of aluminium foil is face down,
6. Rub the paper with the PVC back and forth across the gap,and observe the voltage reading.
7. Replace the PVC with a different material and observe the voltage.

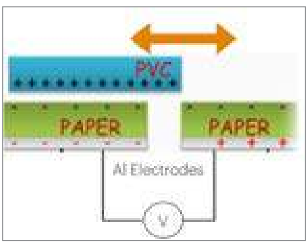
Ensure that a) you take 3 readings for each material and ensure the duration and pressure of rubbing are kept constant to ensure a fair test.

So what happened?

Sliding the insulating material (PVC) against the paper, electrons transfer between the materials due to the triboelectric effect, creating opposite charges on each surface.

As the charged insulator slides across the gap between the electrodes underneath, it creates an imbalance in charge distribution between the two electrodes. The electrons cannot jump the gap, so they must travel through the voltmeter instead, creating the voltage you measure.

Sliding back and forth repeatedly produces alternating current (AC)—electrons flow one direction when sliding forward and reverse when sliding backward.

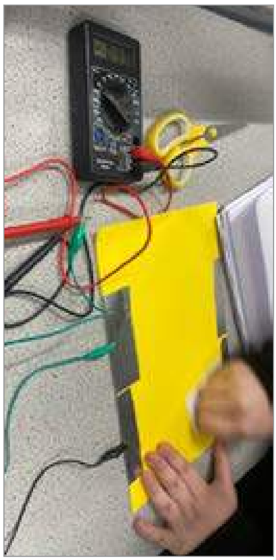


For further information please see:

Wang, Z.L.; Chen, J.; Lin, L. Progress in triboelectric nanogenerators as a new energy technology and self-powered sensors. *Energy Environ. Sci.* 2015, 8, 2250–2282. [Google Scholar]

What next?

- Draw a circuit diagram for your device.
- Does rubbing speed impact the voltage.
- Consider real world applications of your results.



Build a Triboelectric Generator (tapping)

Ireland

Background

This investigation demonstrates the vertical contact-separation mode. When two materials touch and then separate straight apart, voltage is generated

You will need:

- ✓ Two sheets of stiff paper
- ✓ Aluminium foil (enough to cover one side of each paper)
- ✓ Teflon tape (enough to cover one side of a paper)
- ✓ Adhesive tape
- ✓ Scissors
- ✓ Multi-meter.

Follow these steps:

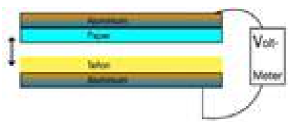
1. Place the aluminium foil on one side of the stiff paper. Secure it with adhesive tape around the edges so that the foil lies flat and smooth on the paper.
2. Attach one of the multi-meter wires to the aluminium foil using adhesive tape, ensuring good electrical contact.
3. Stick the Teflon tape onto one side of the second A4 paper, covering it as evenly as possible.
4. On the opposite side of the same paper (the side not covered by Teflon tape), attach a piece of aluminium foil in the same manner as before.
5. Attach the second multi-meter wire to the aluminium foil on this paper, again ensuring good electrical contact.
6. Place the two sheets of paper on top of each other (cellotaped on one side to create a hinge). The structure will be
   - Paper 1: Aluminium on one side, plain paper on the other
   - Paper 2: Aluminium on one side, Teflon tape on the other
   - The contact interface is: Teflon (Paper 2) touching Plain paper (Paper 1)
   - Both aluminium surfaces face outward (away from the contact zone)
7. Tap on the top paper repeatedly with an insulator (such as a plastic pen, rubber eraser, or wooden ruler). Apply firm, consistent pressure to ensure good contact between surfaces. The insulator prevents you from discharging the system through your body
8. Start with slow, deliberate taps and record the voltage. Gradually increase the frequency of taps, recording the voltage after each change

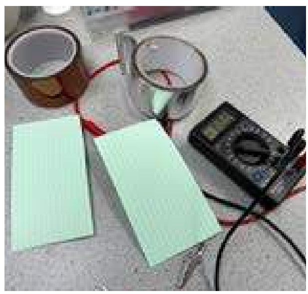
So what happened?

When two different materials (from different sides of the triboelectric series) come into contact, electrons transfer from one material to the other. This creates a charge imbalance: one material becomes negatively charged (gains electrons), whilst the other becomes positively charged (loses electrons). When the materials are separated, an electrical potential difference is created due to the charge imbalance. When the electrodes are connected to a circuit, the potential difference drives electrons to flow from the negative electrode to the positive electrode, constituting an electric current. As the materials are brought back in contact, the current flows in the opposite direction. In a triboelectric generator, the contact and separation process is repeated continuously, producing alternating current (AC)

What next?

- Change the surface area of the Teflon-paper contact.
- Change the materials used in the generator.
- Light an LED with the generator.
- Consider real world applications.





Magnetic Sensors Circuit 1

France and Canada

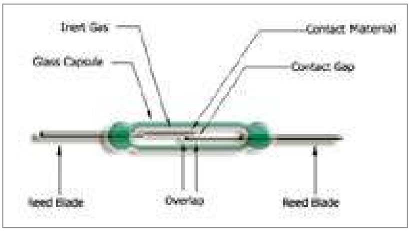
Background

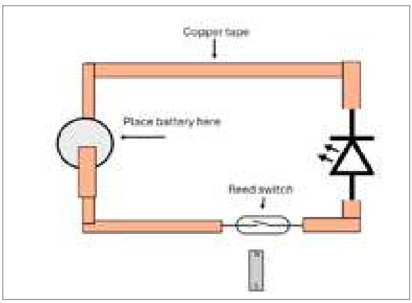
A reed switch first came about in 1936 at Bell Telephone laboratories. The switch consists of a small glass capsule with two ferromagnetic blades separated by a few microns.

Used in burglar alarms and even PillCams which a patient can digest and then images can be taken of the digestive tract. The reed switch allows the PillCam to conserve the battery life as it will only switch on in the presence of an external magnet.

You will need:

- ✓ Reed switch
- ✓ Conductive nylon fabric or copper tape
- ✓ LEDs
- ✓ CR2032 battery
- ✓ Magnet





Follow these steps:

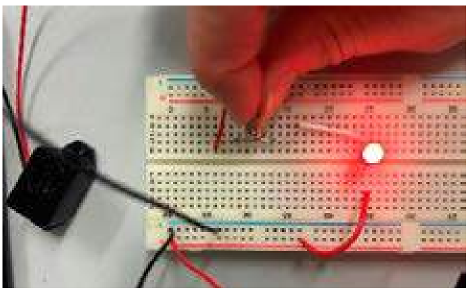
1. Use template above to make the circuit or use a breadboard.
2. Cut the conductive nylon fabric and stick along the circuit track.
3. Make sure to attach your LED with the positive (longer leg) connected to the positive side of the battery and the negative (shorter leg) to the negative side of the battery. You can add a resistor in series to protect the LED.
4. To turn your circuit on bring a magnet close to the reed switch.

So what happened?

When the magnet is brought close to the reed switch the blades touch and the circuit closes causing the LED to light up. It doesn't matter which pole is brought towards the reed switch it will still switch the circuit on.

What next?

Get students to make their own burglar alarm circuit by adding a buzzer into the circuit in series.



Magnetic Sensors Circuit 2

France and Canada

Background

A Hall effect sensor can be used for detecting the strength and direction of a magnetic field.

It consists of a p-type semi-conductor material. When the sensor is placed in a magnetic field the electrons and holes are experience a force pushing the to either side. This produces a potential difference between the two sides.

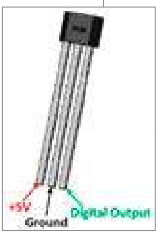
The effect of generating a measurable voltage by using a magnetic field is called the Hall Effect after Edwin Hall who discovered it in 1870.

Bipolar sensors require a magnetic South Pole to operate them and a magnetic North Pole to release them. Unipolar sensors require only a magnetic South Pole to operate and release them as they move in and out of the magnetic field.

They are used for proximity sensing, positioning, speed detection and current sensing applications.

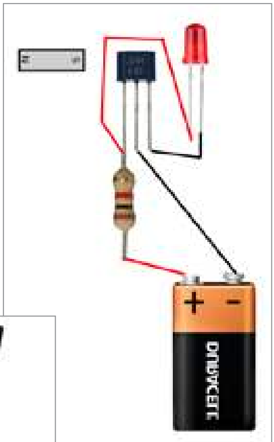
You will need:

- ✓ Hall effect sensor
- ✓ Bread board or solder
- ✓ LED
- ✓ Magnet



Follow these steps:

1. Use a bread board to test your circuit and then you can solder the components directly to a 9 V battery if you want to make a class set.
2. Make sure to attach your LED with the positive (longer leg) connected to the positive side of the battery and the negative (shorter leg) to the negative side of the battery.
3. To turn your circuit on bring a magnet close to the Hall effect sensor.
4. Try South Pole and then North Pole and observe the LED.



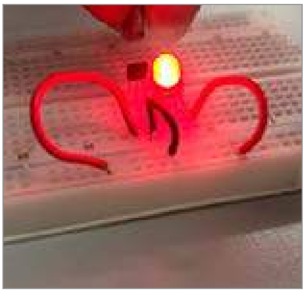
So what happened?

When the South Pole of the magnet is brought close to the front of the unipolar Hall effect sensor (A3144) the LED lights up but switches off again as magnet is moved away.

When using the bipolar Hall effect sensor the circuit is always on but the LED turns off when the South Pole of a magnet is brought toward the front of the sensor. If you now bring a North Pole to the front of the sensor the LED turns back on and will stay on when magnet is removed.

What next?

Get students to design and make their own circuit that triggers an alarm when a door opens.



Pressure Sensitive Circuit

Czechia

Background

Velostat or linqstat is a conductive material that is pressure sensitive.

Velostat is a dielectric polyethylene with embedded carbon powder. When pressure is applied, the carbon particles are pressed closer together which increases the conductive path and hence reduces the resistance. This property makes it useful for pressure sensitive switches in a circuit.

You will need:

- ✓ Velostat
- ✓ Conductive nylon fabric or copper tape
- ✓ LEDs
- ✓ CR2032 battery

Follow these steps:

1. Use template above to make the circuit.
2. Cut the conductive nylon fabric and stick along the circuit track.
3. Make sure to attach your LED with the positive (longer leg) connected to the positive side of the battery and the negative (shorter leg) to the negative side of the battery.
4. Cut the velostat and place under the negative side of the battery.
5. Fold the paper flap over the positive side of the battery.
6. Apply pressure to close your circuit and light your LED.
7. You can increase the number of LEDs in parallel and as you apply pressure they will light up one after the other.

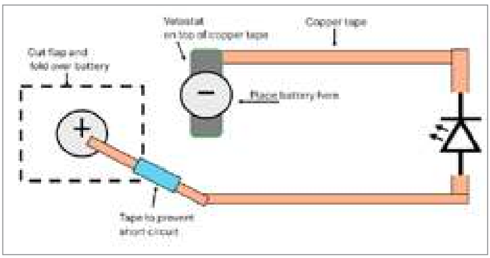
So what happened?

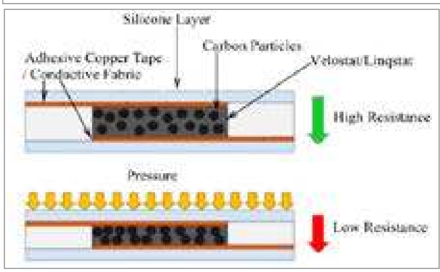
LED lights when pressure is applied. The more pressure the brighter the LED. The resistance is inversely proportional to the pressure applied.

What next?

Try making the touch sensitive light cubes using RGB common cathode LEDs. Students can have great fun making their own circuit and then mixing the primary colours using the touch sensitive circuit.

Templates and further ideas can be found on https://www.voltpaperscissors.com/rgb-touchcube.





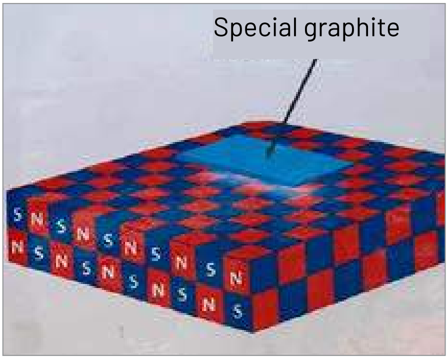
SCAN ME

Magnetic Levitation

France and Canada

Background

Highly ordered pyrolytic graphite (HOPG) is diamagnetic. This means is has the property of being weakly repelled by magnetic fields. When a thin sheet of this graphite is placed above a strong permanent magnet array, this diamagnetic repulsion can overcome gravity, causing it to stably levitate. This works best with strong magnets, such as neodymium, and with smaller, thinner graphite sheets in a square shape.



You will need:

- ✓ Neodymium cube magnets (5 x 5 x 5 mm)
- ✓ Graphite (highly ordered pyrolytic graphite)

Follow these steps:

1. Make a square out of the cube neodymium magnets with alternating pole configurations, as in images below.
2. Place the piece of pyrolytic graphite on the magnets and observe.

So what happened?

The graphite levitates and can slide across the magnets.

What next?

Create a track of neodymium magnets in D-line cable trunk pipe and attach neodymium magnets of opposing poles on a piece of card to levitate and make the Ostrich fly based on the children's story book "The Ostrich Who Could Fly".

Electromagnetic induction

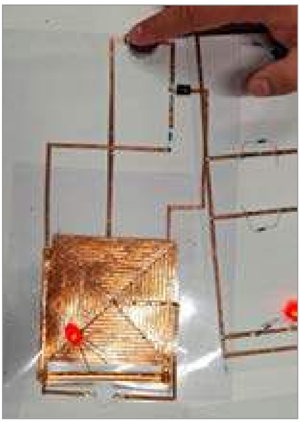
Czechia

Background

Electromagnetic induction can be demonstrated effectively using traditional coils purchased from scientific suppliers. Often these can be quite expensive and bulky. The amounts of turns in the coil and other features are somewhat hidden. A coil made from copper tape can be very effective when explaining some of the variables involved in this concept.

You will need

- ✓ 3 volt batteries,
- ✓ Copper tape,
- ✓ Various LED's,
- ✓ Magnets,
- ✓ Transistors,
- ✓ Resistors,
- ✓ voltmeter,
- ✓ ammeter



Electromagnetic Induction

Follow these steps:

1. Construct the circuit from beginning or from partially made circuits.
2. Using the battery position as a switch, observe what happens when current flows through the coil
3. Measure voltage and current on each path.
4. Replace coil with one of other dimensions or place in a changing magnetic field..
5. Note observations, differences in voltage, current readings.

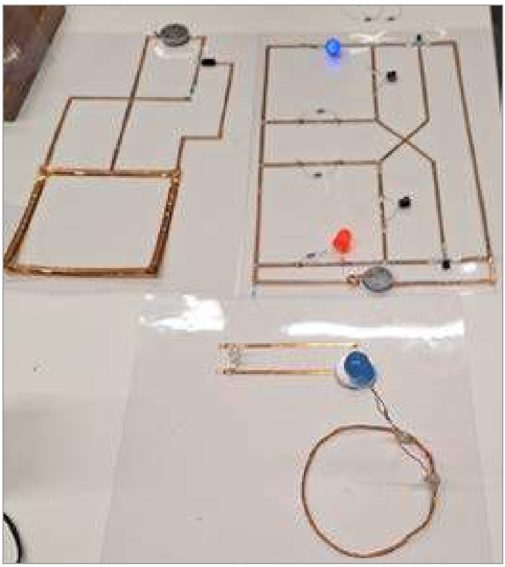
So what happened?

Students get an appreciation for the concept of an electrical circuit. The idea of insulators and conductors arises naturally from the one sided copper tape.

What next?

The circuits can be used to investigate the concepts of voltage , current and resistance.

The link between magnetic and electrical fields can be introduced



Other circuit arrangements

Capacitance

Czechia

Background

Capacitance is a useful topic to introduce the ideas of energy storage and directions of current flow in simple circuits. Conventional capacitors by their design leave much hidden in the same way conventional batteries do.

You will need:

- ✓ 3 volt batteries,
- ✓ Copper tape,
- ✓ Various LED's,
- ✓ Magnets,
- ✓ voltmeter,
- ✓ various materials for dielectric

Follow these steps:

1. Design an individual capacitor using copper tape and various dielectrics
2. Connect the capacitor to the battery to allow it charge
3. Measure voltages for different parts of the circuit
4. Remove battery to allow capacitor discharge through LED

What next?

The circuits can be used to investigate the concepts of voltage , current and resistance.

The link between magnetic and electrical fields can be introduced

An electrolytic capacitor

An electrolytic capacitor - opened

Short circuits

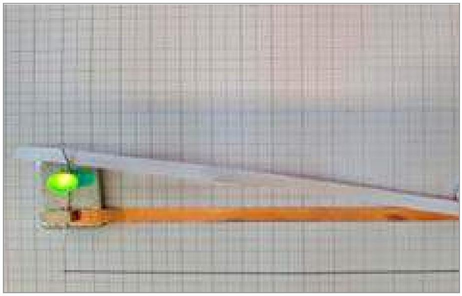
Czechia

Background

The storage and set up of electrical circuits can sometimes be challenging for students and teachers.

You will need

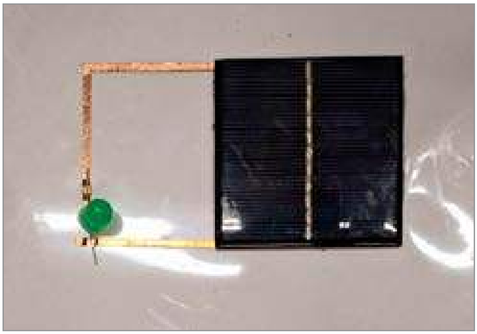
- ✓ 3 volt batteries
- ✓ Copper tape
- ✓ Various LED's
- ✓ Magnets

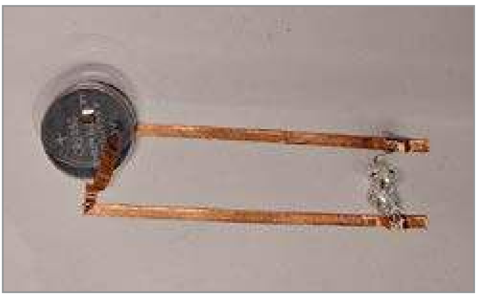


Simple copper tape circuit

Follow these steps:

1. Supply students with 4 types components of mini electrical kit
2. Challenge students to produce light from LED
3. Get students to identify possible insulators, conductors or semiconductors in the circuit
4. Students design a variety of possible switches





Other circuit arrangements

So what happened?

Students get an appreciation for the concept of an electrical circuit. The idea of insulators and conductors arises naturally from the one sided copper tape.

What next?

The circuits can be used to investigate the concepts of voltage , current and resistance

Electrostatic charge strength using distance measurements

Ireland

Background

This investigation explores the triboelectric effect by testing different material combinations to discover which create the most static charge. Distance acts as a proxy for charge strength – by measuring how far away charged materials can attract peppercorns, you can compare charge strengths without specialised electrical equipment. Materials that attract from greater distances have created stronger charges.

You will need:

- ✓ Peppercorns
- ✓ A variety of materials to test (e.g.,PVC, paper, styrofoam, wool, silk)
- ✓ A flat, non-conductive surface (e.g., plastic or wood)
- ✓ A ruler (for measuring distance)

Possible material combinations.

- Wool and PVC pipe
- Silk and glass rod
- Cotton and rubber balloon
- Polyester and plastic comb
- Paper and Styrofoam
- Nylon and aluminium foil
- Human hair and plastic pen
- Fur (or fake fur) and acrylic sheet
- Cellophane tape and cotton
- Teflon and rubber

Follow these steps:

1. Select two materials from the list of combinations.
2. Rub the materials together with consistent force and number of strokes (e.g., 10 strokes).
3. Slowly bring the charged material towards the peppercorns, moving along the meter stick
4. Record the distance at which the first peppercorn jumps towards the charged material.
5. Repeat this process 3 times for each material combination for consistency.
6. Calculate the average distance for each combination
7. Select two other materials and repeat steps 2 to 6

So what happened?

When the two materials were rubbed together, electrons transferred from one material to the other. One material became negatively charged (gained electrons) whilst the other became positively charged (lost electrons). The amount of charge created depended on how far apart the two materials were in the triboelectric series.

As the charged material was brought near the peppercorns, they becam oppositely charged. When the attractive electrostatic force became strong enough the peppercorn jumped towards the charged material.

The distance at which this occurred revealed the strength of the charge generated. Distance acted as a proxy for charge strength.

By comparing the average distances for different material combinations, an experimental ranking can be created that reflects how effectively each pairing generates static electricity and reveals their relative positions in the triboelectric series.

What next?

Rank the material combinations from least to most effective.

Compare experimental results with the actual triboelectric series.

Use small pieces of paper instead of peppercorns and repeat the experiment.

Light Painting

Czechia

Background

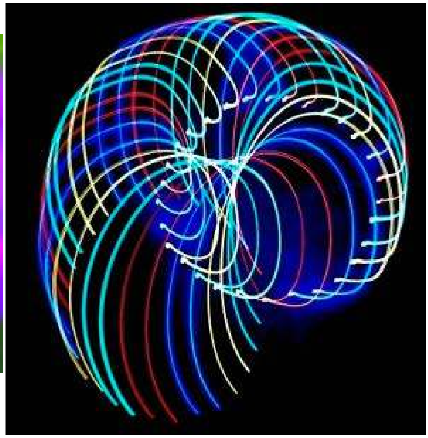
Light trail photography is a type of long exposure photography that highlights the movement of light. By keeping the shutter open for a long period of time you can capture more light hence, showing how it moves across the frame.

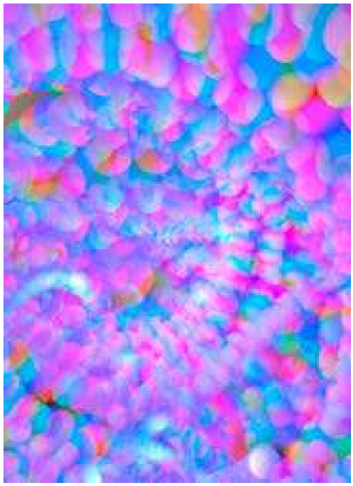
You will need:

- ✓ Smartphone
- ✓ Slow Shutter app (or other)
- ✓ Various light sources

Follow these steps:

1. Download the Slow Shutter app for iPhone.
2. Change capture mode to light trail.
3. Set light sensitivity to full, shutter speed to bulb and ISO to 100.
4. Choose your light source e.g. laser, LED strip lights or Christmas tree lights.
5. In pitch dark room move the light source and press the shutter on the app.
6. You can change the speed of the light source or vary the motion to create different effects.
7. You can add to your picture by opening and closing the shutter building the image.
8. You can vary the colour saturation, hue or brightness in the edit option.





So what happened?

'See Katerina Lipertová's stunning gallery https://eu.zonerama.com/KaterinaLipertova/Album/10083252

What next?

Using a mysterious glowing ball from Educational Innovations you can take light trail photos to show that the white light is actually made up of the three primary colours red, green and blue. There are three oscillating LEDs inside the ball that your eye perceives as white light. When you take a light trail photo you can see the overlapping colours and the secondary colours are then revealed.

Great way to also discuss persistence of vision.

With a good quality camera you can even take a photo of the sky at night showing the movement of the milky way galaxy.

Shedding Light on a Picasso

Greece

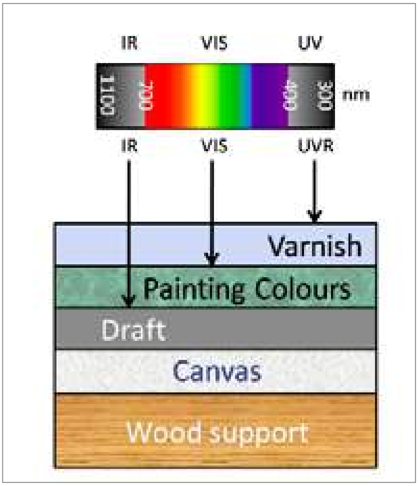
Background

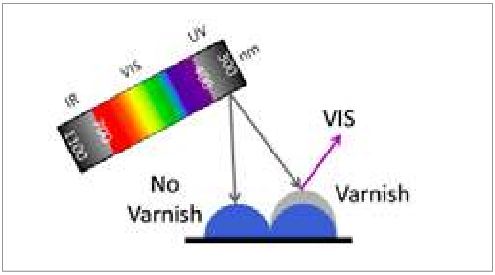
Researcher's have discovered hidden underpaintings, over the past two decades, in multiple works from Pablo Picasso's Blue period. These underpaintings have been discovered using various wavelengths from the electromagnetic spectrum. Picasso sometimes painted over old canvases to save money.

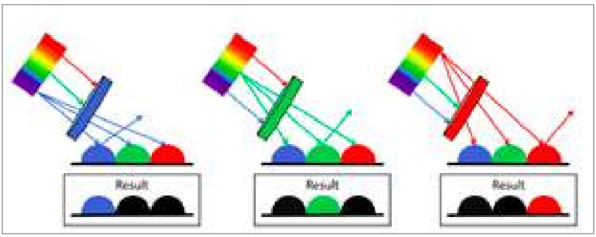
For example, an x-radiograph of Picasso's Crouching Beggar-woman, 1902, rotated 90 degrees has revealed that underneath is the landscape of the Labrinth of Horta, Barcelona.

Infrared technology has shown the portrait of an unknown man beneath Picasso's The Blue Room, 1901.

In general light penetrates the material in the artwork to different degrees depending on its wavelength. We can see figure 1 below that the UV rays only reach the varnish layer, visible light rays down to the main pigment and then IR rays penetrate down to the draft. In figure 2 we can see that if we use filters only certain wavelengths pass through whilst blocking the rest. A red filter would only allow red light to pass through but would absorb blue and green causing the image to look black for those colours. In figure 3 we can see how some varnishes contain special molecules that fluoresce when exposed to UV light.







Figures from https://scienceinschool.org/article/2025/shedding-light-on-a-picasso/

Shedding Light on a Picasso : Activity 1: UV Radiation

Greece

You will need:

- ✓ Watercolour paper
- ✓ Watercolours
- ✓ Acrylic varnish
- ✓ UV lamp

Follow these steps:

1. Get students to paint a picture using the watercolours and watercolour paper and allow to dry.
2. Get one student to cover part of the picture using the acrylic varnish without anyone seeing.
3. Allow varnish to dry.
4. Using the UV lamp get students to find the part of the picture that had been covered by the varnish by looking for fluorescence.

So what happened?

When the picture is illuminated with a normal torch the students do not notice any changes to the painting. When the painting is illuminated with the UV torch they will see part of the painting fluoresces where the varnish is. This can be seen in Papa Smurf's beard on the right below.

What next?

Try the filters in the next investigation.

Shedding Light on a Picasso. Activity 2: Filters

Greece

You will need:

- ✓ Water colour paper
- ✓ Watercolours/markers
- ✓ Optical Filters
- ✓ Smartphone

Follow these steps:

1. Get students to paint a picture using the watercolours and watercolour paper and allow to dry. (Mainly use red, green and blue for best effect.)
2. Place the red filter in front of your camera lens on your phone and take a photo.
3. Repeat for the blue and then green filter.

So what happened?

As can be seen in the images, when the blue filter is used the blue paint appears brighter and the other colours appear darker. The red paint appears brighter with the red filter and the other colours darker and the same with the green filter.

What next?

You can also use the filters with the greyscale setting on your phone to easily identify the areas that absorb the radiation and the (black) and the areas that reflect the radiation (white areas).

This can be found in your settings under accessibility, display & text size, colour filters.

Shedding Light on a Picasso. Activity 3: Infrared Radiation

Greece

You will need:

- ✓ Water colour paper
- ✓ Water colours/markers
- ✓ Graphite pencil
- ✓ Smartphone

Follow these steps:

1. Get students to draw a sketch with the pencil.
2. Cover the sketch with markers or watercolour/oil paint, avoiding the use of black.
3. Get each group to swap their images once the paint is dry.
4. Place the painting in front of the camera. Set the camera to night mode (turn off lights or cover light sensor on the camera) and get students to figure out what the pencil drawing was.

*(Camera must have night mode option for this to work)

So what happened?

The graphite in the pencil absorbs the infrared making it appear black and revealing the hidden picture.

This is like the draft images that have been revealed in some of Picasso's Blue Period paintings.

What next?

Students could do cross-curricular links with the art class to research other art that has been found under paintings using radiation technology. You can also use an IP camera to connect to PC

Light up a house – The secrets of an electrical switch

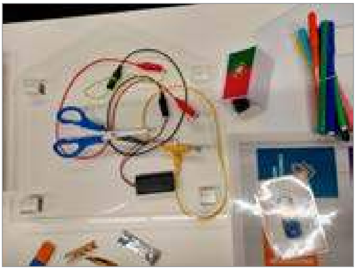
Portugal

Background

This activity helps students explore electric circuits and conductivity through a hands-on, creative project. Students are challenged to design and build a functional light switch that controls a silicone LED strip lighting up a small acrylic model house. Through the process, students learn how electricity flows, how conductors and insulators influence circuits and how switches control the flow of electric current. They begin their exploration through a fun board game called "Lit or Unlit House", which helps them understand the fundamental principles of circuits.

You will need:

- ✓ Model house (small acrylic or cardboard)
- ✓ LED silicone strip (low voltage)
- ✓ Battery pack (AA or 9V) and connector leads
- ✓ Electrical wires with clips or crocodile connectors
- ✓ Board game: "Lit or Unlit House" (printed board, question cards, counters, dice)
- ✓ Conductive materials: paper clips, aluminium foil, coins, metal nails, copper tape, graphite pencil
- ✓ Insulating materials: plastic spoons, wood, rubber bands, fabric, paper



Follow these steps:

1. Introduction and Exploration
   Show a real electrical switch and ask students to speculate how it works. Introduce the terms circuit, conductor, insulator, and switch.
2. Game-Based Learning – "Lit or Unlit House"
   Students play in small groups to learn about circuit concepts: identifying which circuit diagrams are complete or incomplete; predicting whether a bulb will light or not; learning what happens when a material blocks or completes the path.
3. Investigating Conductors and Insulators
   Provide each group with a battery, LED and wire connectors. Ask them to test various everyday materials to see which allow the LED to light. Record observations in a simple table.
4. Designing the Light Switch
   Students create a simple switch to control your LED light in the model house. They demonstrate basic switch principles (open/closed circuits). Students use materials (cardboard, tinfoil, paper clips, etc.) to design a mechanism that connects and disconnects the circuit.
   Testing and Refining (20 minutes)
   Each group tests their light switch. If the LED doesn't light, guide them to troubleshoot connections or material choices.

So what happened?

Students discovered how electricity needs a complete path to flow and how different materials affect conductivity. They learned that switches act as gatekeepers in circuits controlling the flow of current by opening (off) or closing (on) the electrical path.

What next?

- Engineering challenge: Add multiple LEDs and switches to simulate a "smart home" with different rooms lighting up independently.
- Science link: Investigate the difference between series and parallel circuits.
- Technology integration: Use a microcontroller (e.g. Micro:bit or Arduino) to automate the lighting with sensors.

Coloured Shadows

Greece

Background

The primary colours of light are Red, Green, and Blue (RGB). When all three overlap at full intensity, they create white light. When one or more of these colours are blocked by an object, the remaining colors mix to create secondary colours. This demonstration shows that our eyes perceive these mixtures as shadows that aren't black, but vibrant hues like Cyan, Magenta, and Yellow.

You will need:

- ✓ Three light sources (LEDs or flashlights) in Red, Green, and Blue.
- ✓ A plain white screen or a flat white wall.
- ✓ An opaque object (e.g. a pencil).

Follow these steps:

1. Aim all three coloured lights at the same spot on the white screen.
1. Adjust the distance of the lights until the area where they overlap looks as close to pure white as possible.
1. Place the object (pencil) in front of the screen so it casts a shadow
1. Look at the different shadows created. Notice how they overlap and change colour as you move the pencil closer to or further from the screen.

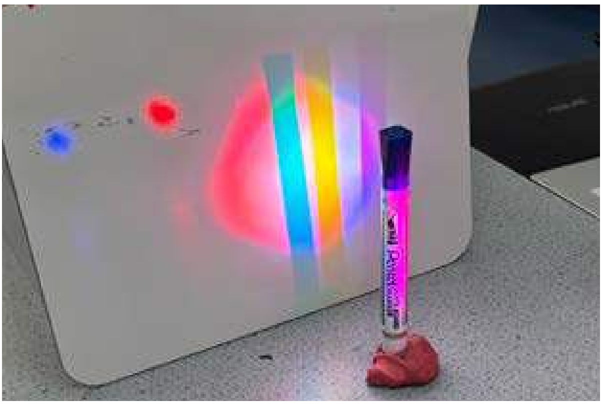
So what happened?

When the pencil is placed in front of the lights, it blocks the light rays from each source at slightly different angles.

- Where the pencil blocks only the Red light, the Green and Blue lights still hit the screen. Since Green+Blue=Cyan, you see a Cyan shadow.
- Where it blocks only the Green light, Red and Blue light combine to create a Magenta shadow.
- Where it blocks only the Blue light, Red and Green combine to create a Yellow shadow.

What next?

Use different shaped objects to see how the secondary colours overlap to create even more complex patterns.



Pringles Pinhole Camera

Germany

Background

A pinhole camera demonstrates the fundamental principles of optics and image formation. Light travels in straight lines, and when it passes through a tiny aperture, it creates an inverted image on the opposite side. Unlike the human eye or modern cameras which use lenses to focus light, a pinhole camera achieves this using only a small opening. The Pringles container provides an ideal light-tight cylindrical body with an appropriate length to serve as the camera's focal length.

You will need:

- ✓ Empty Pringles container with plastic lid
- ✓ Empty aluminium drinks can
- ✓ Black paper
- ✓ Photographic paper (available from photography suppliers)
- ✓ Fine pin or needle
- ✓ Scissors
- ✓ Black electrical tape
- ✓ Access to a darkroom or changing bag for loading film
- ✓ Photographic developing chemicals and trays

Follow these steps:

1. Line the inside of the Pringles container with black paper to prevent internal reflections.
2. Cut a square from the aluminium can, pierce a tiny hole in the centre with a small diameter pin (0.5mm). This will be the aperture of the camera.
3. Cut a hole in the bottom of the Pringles container, and tape the aluminium square over it, ensuring the pinhole is centred and there are no light leaks.
4. Attach black card over the pinhole so that it can be lifted for exposure. This will be the shutter.
5. In a darkroom (red light) or a photographic changing bag, use the lid of the Pringles container as a template to cut a circle out of the photographic paper.
6. Tape this circle to the lid with the light-sensitive side pointing into the container. Secure the lid to the container and seal any gaps with black tape to prevent light leaks.

When ready to take a photo, open the shutter for 2-3 minutes and then close it.

Take the pinhole camera to the darkroom and develop the photographic paper.

So what happened?

The pinhole allowed light rays from the scene to pass through and form an inverted image on the photographic paper. Because light travels in straight lines, rays from the top of the subject pass through the pinhole and hit the bottom of the photographic paper, whilst rays from the bottom hit the top—creating an upside-down image.

What next?

Try different pinhole sizes and observe how this affects sharpness and exposure time.

Experiment with exposure times in different lighting conditions.

3D Light

Bulgaria

Background

When students study reflection and refraction they also investigate mirrors and lenses. As part of this process, they learn to use 2D ray-diagrams and also explore 2D rays in the laboratory using a standard ray-box set-up.

While this approach helps students to understand how light is manipulated using geometric optics, it may unintentionally preclude students from thinking about reflection and refraction in 3D, which is how most mirrors and lenses actually operate. This demonstration uses simple materials to show reflection and refraction of light in 3D.

You will need:

- ✓ A trough with transparent walls.
- ✓ Water
- ✓ Fluorescent ink (most highlighters contain this ink and "invisible ink" pens are also a good source)
- ✓ UV torch (360 lumens)

Follow these steps:

1. Place a concave mirror of short focal length (shorter than height of trough) face up, at the bottom of the trough.
2. Fill the trough with water.
3. Add some highlighter ink to the water (note you can

do this by dipping the tip of a highlighter pen into the water for 30 s or by putting in 5-6 drops of ink from an "invisible pen" - note you may have to experiment here - too little and you won't get sufficient fluorescent glow, too much and the solution starts to become opaque under UV light).
4. Darken the room by turning off lights and closing blinds
5. Turn on the UV torch and shine it so that its light forms a vertical beam which illuminates the surface of the mirror.
6. Observe the water trough from the side.

So what happened?

UV light passes through the water-highlighter solution, strikes the mirror and is reflected back through the solution. Fluorescent molecules in the water absorb high-energy UV photons, entering into an excited state. As they relax back to their normal state they re-emit this energy as lower-energy, longer wavelength photons which are in the visible light range. Thus the path

of the reflected light is made visible as an eerie glow. The cone of light reflected from the mirror converges around the focal point of the mirror.

What next?

Try mirrors of different focal lengths and watch how the dimensions of the reflected-light cone change.

Modify your set up to use lenses instead of mirrors. Try different lens types/shapes, lenses of different focal lengths and combinations of lenses.

Model the lensing effect of the cornea of the eye by filling a round bottom flask with the fluorescent solution and shining the UV light through it. Add converging and diverging lenses in front of the flask to model lens correction for myopia and hypermetropia.

Image sourced from: https://www.phywe.com/experiments-sets/student-experiments/light-path-and-focal-length-of-a-convex-lens_9365_10296/

Visualising Birds Songs and Calls

Portugal

Background

Birds have a unique vocal organ called the syrinx, located where the trachea branches into the lungs. Unlike humans, whose larynx is at the top of the windpipe, the syrinx allows for more complex vocalizations. When air is pushed through the syrinx, it causes thin membranes to vibrate, creating sound waves. Birds use a system of up to seven pairs of muscles to stretch, shape, and control the syrinx membranes. Changing the tension on the membranes alters the frequency of the wave hence, the pitch of the note made by the bird. Adjusting the amount of air passing through the membranes, controls the amplitude of the sound wave hence, the loudness.

Birds songs are complex, musical, and usually longer vocalizations primarily used by males to defend territory and attract mates. Calls are shorter, simpler sounds for more immediate, functional communication like warning of danger, staying in contact with a flock, or begging for food.

Phyphox is a free app that allows you to carry out many physics experiments. One of the functions is an audio spectrum for displaying the frequency spectrum of an audio signal.

This function is a lovely simple way of looking at the differences in Irish birds calls.

You will need:

- ✓ Smartphone
- ✓ Phyphox app
- ✓ Bird calls and songs (scan QR code for birdwatch Ireland audio files) or find birds in your local park and record.

Follow these steps:

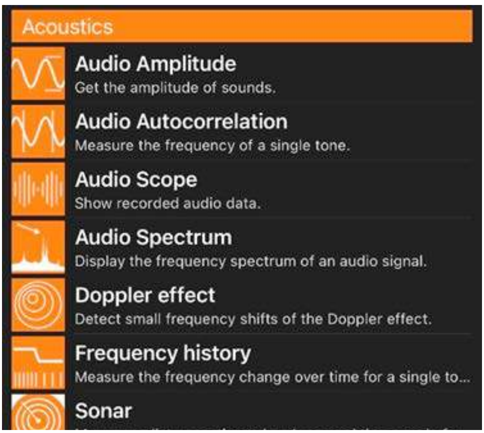
1. Open Phyphox app.
2. Select audio spectrum.
3. Select history for Fourier Transform graph.
4. Open Bird watch Ireland website and select the bird you want to analyse.
5. You can choose to analyse the song or the call.
6. Press play on the audio spectrum on Phyphox, then press play on the audio file of the bird.
7. Let the call/song play and take a screenshot of your Fourier transform graph.
8. Press pause.
9. If you go to spectrum on Phyphox you can see the peak frequency recorded and the spectrum graph.
10. If you go to raw data on Phyphox you can see the amplitude of the bird's call.

So what happened?

'Here are some samples of some Irish birds' calls.

Calls can be repetitive and in short bursts making it easier to analyse the graph.

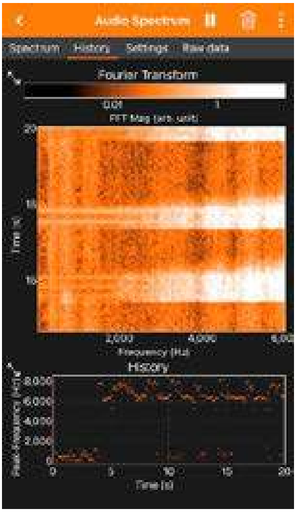
The bright white lines show when the call is made, the frequency and the time between the call can also be measured.

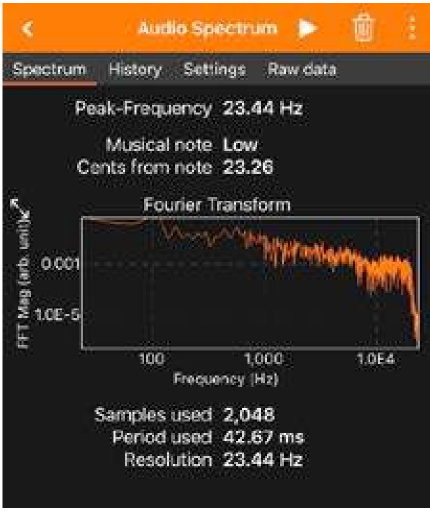


What next?

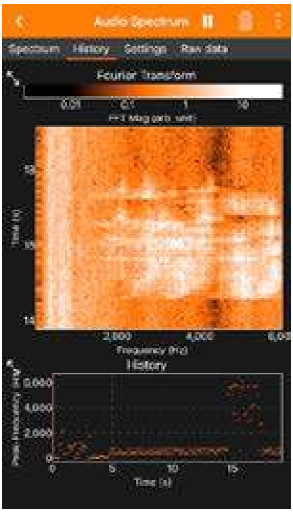
You can also export the raw data to an Excel file where students can use formula to find the range of frequencies in the different birds' calls using max/min function or even create their own graph selecting some of the data.

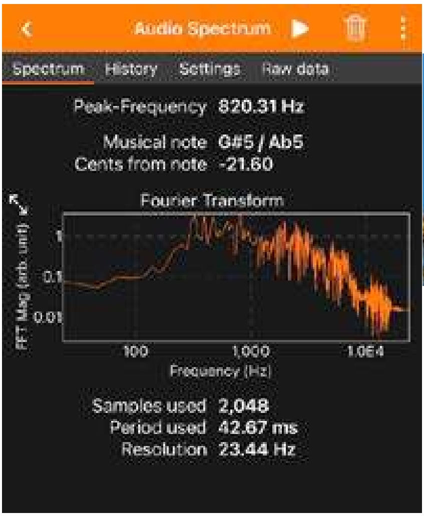
SCAN ME





1. Wren: A sharp, abrupt "check". Often rapidly repeated creating an agitated churr.





2.Blackbird: Repeated "chack chack chack" clucking sound, followed by high-pitched "chink chink chink" when agitated. Also a soft "whuh" and thin wispy "tseep".

Pythagorean Cup

Hungary

Background

The Pythagorean cup dates back to the 1st century AD and is also known as the greedy cup and Tantalus cup. It looks like a normal drinking cup, except for a column which protrudes through the centre of the cup's base. The cup functions normally, unless you get too greedy and fill it close to the top.

Image sourced from: https://historycollection.com/pythagoras-greedrycup-and-other-lesser-known-ancient-world-facts/

You will need:

- ✓ A disposable cardboard cup.
- ✓ Flexible plastic tubing or maybe a bendy straw
- ✓ Hot glue gun or other form of water-proof glue.
- ✓ Water.

Follow these steps:

1. Puncture the bottom of the cardboard cup with a pencil.
2. Pass the plastic tubing from inside the cup through this hole so that it protrudes through the base.
3. Secure the tubing in place and seal the hole using generous amounts of hot glue.
4. Bend the plastic tubing to make an inverted Ushape inside the cup. Use a rubber band to maintain the U

bend. Cut the tubing to the length such that it reaches down to within 1 mm of the cup's base. Note that the height of the U bend determines how far you can fill the cup before it empties.
5. Fill the cup to different heights and observe its behaviour.
6. Fill the cup so that the water level exceeds the height of the U bend and observe what happens.

So what happened?

Up to the point where the water level is below that of the U-bend the cup holds its contents. Once the water level exceeds the U-bend height the water starts to empty through the plastic tubing. It continues to do so until the cup is (almost) empty.

How does it work?

As water fills the cup the water level in chamber A and chamber C are the same (Pas-

cal's principle of communicating vessels). The air pressure inside chamber B is equal to atmospheric pressure (since it's open to the atmosphere). Once the water level rises above the lower edge of the U bend, the weight of the water under gravity causes the water to flow through chamber B and at the same time expells the air therein.

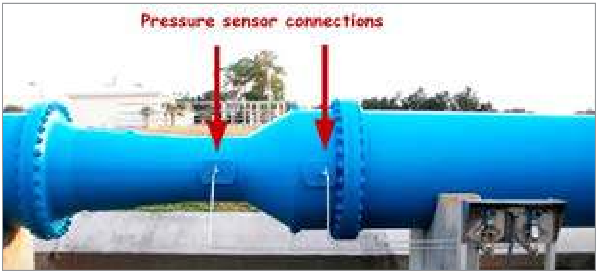
Even when the water level in Chamber A falls below the lower edge of the U bend, flow continues as there is no air pressure in chambers B and C to resist this flow. The water in chamber A forms a seal over chamber C/B preventing air from entering. The water continues to flow until the water level dips below the lower tip of chamber C and this airtight seal is broken.

What next?

There are many different modifications to the original Pythagorean design, including versions which conceal the siphon tube inside their handles or even within their walls. If you have access to a 3D printer, you can download Pythagorean-cup designs from websites such as https://www.thingiverse.com/. The devious pythagorean cup is an example of one such design which includes the siphon in its walls.

Bernoulli's Principle in Action

Kazakhstan



Background

The physics of fluid flow has many applications in the world around us, from generating the lift which keeps airplanes in the air to the ability to bend a free-kick around a wall in soccer. This demonstration from Kazakhstan may be used to demonstrate Bernoulli's principle, that is that as the speed of airflow increases, pressure drops.

You will need:

- ✓ Leaf blower (or similar)
- ✓ 1 x 28 mm plastic elbow joint
- ✓ 1 x 28 mm plastic t-joint
- ✓ 1 x 28 mm plastic straight connector
- ✓ 2 x 28 mm to 22 mm plastic reducer connector
- ✓ 1 x 22 mm plastic t-joint
- ✓ 2 x 22 mm to 15 mm plastic reducer connector
- ✓ 1 x 15 mm t-joint
- ✓ 1 x 15 mm end cap
- ✓ 1 x 28 mm rubber bung
- ✓ 2 x ping-pong balls
- ✓ 1 x 28 mm pipe bracket
- ✓ 1 x 15 mm pipe bracket
- ✓ 3 x 28 mm rubber reducer
- ✓ 1 x wooden base

Follow these steps:

1. Assemble your set-up as per the image. The horizontal section of piping should start on the left-hand side with a diameter of 28 mm, reducing to a diameter of 22 mm and ending up on the right-hand side with a diameter of 15 mm. Each different width of pipe should have a vertical outlet which has a top diameter of 28 mm and has a rubber reducer insert.
2. Plug one of the vertical outlets using the rubber bung.
3. Place a ping pong ball on top of each of the open outlets.
4. Predict which ball will rise highest when the air is turned on. Explain your reasoning.
5. Turn on the leaf blower and blow air in through the left-hand side of the set-up. Observe what happens.

   Compare your observations to your prediction.
6. Repeat with a different pair of vertical outlets.

So what happened?

As airflow increases in speed, air pressure drops. This is Bernoulli's principle.

Each vertical outlet is connected to a section of pipe with a different diameter. The speed of flow through each section depends on the diameter of the pipe and hence the pressure also depends on the diameter of pipe. Because of this difference in pressure, the ping-pong balls float at different heights on each outlet.

What next?

With access to some 3D design software and a 3D printer you can also make a version of this demonstration.

Flow meters (Venturi meters) are based on this principle. By measuring the pressure difference across two different (and known) pipe diameters the flow rate inside the pipe can be calculated.

Visualising Streamlines

Kazakhstan

Background

The physics of fluid flow has many applications in the world around us, from generating the lift which keeps airplanes in the air to the ability to bend a free-kick around a wall in soccer. In this ingenious demonstration from Kazakhstan, we gain an important insight into this world as we see why a ping-pong ball remains stable in a column of moving air.

You will need:

- ✓ Hairdryer
- ✓ Small sieve (fine mesh)
- ✓ Sewing thread
- ✓ Ping-pong ball
- ✓ Duct tape

Follow these steps:

1. Place the ping pong ball in a vertical steam of air from the hairdryer and measure how high above the hairdryer it floats.
2. Cut approx 20 threads of equal length (make sure their length exceeds the distance at which the ping pong ball floats) and attach to the sieve at regular intervals by knotting through the mesh.
3. Attach the sieve to the nozzle of the hairdryer using duct tape. Note depending on your hairdryer and sieve, this may take a little or some work. The aim is to have the majority of air which leaves the hairdryer passing through the mesh.
4. Turn on the hairdryer, point the nozzle in the vertical direction and observe the behaviour of the threads.
5. Gently place a ping-pong ball into the airflow such that it floats. Observe the behaviour of the threads.

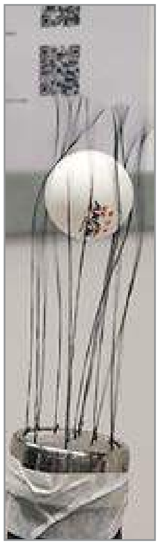
So what happened?

Streamlines are used to understand fluid flow. The closeness of streamlines is an indicator of speed of flow. The faster a fluid moves, the lower the pressure.

Initially the streamlines are evenly spaced indicating that the speed of flow of the air is constant across the stream.

When the ping-pong ball is inserted, the airflow is disrupted. As the air moves around by the edges of the ball it speeds up. This is evidenced by the streamlines around the ball being closer together. This in turn means that there is a region of low pressure around the ball.

The ping-pong ball is stable in the airstream due to the fact that if it starts to "fall out of the airstream" it encounters higher air pressure from the surrounding still air, which forces the ball back into the stream.



What next?

Tilt the hairdryer to find the maximum angle at which the pressure difference inside and outside the stream keeps the ball trapped.

Build a similar set up to investigate the lift generated by an aerofil.

Creation of Self-Stressed Structures

Ukraine

Background:

This lesson introduces students to tensegrity technology an engineering principle that combines tension and integrity to create self-supporting structures. The term tensegrity is derived from the words tension and integrity, meaning "a tense connection." Tensegrity structures are made from rods and ropes or strings, where the rods work in compression and the ropes work in tension and importantly, the rods never touch each other. This activity allows students to explore the relationship between geometry, balance and physical forces. Through building their own models, students develop 3D visualization and spatial reasoning, creative and engineering skills as well as an understanding of physical principles such as equilibrium, vector forces and potential energy minimisation.

You will need:

- ✓ Wooden sticks, rods or straws (4-6 pieces)
- ✓ Elastic cords, fishing line or string
- ✓ Scissors
- ✓ Hot glue gun or adhesive tape
- ✓ Small weights (e.g. washers or coins)
- ✓ Cardboard or foam base for mounting the structure
- ✓ Ruler and protractor
- ✓ Notebook for design sketches and reflections.

Follow these steps:

1. Introduce the concept of tensegrity using images or short video demonstrations. Explain how tensegrity structures rely on the balance between compressive rods and tensile cables, forming a self-stressed structure that appears to float or suspend in space.
2. Students sketch a simple tensegrity model design in their notebooks, labelling which parts will be in tension and which will be in compression. Discuss potential materials and proportions.
3. Building the Structure - Cut rods and strings to the required lengths. Assemble the base and attach the first set of cords to form tension lines. Gradually attach the rods, ensuring they do not touch each other. Adjust the strings until the structure becomes stable and self-supporting. Test the structure's stability by gently pressing it from different directions.

So what happened?

Through the construction of their own tensegrity models, students experienced first-hand how forces of tension and compression interact to create structural stability. They observed how small adjustments affect balance, demonstrating key physics and mathematical concepts (Transformation of figures in 3D space; Principle of minimum potential energy; Functional dependencies between size, angle and stability; Vector relationships within a structure. Students also developed engineering thinking by testing, redesigning and problem-solving collaboratively. The process revealed how art and physics intersect in architectural design, reinforcing STEM principles through tactile experience.

What next?

- Students make like to explore the following:
- Mathematics connection: Calculate vector magnitudes or tension forces using trigonometry.
- Physics connection: Experiment with different materials (e.g. elastic vs. non-elastic strings) to see how they affect equilibrium.
- Art connection: Create aesthetic tensegrity sculptures exploring symmetry and pattern.

Floating Sticks: Build a Tensegrity Structure

Ukraine

Background:

The portmanteau Tensegrity (a combination of "tension" and "integrity") was coined by Buckminster Fuller, an architect, engineer, and inventor, in the 1950s. who was fascinated by how structures could balance forces of tension and compression to create stability.

You will need:

- ✓ 9 rubber bands.
- ✓ 3 wooden dowels (a length of a HB pencil)
- ✓ 6 small screws that will be fastened to the end of each dowel.

Follow these steps:

1. Place a screw on each end of all three dowels. These screws will serve as anchor points for the rubber bands.
2. Setup the 3 dowels in your hand as shown in the picture 1(1-tensegrity and 2-tensegrity).
3. Attach one rubber band between non-adjacent ends of dowels on opposite levels as shown in the picture (3-tensegrity). You will be using 3 rubber bands in total for this.
4. The rubber bands should pull against each other, creating a balance of tension and compression that gives the prism its rigidity.
5. Using 3 rubber bands, connect each pair of adjacent dowel ends to form a secure triangular base.
6. Attach the rubber bands between the screws at each junction.(4-tensegrity)
7. Using the last 3 rubber bands, connect each pair of adjacent dowel ends to form a secure triangular top.
8. After securing all rubber bands, gently adjust the dowels and rubber bands to ensure the structure stands evenly.(5-tensegrity)

So what happened?

The tripod stands supported by the tension in the rubber and the compression of the wooden dowels.

The tension in the rubber bands keeps the dowels in position, while the dowels provide rigidity against the forces exerted by the rubber bands. This balance of forces is what makes the structure stand and gives it its unique floating appearance.

What next?

Build a 4 structure, 6 structure. Combine prisms together to make more complex structures.

Tangible statistics: Listen to the Data

Italy

Background

Tangible statistics makes data multi-sensory, helping students experience mathematical concepts through sound as well as sight. This activity uses Desmos' audio trace feature to help students develop intuition about different function types. As the audio plays, changing pitch represents the y-value of the function, allowing students to recognise patterns in exponential growth, periodic oscillation, and polynomial curves through sound alone.

This approach supports students with visual impairments, strengthens conceptual understanding, and makes abstract concepts more memorable.

You will need:

✓ Device with internet access to desmos.com/calculator and connected to a speaker

✓ Pre-prepared Desmos graphs (linear, quadratic, exponential, sine/cosine, etc.)

✓ Paper and pencils for students

Follow these steps:

1. Show students how Desmos' audio trace works using a simple linear function. Click on the graph line and press the audio trace button (speaker icon). Explain that higher pitches represent higher y-values.
2. Play the audio trace of your first function 2-3 times without showing the graph. Ask students to sketch what they hear, considering:

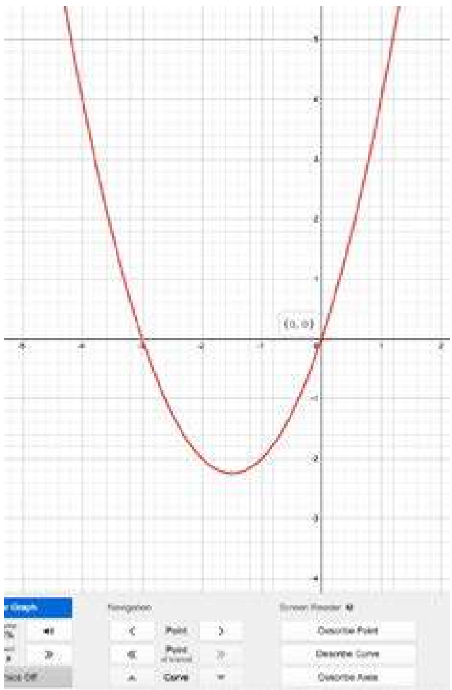
- Is the rate of change constant or changing?
- Does the pitch increase steadily, accelerate, or oscillate?
- Are there turning points or repeated patterns?

So what happened?

- Students quickly develop listening strategies.
- Exponential functions sound like they're "taking off" with accelerating pitch
- Sine waves produce recognisable, repeating patterns
- Quadratics show smooth curves with pitch rising then falling (or vice versa)
- Students with musical training often grasp patterns more quickly.

What next?

Input actual datasets and use the desmos audio trace to connect functions to real phenomena.



Looking at constellations

Bulgaria

Background:

Children's first interaction with the stars of the night sky is often through learning about the shapes and names of the more popular constellations. This may lead to a misconception that the stars in a given constellation are close together in space, whereas the reality of a 3D universe means they may be separated by astronomical distances and have very little effect on each other. This simple activity provides children with the chance to observe how distances in 3D may be very different to perceived distances in 2D, while also learning about the nomenclature of stars within constellations and star colours/temperatures.

You will need:

- ✓ White and black card (stiff enough to stand up)
- ✓ Playdough (white, blue, red, yellow)
- ✓ Wooden skewers.

Follow these steps

1. Print out an enlarged copy of a constellation on A3/A4 paper (see example of Cassiopeia) and stick to a piece of white card. Stand up the card.
2. Predict which stars are closest to each other.
3. Make models of each star using the coloured playdough and skewers.
4. Search up the distance of each star from earth (see values for Cassiopeia).
5. Place a black piece of card on the table top in front of the constellation print out.
6. Using playdough as a base, position each star on the black card such that:
   - they align with the image of the constellation when viewed at a distance
   - their locations from the front are scaled in accordance with their known distance from earth.
7. Which stars are closest to each other? How does your model compare to your prediction?

So what happened?

Because stars are so far away, we see them as a 2D projection on an imaginary surface known as the celestial sphere. This obscures the fact that the stars are located in a 3D universe and while we have historically organised them into groupings (called constellations) based on this 2D projection, such stars may actually not be close to each other.

What next?

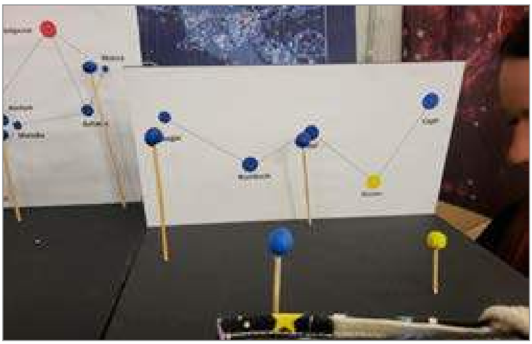
Research other constellations or groups of constellations and investigate what stars are close to each other.

Are some stars in different constellations closer to each other than ones in the same constellation.

Learn about the Bayer system for naming stars in a constellation based on brightness.

Learn about the different colour/spectral classification of stars and what this means for their lifecycle.

Learn how non-scientists took real astronomical observations and used them to develop the signs of the zodiac (definitely not science)



Cosmic Ray App

Czechia

Background

nSCIr runs the Cosmic Ray Observer which is a distributed cosmic ray detector that uses smart phones to collect cosmic rays.

Get the iOS app to take part in the global physics experiment.

The application works by detecting bright spots in the phone's camera when no light is entering. Some of these bright flashes are a result of cosmic rays or nearby radioactivity.

Cosmic rays are particles from outer space that travel across the universe. They can be made by the sun, stars exploding and even black holes. Most cosmic rays are blocked by our atmosphere and magnetic field but some strike particles in the atmosphere creating a shower of secondary particles.

The term cosmic ray dates back to 1925 and was coined by Robert Millikan.

You will need:

- ✓ A smart phone
- ✓ Electrical tape (black) or aluminium tape

Follow these steps:

1. Download the Cosmic Ray App from the Appstore.
2. Cover your camera lens with black electrical tape or aluminium tape to minimise background light.
3. Open the app.
4. When the app is open for long periods of time it will take a photo each time it detects an event, hence, it is best to have your device plugged in charging.
5. The phone can be placed in any orientation, but it's easiest to keep it dark if it is face up, with the main camera facing down, on a flat surface.
6. Muons can penetrate through roofs and walls, so it does not matter if you place the phone inside or outside, near a window or not.

So what happened?

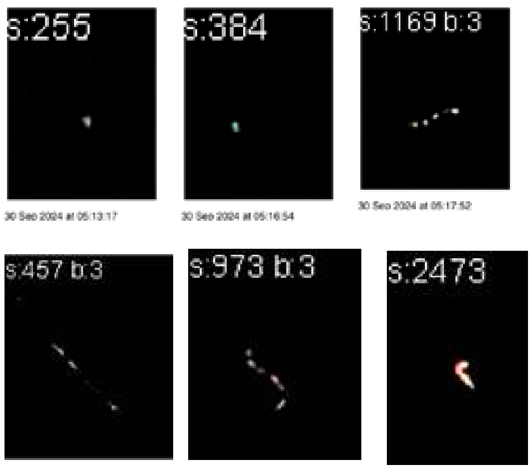
Bright flashes are detected and photos are taken. Most are a single bright dot which can be a result of background electrical noise but a few photos will show up a bright trail which could be muon trails.

What next?

You can bring radioactive sources nearby.

You could also try the app DECO for android phones.

Try the smartphone neutrino detector VENu developed by Oxford students.



Albedo

Germany

Background

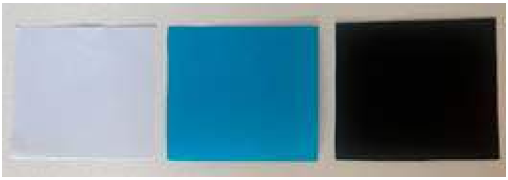
Albedo is the measure of a surface's reflectivity. Ice and snow have a high albedo, reflecting a large portion of the sun's energy (up to 70%), while the ocean has a low albedo, absorbing most of the sun's energy.

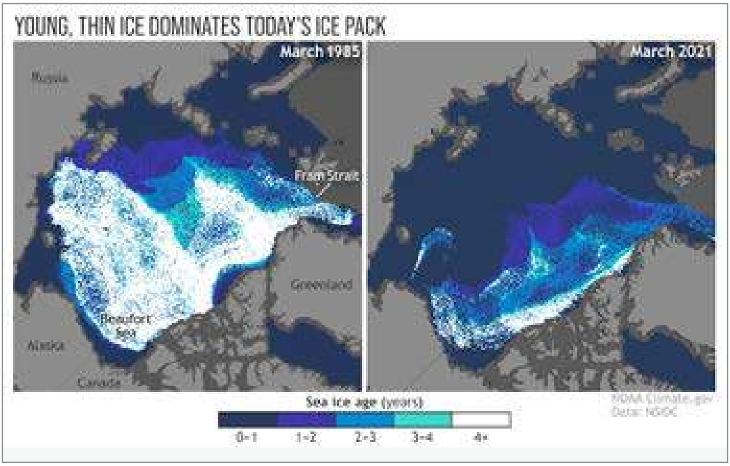
Arctic sea ice extent has been declining at a rate of about 13% per decade, based on data from 1979 to 2012, with the summer minimum extent consistently below the 1981–2010 average since 2007.

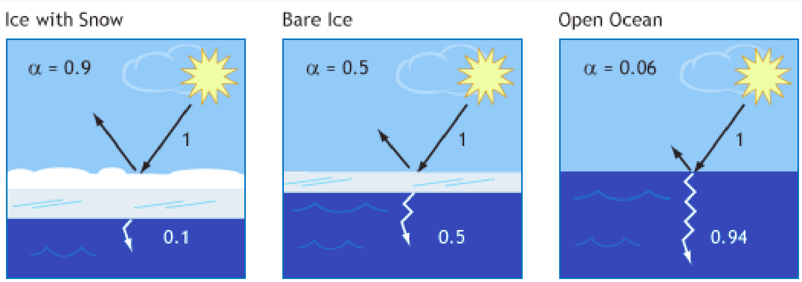
Also the ice itself has changed in thickness and age as can be seen in the image from NOAA climate.gov below.

You will need:

- ✓ Strong table lamp (not LED bulb)
- ✓ White paper, blue paper and dark blue paper.
- ✓ Infrared thermometer







Credit: The National Snow and Ice Data Center

Follow these steps:

1. Cut the pieces of paper to the same measurements.
2. Place the paper on a flat surface and use the infra-red thermometer to meas-ure the initial temperature of each piece of paper.
3. Place the lamp directly over the paper and illuminate each piece of paper for 5 minutes, keeping the height fixed.
4. Record the final tempera-ture of each piece of paper.
5. Calculate the change in temperature for each piece of paper.

So what happened?

The white paper will reflect the heat the most so its final temperature will be the low-est, whereas the darker paper will absorb the most heat and will have the highest final temperature.

What next?

Play the ice-albedo feedback loop dice game to enhance students understanding of how rising sea temperatures is causing the sea-ice to melt which in turn exposes more dark sea surface which in turn absorbs more of the sun's radiation. Also get students to

Ice-Albedo Feedback Loop

Germany

Background

As the climate warms more ice and snow melts which exposes the darker ocean or bare ground.

The newly exposed darker surfaces absorb more solar energy instead of reflecting it. This absorbed energy heats the water and land, leading to more warming. The increased warming causes even more ice to melt, and the cycle continues to amplify itself.

This is a positive feedback loop. The initial change is amplified leading to larger effects.

This process is a major factor in polar amplification and is considered a significant contributor to climate change, especially in the Arctic.

You will need:

- ✓ 2 lunch box containers
- ✓ 12 dice
- ✓ Table for results (see image attached)

Follow these steps:

1. Label one container ice and the other water.
2. Place 12 dice in the ice container and 0 dice in the water container.
3. Summer: Roll all the ice dice. 1s and 2s represent ice melt and must be transferred to the water container.
4. Record the number of ice dice remaining in the table.
5. Winter: Take as many water dice as there are ice dice and roll them (take all the water dice if there is less water dice than ice dice). All the 1s and 2s remain water and the rest become ice. Transfer the ice dice to the ice container.

Water Ice

6. Record the number of ice dice in the table.
7. Repeat for 20 rounds.
8. Start a new game but this time place 3 dice in the ice container to start and 9 dice in the water container.
9. Draw a graph of the ice in summer and winter for the 20 rounds.
10. Compare the graphs from both games with the ice-albedo feedback loop and discuss how the amount of ice at the beginning affects the amount of ice at the end of the game.

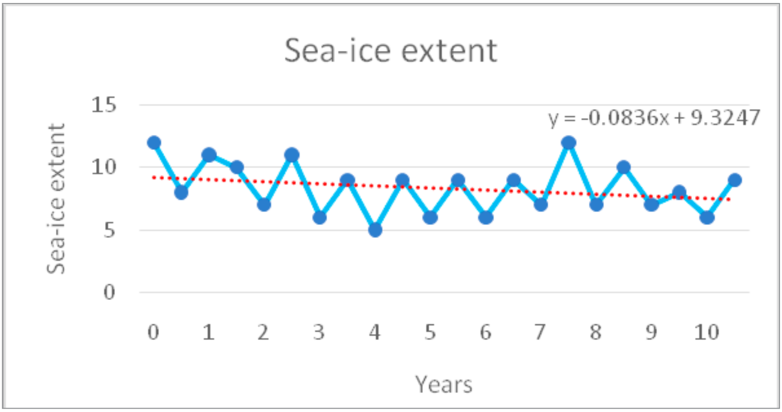
So what happened?

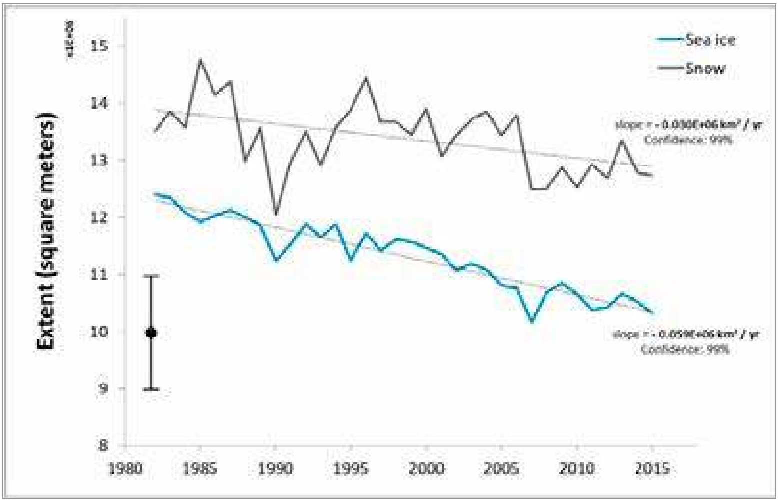
Ice cover can be seen to increase and decrease from winter to summer.

See sample graph plotted using MS Excel from data collected.

Compare graph from the game with the graph below from actual data collected and presented in Polar Science, Vol 28, June 2021, 100617 on www.sciencedirect.com

Round	1	2	3	4	5	6	7	8	9	10	11	12	13
Ice (summer)													
Ice (winter)	12												





14	15	16	17	18	19	20

What next?

Use www.meereisportal.de for further data analysis using the maps and graphics investigating sea-ice extent from 1973 to 2025 in the Arctic or Antarctic.

Use a smartphone as a cosmic ray detector

Czechia

Background

Cosmic rays enter Earth's atmosphere and collide with atmospheric nuclei, initiating an "air shower" - a cascade of secondary particles including muons that reach ground level. About one muon passes through your body every second, yet they remain completely invisible to us.

In addition to sensing visible light, the CMOS camera sensor in smartphones and webcams can detect both infrared and ionising radiation. When high-energy particles strike the silicon semiconductor in the sensor, they generate an electrical signal - demonstrating the photoelectric effect, but with particles instead of photons. By covering the camera lens with black tape, visible light is blocked whilst allowing high-energy cosmic particles to pass through and interact with the sensor.

The smartphones will the Soramame app, available on both iOS and Android stores. This app is part of a global monitoring project developed by Kanagawa University in Japan.

https://soramame.n.kanagawa-u.ac.jp/en/

You will need:

✓ iPhone or Android smartphone (preferably an older device not in daily use)

✓ Black electrical tape or aluminium foil

✓ Charging cable

Follow these steps:

1. Download and Install

- iOS: Search "Cosmic Ray Detector SORAMAME" in the App Store

- Android: Search "Cosmic Ray Detector SORAMAME" in Google Play Store
- Install the app on your device

2. Prepare Your Phone

- Cover the rear camera completely with black electrical tape
- Ensure no light can enter - check for gaps around the edges
- The app will alert you if light blocking is insufficient

3. Initial Setup

- Open the Soramame app
- Grant location permissions (important for scientific data - allows researchers to map cosmic ray intensity globally)
- Connect to charger - keep plugged in throughout the observation period

4. Calibration Phase

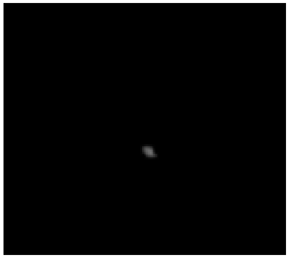
- When launched for the first time, the app enters a learning phase to determine your phone's noise level
- During this phase, the detection rate may temporarily appear very high - this is normal!
- Keep the app running for at least 3 hours after initial launch for accurate calibration
- Do not disturb the phone during this period

5. Once calibration is complete, the "Keep the current threshold value" option will be checked

- keep the app open with screen visible
- Place the phone on the desk
- Ensure room is reasonably dark or camera remains covered with black tape

So what happened?

1. Rings appearing on screen as cosmic rays strike the sensor
2. Each ring shows exactly where a particle hit
3. Tracks from charged particles are displayed in real time as images
4. Tap the graph icon (upper right corner) at any time
5. View your detection history without stopping the observation
6. See frequency graphs showing your rate over time
7. Compare with global network data



detected cosmic ray

_cosmic ray detector screen for ios and android

What next?

Use the app when travelling on a plane to investigate if altitude has an effect on the detection rate

Check is it possible to shield the detector from the cosmic rays by putting it in a cabinet, under the stairs, in a box etc

Note:

The Soramame smartphone app provides an excellent introduction to cosmic ray detection by counting individual muons and connecting you to a global research network, it has one limitation - it only records that a particle was detected, not the path it took. For a more visual and dramatic demonstration of cosmic rays passing through matter, the webcam detection method offers a significant advantage: it reveals the actual trajectories of individual particles as visible tracks across the sensor, creating accumulated images that show exactly where each cosmic ray travelled

Soramame_detectors worldwide

Use a Webcam to detect Cosmic Rays

Czechia

Background

The Soramame smartphone app successfully counts cosmic ray muons, it only shows where particles were detected, not the paths they travelled. The webcam method provides superior visualisation by revealing actual muon trajectories as visible tracks across the sensor. The Theremino Particle Detector software superimposes frames captured by the webcam to create a "long exposure" effect, allowing particle traces to accumulate over time rather than disappearing after each frame. This creates striking images showing the paths cosmic rays take as they pass through the detector - transforming invisible radiation into visible evidence.

You will need:

- ✓ Inexpensive webcam
- ✓ Windows PC or laptop with USB port
- ✓ Black electrical tape
- ✓ Theremino Particle Detector (free)
- ✓ Download from: https://physicsopenlab.org/resources-downloads/
- ✓ Projector or large monitor (for classroom demonstrations)

Follow these steps:

Visit: https://physicsopenlab.org/resources-downloads/ and Download: Theremino_ParticleDetector_V1.1.z

1. Wrap black electrical tape completely around the lens area. Use 3-4 layers of tape for complete light blocking
2. Plug webcam into USB port. Windows should recognise it automatically. Wait for "device ready" notification
3. Launch Theremino Particle Detector: Configure webcam settings:

- Click "Camera Settings" button
- A settings window will appear
- Apply these critical settings:

Setting	Value	Why
Exposure	-7	Corresponds to 0.1 seconds - minimises noise
Gain	255	Maximum - increases sensitivity to faint signals
Sharpness	255	Maximum - makes tracks more visible
White Balance	Auto or disabled	Not critical
Focus	Manual (if available)	Prevents auto-adjustment
Focus	Manual (if available)	Prevents auto-adjustment

- Tick the "Exp." checkbox if present
- Close settings window

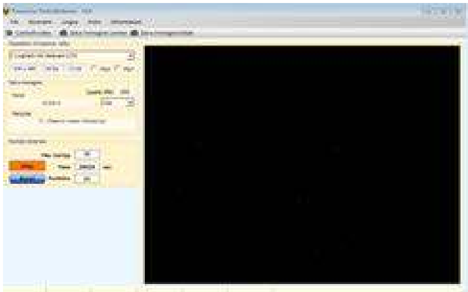
4. Set detection parameters:

- In the "Particle Detection" section (bottom left): Min. Energy: Set to 7 (range 0-255)
    - This is the brightness threshold
    - Pixels below 7 = noise (ignored)
    - Pixels above 7 = potential particle detection

- Ev. Separation: Set to 30 px (range 0-100)
  - Minimum distance between events
  - Prevents counting one particle multiple times

Before starting cosmic ray detection, verify complete darkness:

Click the START button. Look at the main display window (right side of screen)



theremino software

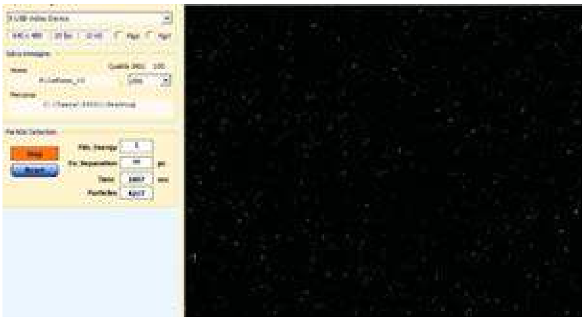
What you should see:

- Completely black image – no grey areas
- Pixel values should all be near 0

If you see anything other than black:

🔴 Light is leaking into the enclosure

- Click STOP
- Add more tape around all gaps
- Retest until completely black



cosmic ray trace

Once verified black:

- Click RESET to clear the display
- Click START button Watch the main display window

So what happened?

- Black background: No visible light present (complete darkness)
- White spots and streaks: Cosmic ray muons passing through sensor
- Accumulated effect: Each frame adds to previous ones - tracks persist

What next?

1. Compare with smartphone detector.
2. The following site has further details.
3. https://physicsopenlab.org/2016/05/22/webcam-particle-detector-measurements/

Detecting an Exoplanet

Spain

Background:

Exoplanets are planets which orbit stars outside of our solar system. Over the past 20 years, the number of exoplanets discovered has increased dramatically. There are a number of methods used to find exoplanets, but the most successful is the transit method. This demonstration, based on a model from Spain, but adapted to use the IOP light grapher, shows the principle of the transit method.

You will need:

- ✓ A lamp
- ✓ Lollipop sticks
- ✓ Playdough
- ✓ Laptop with webcam
- ✓ IOP Graphing software: https://spark.iop.org/LG

Follow these steps:

1. Make some planets of different sizes, using the playdough and attach to lollipop sticks for holding.
2. Turn on your lamp, open the IOP graphing software using a browser on your laptop (when requested, allow the software to access your webcam) and align the light from the lamp with the target (see this video for further instructions): https://www.youtube.com/watch?v=V2A3vEU_cWE.
3. Click the Capture data button and observe the light curve produced. It should approximate a horizontal line.
4. Click the Capture data button again, but this time move one of your home-made planets from left to right in front of the lamp. Observe the light curve produced. It should have a dip in it.

So what happened?

As your home-made planet passed in front of the lamp, the amount of light energy captured every second by your webcam was reduced leading to a dip in your light curve. When your home-made planet is not in front of the lamp the light level returns to its original value. This is the approach used by astronomers to detect exoplanets. While the planets are often too small and not bright enough to detect, when they pass in front of their star the amount of light from that star, as captured by a telescope here on earth dips. By measuring the size of this dip, astronomers can estimate the size of the planet. By measuring how often the dip occurs, astronomers can estimate the orbit of the planet.

What next?

What effect does the size of the planet used have on the transit light curve?

What effect does the distance between the planet and the lamp have on the light curve? If the planet doesn't move across the middle-line of the lamp, does this affect the light curve?

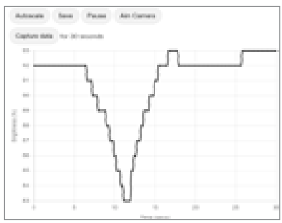
Can you design a solution to make the planet transit across the star at constant speed?

The dip in the light curve (known as the transit depth) is described by the relationship:
$\delta = R_p^2 / R_s^2$, where R_p is the radius of the planet and R_s is the radius of the star.

Can you explain why this is so? Can you use your light curves to estimate the radius of your home-made planets?

Note: There will be a large error on this estimate due to the fact that the light source and planet are close to the webcam.

Aligning the lamp with the light-



Sample graph

Exoplanet XO-6b Size Estimation

Spain

Background:

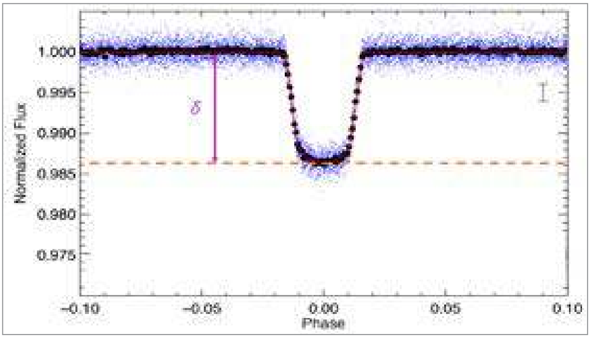
Exoplanets are planets which orbit stars outside of our solar system. Over the past 20 years, the number of exoplanets discovered has increased dramatically. There are a number of methods used, but the most successful is the transit method. This activity from Spain, uses real astronomical data to understand how astronomers use the transit method to calculate the size of an exoplanet. The exoplanet used is XO-6b which orbits around its parent star XO-6.

You will need:

- ✓ Radius of XO-6 star: 1.343×10^9 m
- ✓ Transit Light Curve for XO-6b (Ridden-Harper et al., 2020)
- ✓ The transit depth equation, $\delta = R_p^2 / R_s^2$, where R_p is the radius of the planet and R_s is the radius of the star.

Follow these steps:

1. Satisfy yourself as to the origins of the transit depth equation by writing the circular area of the planet (as an algebraic expression) as a fraction of the circular area of the star (also as an algebraic expression, and simplifying.
2. By examining the transit light curve for XO-6b, estimate the transit depth.



XO-6b transit light curve with transit depth highlighted. Adapted from Ridden-Harper, A., Turner, J. D., & Jayawardhana, R. (2020). TESS Observations of the Hot Jupiter Exoplanet XO-6b: No Evidence of Transit Timing Variations. The Astronomical Journal, 160(6), 249.

3. Using the transit depth equation, the value for the transit depth and the known radius of the parent star XO-6, calculate the radius of the planet XO-6b.

So what happened?

The transit depth is the dip in light received from the star XO-6, due to the planet XO-6b passing in front of it. The size of the dip depends on the size of the planet. A larger planet will block out more light, resulting in a larger transit depth. A smaller planet will block out less light, resulting in a smaller transit depth. Since the areas of the star and planet seen by a telescope on earth are the areas of circles, the ratios of these areas equals the transit depth. Since the area of a circle is proportional to its radius, , if we know the radius of the parent star we can use the transit depth to work out the radius of the planet.

What next?

There's lots of transit data available online. Find it and use the transit-depth equation to work out the radius of these planets. Check your calculation against the accepted values for the radius of these planets.

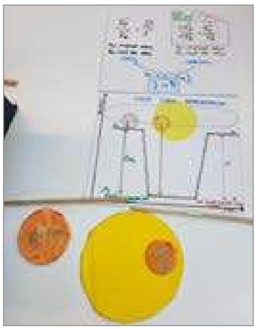


Image from festival showing how the light curve relates to the motion of the exoplanet in front of its star

Cosmic Ray Detector (Cloud chamber)

Czechia

Background

Cosmic rays are high-energy particles that travel through space and constantly bombard the Earth. They originate from powerful cosmic events such as supernova explosions, the Sun, and distant galaxies. When these particles enter Earth's atmosphere, they collide with air molecules and produce cascades of secondary particles. While most cosmic rays are absorbed high in the atmosphere through these collisions, some make it to ground level. We can make these 'visible' to our eyes by creating a basic cloud chamber.

You will need:

- ✓ Clear plastic container
- ✓ Felt to cover the bottom of the container
- ✓ Baking tray (black)
- ✓ Plastic tray
- ✓ 500 mlLof IPA (2-propanol)
- ✓ 5kg of dry ice
- ✓ Torch (bright beam)
- ✓ Neodymium magnets
- ✓ Heat resistant gloves
- ✓ Safety goggles

Follow these steps:

1. Wear gloves and goggles at all times.
2. Soak the felt with the alcohol and fix to the inside of the clear container using the magnets.
3. Assemble your set-up as per the image and ensure the room is dark.
4. Let the detector sit for approx 20 minutes until a slowly falling mist is observed inside the chamber when illuminated with the torch. Note that at the start the mist will fall too quickly for it to work as a detector. When the mist is light and slow moving, illuminate the region just above the baking tray. Observe the mist for several minutes, watching out for the appearance of short-lived white trails. You should see a handful over the course of a minute.

Electron or positron - straight trail. These are very common.

Alpha particle - thick straight track

Muon transformation into an electron signified by the 90 degree change in direction

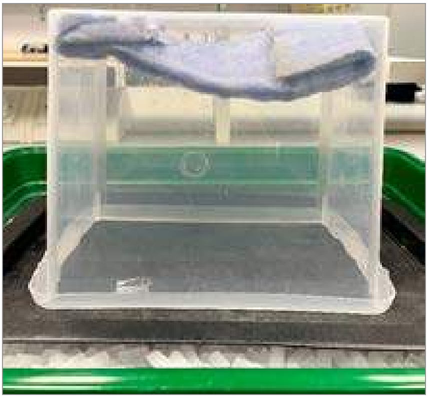
So what happened?

The fine alcohol mist inside the plastic container is a supersaturated vapour. Cosmic rays are high-energy, charged particles and as they pass through the vapour, they knock electrons from the vapour molecules, creating ions which act as nucleation sites, around which the alcohol vapour condenses. Thus the cosmic ray leaves a vapour trail behind it as it travels. Cloud chambers were an important tool helping physicists identify the variety of subatomic particles. Car Anderson used a cloud chamber to discover the positron in 1932 and again to discover the muon in 1936.

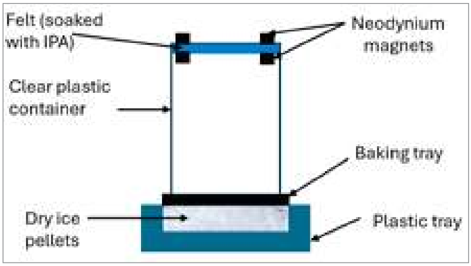
What next?

Cosmic rays are made up of several different types of particles, including electrons, positrons, muons and alpha particles. They each leave behind differently-shaped vapour trails. Look for these in your cloud chamber.

For additional information on making a cloud chamber please sett: https://home.web.cern.ch/news/news/experiments/how-make-your-own-cloud-chamber



General set up of cloud chamber



Set-up Diagram

Illumination using the torch is tricky and needs to be done at the correct angle with respect to the baking tray. The observer should not look into the torch, rather they should look in the vapour cloud just above the baking tray and down towards the baking tray.

For further information on the shape of vapour trails produced by cosmic rays see: https://scoollab.web.cern.ch/sites/default/files/documents/20200521_JW_DIYManual_CloudChamber_v7.pdf

Ripple in vapour caused by an alcohol droplet falling from felt

Alcohol vapour illuminated by the torch

Very faint track (straight line)

Primary

The Coin Thief

Bulgaria

Background

This is a simple experiment from Bulgaria exploring the refraction of light through water.

Refraction of light can cause objects to be reflected in places other than where they actually are.

You will need:

- ✓ a coin
- ✓ a clear jar with a lid
- ✓ a white sheet of paper
- ✓ water

Follow these steps:

1. Place a coin on a white sheet of paper.
2. Put a transparent jar on the coin and look through the side of the cup.
3. The coin is visible through the empty cup.
4. Fill the cup with water and look again - this time the coin is not visible.

So what happened?

When water is added to the jar, light that passes through the jar is refracted, and so the light from the coin does not travel directly to our eyes. Refraction is the bending of light as it passes from one medium to another with a different density. In this case, light travels from the water (denser medium) into the air inside the jar (less dense medium). When light rays move from water to air, they bend away from the normal (the imaginary line perpendicular to the surface at the point of incidence). This bending changes the direction of the light rays.

In simpler terms, adding water changes the path of the light coming from the coin in such a way that it no longer reaches your eyes, making the coin appear invisible. Therefore it appears as if the coin has disappeared.

What next?

More investigations can be done with varying amounts of water.

Does the amount of water in the jar make a difference to whether the coin remains visible or not?

Separating Salt and Pepper

Bulgaria

Background

This experiment from Bulgaria shows how salt and pepper can easily be separated using static electricity.

You will need:

½ a teaspoon of salt

½ a teaspoon of ground black pepper

small plate

plastic spoon

woollen scarf or jumper

Follow these steps:

1. Mix the salt and pepper on a plate
2. Rub a plastic spoon on a woollen scarf or jumper.
3. Hold the spoon over the salt and pepper mixture.
4. Slowly lower the spoon to the mixture and see what happens.

So what happened?

When you rub a plastic spoon with a woolly scarf, you are transferring electrons from the scarf to the spoon. This process charges the spoon, giving it a negative static charge. Static electricity is the result of an imbalance between positive and negative charges in objects.

How It Works:

1. **Charge Attraction:** Once the spoon is negatively charged, it can attract objects with an opposite or neutral charge. In this case, the pepper particles, being lighter and more easily influenced by static charges than salt, are attracted to the charged spoon.
1. **Difference in Mass:** Pepper particles are generally lighter than salt particles, so they are more easily lifted and attracted by the static charge on the spoon.
1. **Effect of the Charge:** As you bring the charged spoon close to the mixture of salt and pepper, the pepper particles will jump up and stick to the spoon due to the attraction between the negatively charged spoon and the neutral or positively charged pepper particles. The salt particles, being heavier and less susceptible to static charges, remain in place.

What next?

Can this experiment be replicated with other objects like balloons, clear biros etc.

Other investigations with static electricity and balloons are a nice follow up to this experiment.

Primary

The Magic of Winter STEM

Ukraine

Background:

These experiments from Ukraine combine STEM with the wonder of the winter season.

Having children make fake snow and indoor snowmen can introduce young students to the season of winter, and also introduce young students to the properties of different materials.

Children apply their basic knowledge and skills from mathematics, technology, art, and science through hands-on activities and improve observational, experimental and inquiry-based skills. These experiments are eco-friendly with reasonable expenses.

You will need:

- ✓ baking soda
- ✓ shaving foam
- ✓ liquid soap
- ✓ flour, water, salt
- ✓ rolling pin
- ✓ cookie cutters
- ✓ mixing bowl
- ✓ spoon or spatula
- ✓ skewer (for making holes)
- ✓ glitter, acrylic paints, ribbon, varnish (optional)
- ✓ baking sheet and parchment paper

Accessories for decorating: small beads, buttons, twigs, or any small decorative items to use as eyes, nose, arms, etc

Follow these steps:

Instructions for making fake snow:

1. Pour the baking soda into the bowl

- Start by adding 2 cups of baking soda to your mixing bowl. You can adjust the quantity based on how much fake snow you want to make.

2. Add shaving cream gradually

- Shake the can of shaving cream well and start adding it to the baking soda a little at a time.
- Begin with about 1/2 cup of shaving cream and mix thoroughly with the baking soda using your spoon or spatula.
- Continue adding small amounts of shaving cream and mixing until you achieve a light, fluffy, and moldable consistency that resembles real snow.
- The texture should hold together when squeezed but crumble like real snow when rubbed between your fingers.

Tips:

- If the mixture is too dry and crumbly, add a bit more shaving cream.
- If it's too wet and sticky, add more baking soda.
- Store the fake snow in an airtight container or ziplock bag to keep it usable for a few days.
- This fake snow is generally safe to touch but should not be ingested. Supervise children during playtime to ensure safety.

Cleanup:

- The mixture can be easily cleaned up with water. Dispose of it in the trash rather than washing it down the drain to avoid clogging.

Instructions for making snowmen:

1. Pour the baking soda into the bowl

- Add 2 cups of baking soda to your mixing bowl.

2. Add the liquid soap gradually

- Start by adding about 2 to 3 tablespoons of liquid dish

soap to the baking soda.

- Mix the ingredients together thoroughly using a spoon or spatula.

3. Adjust the consistency

- If the mixture is too dry and crumbly, add a little more liquid soap, a teaspoon at a time, and continue mixing.
- The ideal consistency should be moldable and hold together when shaped, similar to real snow.

4. Shape the Snowman

- Once the mixture is ready, take some of it and shape it into three balls—small, medium, and large—for the snowman's body.
- Stack the balls with the largest on the bottom and the smallest on top.

5. Decorate Your Snowman

- Use small beads, buttons, or other craft items to create the eyes, nose, mouth, and buttons of your snowman.
- Use small twigs or pipe cleaners for arms.

6. Let the Snowman Sit

- The snowman should hold its shape well, but if it starts to sag, try adding a bit more baking soda to the mixture or placing it in the fridge to firm up.

Tips:

- Play Around with the Ratios: Depending on the soap you use, you might need to adjust the amount of baking soda or soap to get the right texture.
- Add Scents or Colors: You can mix in a few drops of essential oil for a pleasant scent or food coloring to make your snowman more colorful.
- Storage: If you want to keep the snowman, place it in a cool area. If it dries out, you can break it down and remix it with a little more liquid soap.

Instructions for making salt dough winter decorations:

1. Mix the Ingredients

- In a large mixing bowl, combine 2 cups of flour and 1 cup of salt.

- Gradually add about 1 cup of water while stirring, until the mixture forms a dough. If the dough is too sticky, add a bit more flour; if it's too dry, add a little more water.

2. Knead the Dough

- Knead the dough for about 5-10 minutes until it's smooth and pliable. This helps to evenly distribute the ingredients and make the dough easier to work with.

3. Roll Out the Dough

- Lightly flour your work surface and roll out the dough to about 6mm thickness using a rolling pin.

4. Cut Out Shapes

- Use winter-themed cookie cutters to cut out shapes like stars, snowflakes, trees, or mittens.
- If you want to make ornaments, use a straw or skewer to poke a hole at the top of each shape for hanging.

5. Bake the Decorations

- Preheat your oven to 120°C.
- Place the cut-out shapes on a baking sheet lined with parchment paper.
- Bake in the preheated oven for 2-3 hours, or until the decorations are completely dry and hard. Baking time may vary depending on the thickness of the dough.

6. Cool the Decorations

- Once baked, remove the decorations from the oven and let them cool completely on a wire rack.

7. Decorate (Optional)

- Once the decorations are cool, you can paint them with acrylic paints, add glitter, or decorate them in any way you like.

8. If you made ornaments, thread a ribbon through the hole and tie it to hang on your tree or around your home.
9. Varnish (Optional)

- To make your decorations more durable, you can apply a coat of clear varnish once the paint is dry.

Tips:

- Storage: Store your salt dough decorations in a cool, dry place. If stored properly, they can last for several years.
- Creative Ideas: You can press objects like leaves, pine needles, or lace into the dough before baking to create interesting textures.
- Alternative Drying Method: If you don't want to bake the decorations, you can let them air dry over several days. However, baking will speed up the process.

What next?

Investigate other materials to see if any would be suitable for making other winter themed decorations.

Examine the mixtures under the microscope. In what way are the mixtures similar? In what way do they differ?

Constructing Flood Defences

Ireland & France

Background

Flooding is a major worldwide environmental issue. Students in France and Ireland have incorporated all aspects of STEM in order to construct flood defences to deal with flooding problems in populated areas.

You will need:

- ✓ Trays (one per group), markers, plastic or metal lids, coins or weights, small figurines of people, jugs or empty bottles, stopwatch, pencils and paper
- ✓ Materials for constructing flood defence such as - different size stones, balloons, newspaper sheets, plasticine or play-doh, cotton wool, small bags filled with sand and sealed, lolly sticks, foam tubes

Follow these steps:

Your challenge is to:

- Plan your flood defence barrier.
- Purchase or collect the materials you need.
- Construct your barrier.
- Time how long your figurine can stay safe from the flood water.

1. Gather some materials.
2. Consider which materials would be useful in constructing a flood defence.
3. Collect suitable materials. (Optional Maths extension: price the materials and use play money to "buy" the materials within a given budget)
4. Construct a flood defence.
5. With an "island" on one side of the tray, pour water into the other side of the tray.
6. Time the amount of time that the figurine stays safe from the flood.

So what happened?

Flooding is a natural event due to heavy rainfall, storm surges and very high tides. Areas along the coast are particularly vulnerable to flooding.

Flood defences can prevent damage from floods.

What next?

The students can design a flood defence that is portable / could be used for a house / doorway.

They can think about what might happen if the flooding is due to high waves. Would the same design work?

Students can identify which parts of the world are most vulnerable to flooding.

They may also identify coastal cities around the world.

Mopping Up Oil Spills

Greece

Background:

Oil spills in our oceans can be a major environmental hazard. This wonderful investigation from Greece can give students a practical understanding of the different methods of mopping up oil spills and relating this to actual methods of cleaning up oil spills in the ocean.

You will need:

- ✓ One clear container
- ✓ Clean water
- ✓ Cooking oil (virgin olive oil works best)
- ✓ Small items (e.g., plastic toys, beads, or paper pieces) to represent pollutants
- ✓ Spoon
- ✓ Pipet
- ✓ Wooden tongs
- ✓ Cotton
- ✓ Volumetric cylinder or measuring cup
- ✓ Optional : dishwasher soap, a feather

Follow these steps

1. Setting the stage: Begin with a container filled with clean water to represent an unpolluted environment.
2. Introducing the oil spill: Simulate an oil spill by adding vegetable oil to the water, mimicking a real-life scenario.
3. Observing effects: Visualise and observe how the oil spill affects water quality, emphasising changes in appearance and clarity.
4. Attempting cleanup: Provide various materials for students to select tools they believe will effectively clean the oil spill. Let the students explore the different methods and reflect on the most effective method and also the one that may be used in a larger scale for cleaning actual ocean oil spills.

So what happened?

Students use various methods to try and clean the oil spill from the water. They may measure the amount of oil collected with a volumetric cylinder or a measuring cup.

What next?

Students may also observe the effect that oil spills have on birds by dipping feathers in the oil and then attempting to clean the feathers of oil.

Adding liquid soap to the oil spill causes the oil to dissipate but students then must decide if this makes the oil actually disappear, or does it in fact make the oil spill more difficult to contain and to clean.

Greenhouse in a Bag

Latvia

Background:

Germinating seeds in a bag is a fun way for children to view how seeds transform into plants. Seeds don't need soil to start germinating, so you can place them in a sunny window and they will start sprouting right away. This allows students to watch how seeds sprout, which is a process normally hidden by dirt. There is a lot to learn in this experiment, yet it is so simple to do!

A working model of the water cycle is also clearly visible in this experiment, inside the sealed plastic bag. Evaporation of the water, condensed water vapour and water droplets are all clearly visible as the bag hangs on the window in the sunlight.

You will need:

- ✓ A clear plastic bag
- ✓ Cotton wool
- ✓ Peas
- ✓ Some water

Follow these steps:

1. Fold the cotton wool to fit in a snack-sized plastic bag. Once the cotton wool is inserted, place the seeds on the cotton wool. Don't crowd them - they need room to breathe.
2. Wet the cotton wool using the dropper. The cotton wool should be completely moistened, but not soaked. If it is too wet, the seeds will develop mould and rot.
3. When the cotton wool is completely wet, place it on the table and press the plastic bag closed. Air should not be able to get in or out of the bag. A small microclimate has been created within the sealed bag!
4. Using duct tape (it won't leave marks on windows), tape the bags to windows that get direct sunlight every day. The seeds should warm up and germinate.

5. Check the seeds every few days. Some will germinate faster than others.The growth of the roots will be clearly seen.
6. Once the seedlings have reached the top of the bag, carefully remove them and place them in pots.
7. Observe and record the growth over time.

So what happened?

The seeds germinate and grow into seedlings and then plants.

What next?

- Record the germination of peas by drawing and measuring them daily.

- Plant more than one type of bean or seed to compare the speed at which they grow.

Primary

Harnessing the Water Cycle to purify water

Portugal

Background:

Looking at what happens to polluted water within the water cycle.

This experiment simulates the water cycle to illustrate how it acts as a natural water filter. Using a five-litre bottle, red dye, plastic film, and a stone, students witness the stages of evaporation, condensation, and precipitation. After two hours near a sunny window, clear rainwater collects in the cup, demonstrating the water cycle's purification process and its vital role in maintaining clean water sources.

You will need:

- ✓ A 5-litre plastic bottle (cut at the top to create an open container)
- ✓ Food colouring to dye the water
- ✓ A cup (to collect the "rain")
- ✓ Plastic film or plastic wrap to cover the top of the bottle
- ✓ Scissors
- ✓ A small, heavy stone or weight (to apply pressure and simulate rain)
- ✓ Water
- ✓ Sunlight (to place the setup near a sunny window for evaporation)
- ✓ A pot with a plant to simulate the soil and a tree (optional)

Follow these steps:

1. Begin by remembering the concept of the water cycle and explaining that the experiment will simulate this natural process.
2. Choose the container. A 5-litre bottle is suitable (students may be stimulated to reuse big plastic food containers, or a glass tub)
3. Cut a square hole in the top side of the 5-litre bottle (e.g. ~ 12 cm).

4. Add about 500 mL of water to the bottle and and add a few drops of food colouring. This represents the initial impurities.
5. Place the cup inside the bottle. Make sure it is dry inside and show it to the students.
6. Cover the top of the bottle with plastic film, making sure it's sealed tightly.
7. Place the small, heavy stone on top of the plastic film, above the cup.
8. Put the setup near a sunny window where it can receive direct sunlight.

So what happened?

The experiment illustrates how water is naturally purified as it evaporates from the Earth's surface, condenses in the atmosphere, and then precipitates back to the surface as clean and clear water, leaving impurities behind. This process ensures that the water we receive in the form of precipitation is relatively pure and safe for various uses.

A similar process takes place when salt is formed: water vapour rises into the atmosphere, leaving salt crystals behind.

What next?

As the experiment ends, it is important to emphasise that the knowledge gained here extends beyond the classroom.

The water cycle illustrates the Earth's ability to maintain clean water resources. This understanding empowers students to become responsible stewards of the environment and advocates for sustainable water use.

If possible, teachers may consider arranging a field trip to a local water treatment facility or a natural water source to observe the water cycle in action and learn about real-world water treatment methods.

Primary

Shine Some Light on Physics: Magnetism

Serbia

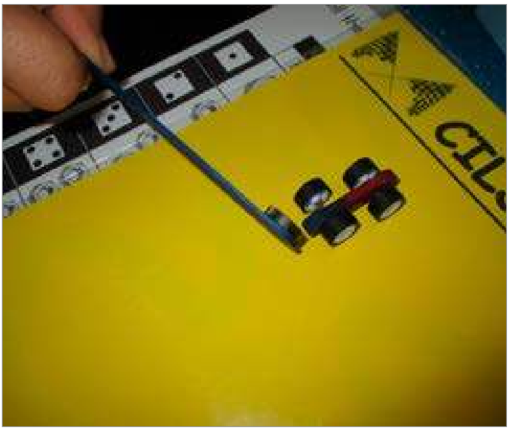
Background

Young students will love to discover some of the properties of magnetism for themselves by carrying out these simple experiments from Serbia.

You will need:

- ✓ Two identical copies of a picture
- ✓ small magnets
- ✓ bar magnet, wheels, skewers, straws
- ✓ wand magnets
- ✓ dice
- ✓ magnetic pieces

Follow these steps (1)



1. Discovering north and south poles of a magnet, magnet attraction and repelling
2. Laminate two identical copies of a picture.
3. On one picture stick a number of small circular magnets.
4. Cut the other picture into large pieces.
5. Stick a magnet onto each piece, corresponding to the magnets on the base picture.
6. (for one piece place the magnet in the direction so that it won't stick well on the corresponding picture: north facing north or south facing south. All other pieces of the puzzle should have pieces that stick directly to the picture underneath: north facing south)

So what happened?

The students should notice that although the puzzle seems easy to complete, one piece does not stick properly in the correct place.

This should give them the opportunity to try and discover how magnets will repel each other if both magnets are north facing each other (or south).

This should lead to a discovery of north and south poles on varying types of magnets (bar magnets, horse shoe magnets etc) and how magnets attract or repel each other.

Follow these steps (2)

Play a car race game with magnets

1. Make a race car with a bar magnet as the chassis (or frame) of the car.
2. Two straws should be stuck on the bottom of the magnet,a skewer goes through each straw and into the wheels.

So what happened?

Two cars race each other on a laminated race board.

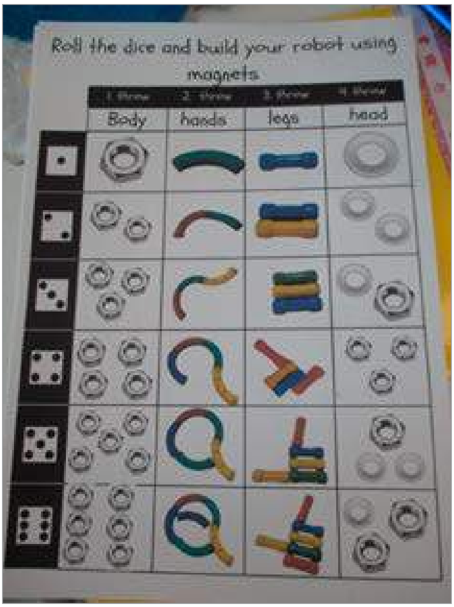
They race when a wand magnet is placed behind the car. The students should soon notice that the car will run to the finish line when the north pole of the wand magnet is put close to the north pole of the race car.

Students can retry the race using the south facing poles of the cars and the wands.

Follow these steps (3)

Make a magnetic robot

1. Collect magnetic pieces.
2. Use a die and the pieces to construct a magnetic robot.



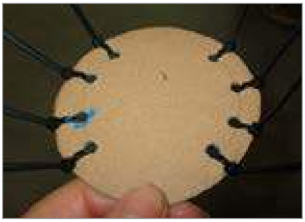
So what happened?

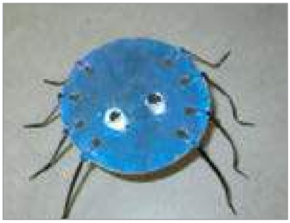
Students combine creativity with understanding of the properties of magnets while having fun.

Primary

Shine some light on Physics: Forces & Gravity

Serbia





Background

Designing and making simple toys which help in the understanding of gravity, inertia, and push and pull forces.

You will need (1)

- ✓ cardboard
- ✓ hole punch
- ✓ small cable ties
- ✓ google eyes
- ✓ paint or colours
- ✓ a drinks straw

Follow these steps: Cable tie spiders

1. Cut out a cardboard circle or oval
2. Use a hole punch to punch 4 holes on each side of the card
3. Thread and tie off a cable tie in each of the holes.
4. Turn the card over and decorate the spider with colours and eyes

So what happened?

Can you get the spider to move?

(The spider can be moved if you push down on the spider and then let go - the spider will jump.

The spider will also move if you blow air at it through a straw)

What next?

How can you move a toy car? Can you classify each of these ways into push forces and pull forces?

You will need (2)

- ✓ sheets of paper
- ✓ feathers
- ✓ 2 small containers
- ✓ marble
- ✓ 2 styrofoam eggs

Follow these steps: Gravity and Inertia

1. Drop two exact sheets of paper to the ground. They will fall at the same rate and land at the same time.
2. Now squeeze one piece into the shape of a ball. When both are dropped, which will land first?

So what happened?

Although both pieces of paper have the same mass and weight, the ball shaped paper will fall faster and land on the ground more quickly than the flat piece of paper. This is because the flat paper is affected by air resistance whereas the ball shaped piece of paper is less affected by air resistance.

Drop two styrofoam eggs. They should hit the ground at the same time.

Can you think of a way to make the eggs to the ground fall more slowly? Would adding feathers to the styrofoam eggs help the eggs to fall more slowly? How can you test this?

So what happened?

The styrofoam egg with feathers WILL fall more slowly than the styrofoam egg with no feathers.

Follow these steps: air resistance

1. Drop a small marble and a feather. Which should land on the ground first?
2. (The marble is less affected by air resistance and will land first)
3. Now put the marble into one small container and the feather into another small container.
4. When you drop these two containers, will the container containing the marble still land first?

So what happened?

Both containers are the same shape and so are equally affected by air resistance.

They will both land on the ground at the same time.

What next?

Watch a video of a feather and a hammer being dropped on the moon during the Apollo 15 mission in 1971. How does lack of air resistance affect which will land on the surface of the moon?

You will need (3)

- ✓ a cardboard or wooden board
- ✓ strips of sandpaper, plastic, tinfoil, cardboard, cloth, rubber
- ✓ small pieces of wood or rubber
- ✓ wooden blocks
- ✓ small shoe or other small toy

Follow these steps: testing friction

1. Paste strips of different materials onto a wooden or cardboard board.
2. Use the small shoe or other small toy to investigate how slowly or quickly the shoe will move along each strip. How can we measure this fairly?

So what happened?

The shoe will travel at different speeds along each surface. A timer can be used to time how fast the shoe can move on each surface. It is important to keep the ramp tilted at the same angle each time.

What next?

- Stick different materials onto wooden blocks.
- Instead of the shoe or toy, use these wooden blocks to investigate friction between different materials.

Shine some light on Physics: Light

Serbia

Background

A series of simple light experiments from Serbia using light from torches to allow young students to make their own discoveries about light.

You will need:

- ✓ An A3 or A4 picture of a forest scene
- ✓ Cut out silhouettes of forest animals
- ✓ White sheet of paper in the same size (A3 or A4)
- ✓ A torch (flashlight)
- ✓ Toilet roll
- ✓ Scissors
- ✓ Clear plastic

Follow these steps (1)

Find the animals in the forest:

1. On the reverse side of the forest scene picture stick the silhouettes of forest animals.
2. Stick the plain white sheet of paper over the silhouettes so they are not visible from the back of the forest scene picture.
3. Now shine the torch (flashlight) from the back of the picture.
4. Which animals can you find?

So what happened?

When the light is shone on the back of the picture, shadows of the animals are seen. As the torch (flashlight) is moved closer to the picture, the images change size.
When playing this game the students should gain an understanding of the relationship between light and shadows.

What next?

Students can tick off animals found on a tick sheet.

Follow these steps (2)

1. Make your own animal shadows
2. Cover one end of a toilet roll with clear plastic.
3. Cut out an animal silhouette.
4. Stick the silhouette onto the plastic.
5. Shine a torch (flashlight) through the toilet roll to make a shadow of the animal.
6. Can you put the shadow of the animal on the forest picture?

So what happened?

When the light shines through the toilet roll the shadow of the animal will be seen.

The size of the shadow will be affected by how close the torch (flashlight) is to the animal silhouette.

What next?

Students can also experiment with shadows outdoors in sunny weather.

Shine some light on Physics: Sound

Serbia

Background

When a hex nut is placed inside a balloon and then spun inside the inflated balloon a buzzing sound can be heard from the balloon.

You will need:

✓ Balloons of different sizes
✓ Hex nuts of different sizes

Follow these steps

1. Place a hex nut inside a balloon and carefully blow up the balloon.
1. Hold the balloon in one hand while swirling the balloon around.
1. You will hear a buzzing sound from the hex nut inside the balloon.

So what happened?

When a hex nut is swirled inside a balloon, the combination of the nut's motion, the balloon's material properties, and the air inside the balloon produces a distinctive sound. The vibrations and resonance of the balloon's surface, coupled with the friction and impacts from the hex nut, generate complex acoustic patterns that are amplified by the balloon acting as a resonating chamber. This results in the unique and sometimes eerie sound that is heard.

What next?

- Investigate: Does the size of the hex nut affect the sound produced?
- Does the size of the balloon or of the hex nut affect the sound produced?

Primary

Tangible statistics - using wool to build a participatory graph

Ireland

Background

This activity involves using coloured wool to create visual data representations on a board. Students design a questionnaire and use knobs with wool to depict different answers, creating a visual pattern that reveals statistical insights.

You will need:

- ✓ A3 or larger plywood (3 mm)
- ✓ Different colours of wool
- ✓ Nails to used as knobs
- ✓ pencils/pens/paint for decoration

Follow these steps:

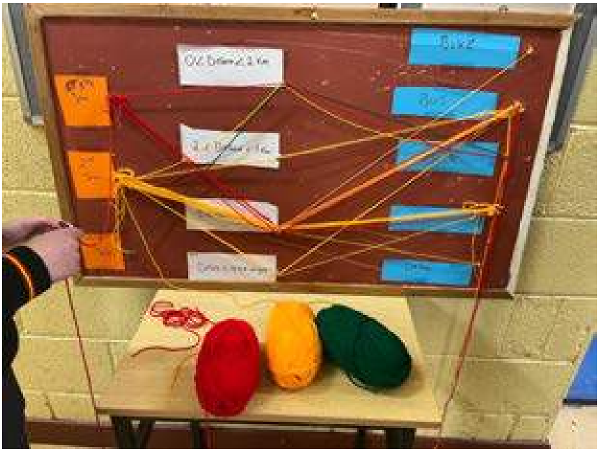
1. Create a survey and put the questions on the board.
2. Place balls of coloured wool next to the assembled board with round-edged scissors.
3. Participants answer questions by wrapping wool around the corresponding knobs, gradually creating a visual data pattern.

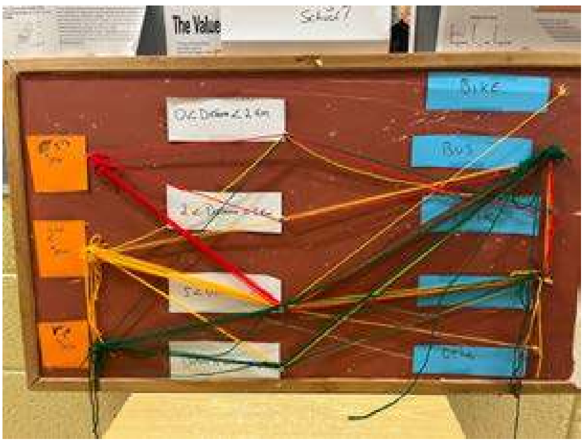
So what happened?

As participants interact with the board, a visual representation of data emerges through the intersecting patterns of coloured wool.

What next?

1. Analyse the patterns and draw conclusions about the data
2. Translate the wool visualization into digital graphs





Paper, brush and colours straight from nature

Finland

Background

This interdisciplinary lesson combines Art, Science and Environmental Education, inviting students to explore creativity through sustainability and natural resources. Learners will gather natural materials to create handmade paper, natural brushes, and plant-based paints.

You will need:

For collecting materials:

- ✓ Small baskets or reusable bags
- ✓ Scissors or garden shears

Natural materials (examples):

- ✓ For paper: dried leaves, grass, flower petals, small plant fibres, recycled scrap paper
- ✓ For brushes: twigs, feathers, dried grass, pine needles, moss, string or thread for binding
- ✓ For colour/paint: flower petals (pansy, marigold, rose), berries, beetroot, turmeric, spinach leaves, charcoal, coffee, soil, clay

For processing and painting:

- ✓ Mortar and pestle or flat stones (for grinding pigments)
- ✓ Small jars or bowls
- ✓ Water and spoons for mixing
- ✓ Strainers or muslin cloth
- ✓ Recycled paper or cotton cloth for painting surface
- ✓ Paper towels or sponges

Follow these steps:

1. Gathering from Nature Take a nature walk around the school grounds or nearby park. Collect small amounts of materials (leaves, petals, twigs, soil)
2. Making Natural Paper
   Tear recycled paper and soak it in water for several hours. Blend or mash the paper into pulp. Mix natural fibres or small pieces of leaves and flowers into the pulp. Spread the mixture evenly on a screen or mesh. Let excess water drain, then press gently with a sponge. Leave to dry overnight.
3. Creating Brushes from Nature Provide twigs, feathers and dried grass. Tie bunches of natural materials to twigs using string to form brush tips. Experiment with different shapes and textures (wide, soft, stiff or pointed). Encourage students to test the brushes with water to see the marks they make.
4. Making Natural Colours and Paint Place petals, berries or soil in small bowls. Crush or grind with mortar and pestle, adding small amounts of water. Strain the liquid through muslin to create coloured dye. Add natural binder (honey, flour paste or egg yolk) to thicken the mixture into paint. Experiment by mixing pigments for example turmeric (yellow) + beetroot (red) = orange.
5. Painting with Nature Using their handmade brushes and natural colours, students create artwork on their handmade paper.

So what happened?

Students experienced how materials from nature can be transformed into creative tools and artistic expressions.

What next?

Possible extension activities:

Science connection: Explore how natural pigments change under sunlight (test fading over time). Discuss why some plants produce stronger dyes than others.

Environmental education: Compare the environmental impact of natural vs. synthetic art materials. Encourage upcycling and eco-friendly creativity in future art projects.

Maths and measurement: Record pigment quantities and ratios to see how colour intensity changes.

Building connections in STEM

Ireland

Background:

Finding connections between various phenomena in STEM education can greatly enhance understanding of distinct concepts. Graphing is a key component of representing and analysing data. Building bricks allow for a great diversity of representations. The possibility of using a 3-D graph with a variety of colours and shapes can prove very effective

You will need:

✓ Building bricks
(Red, yellow 2x2, Blue 6x2)

Follow these steps:

1. Starting with one red brick connected underneath centre of blue, students keep adding yellow bricks until body topples over
2. The result is graphed using building bricks of the same colour in a method of the students choosing
3. A second red brick is added underneath the blue and students observe how many yellow brick need to be added to cause instability

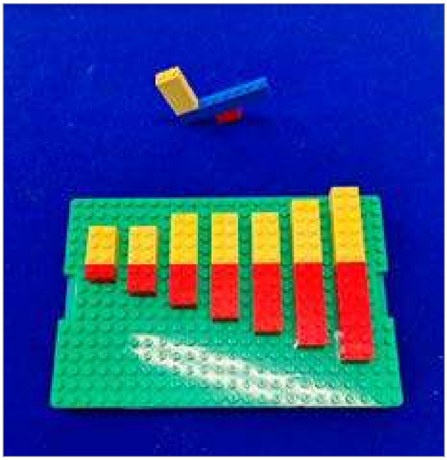
So what happened?

Patterns are identified between stem height and number of bricks needed to cause body to topple over

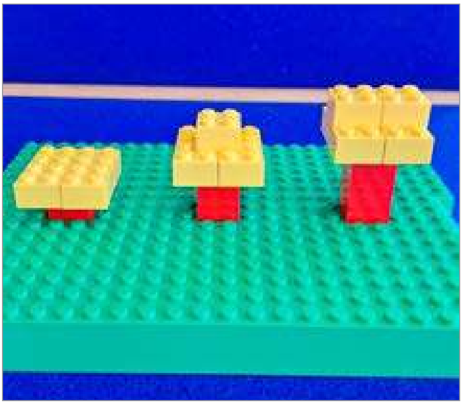
Students represent results in various methods.

What next?

Building bricks are used to model results from investigations carried out with conventional apparatus.



Bar chart- type representation



ID representation

Running Rainbows – physical and chemical regularities

Bulgaria

Background:

This activity introduces children to the scientific concepts of capillary action, colour mixing and water absorption through a simple and visually striking experiment called "Running Rainbows." Capillary action is the process by which water travels upward through tiny spaces in materials like paper towels due to cohesion (water molecules sticking together) and adhesion (water molecules sticking to other surfaces). The activity encourages observation, prediction, and inquiry, as students watch coloured water "walk" or "run" up paper towels from one cup to another, forming new colours in between.

You will need:

- ✓ . 6 clear plastic cups or jars
- ✓ Paper towels (strong, absorbent type)
- ✓ Food colouring (red, yellow, blue — the primary colours)
- ✓ Water (enough to fill cups halfway)
- ✓ Scissors
- ✓ Tray or flat surface for setup

Follow these steps:

1. Arrange six clear cups in a circle or straight line.
2. Fill every other cup halfway with water (e.g. cups 1, 3 and 5). Leave cups 2, 4 and 6 empty.
3. Add a few drops of red food colouring to the first cup, yellow to the third and blue to the fifth. Stir gently.
4. Cut paper towels into long strips (about 3–4 cm wide) and fold them lengthwise several times.
5. Place one end of each paper towel into a cup with coloured water and the other end into the next empty cup, forming a bridge. Continue around until all cups are connected.

So what happened?

Children discovered that water can move upward and sideways through paper towels because of capillary action and that new colours are formed when two coloured waters meet. They observed a real-time physical process that demonstrates how water moves through natural materials just like how plants draw water from their roots to their leaves.

What next?

- Plant science connection: Show how this process happens in nature by placing a white carnation or celery stalk in coloured water overnight and observing the colour change in the petals or leaves.
- Maths connection: Measure how far the water travels in the paper towel over time.
- Design challenge: Ask children to arrange cups in different colour orders to see what new colours they can create.

Art in Engineering – Europe in Three Dimensions

Finland

Background:

This interdisciplinary lesson integrates Art, Engineering and Geography through a hands-on, inquiry-based project where students design an interactive installation titled “Europe in Three Dimensions.”

In this installation, a LEGO EV3 robot acts as a “tourist” who journeys across Europe, exploring the art, culture and architecture of the region. The robot navigates a 3D map or model of Europe, moving through landmarks designed and built by the students.

Each group of students represents a different European region and creates a robotic pathway demonstrating mechanical movement using simple machines (levers, pulleys, gears, inclined planes, etc.); miniature artistic models or architectural landmarks (e.g. the Eiffel Tower, Colosseum, Parthenon etc).

The project enables students to understand and apply engineering principles (simple machines, mechanical movement); appreciate European art and architecture across the region; develop teamwork, creativity and communication skills; program and control a LEGO EV3 robot.

You will need:

- ✓ LEGO Mindstorms EV3 kits (one per group)
- ✓ Laptops or tablets with EV3 programming software
- ✓ Cardboard to create the “map” of Europe
- ✓ Art materials: paints, coloured paper, clay, recycled materials, glue, markers
- ✓ Rulers, scissors, cutting tools
- ✓ Small motors, gears, pulleys and axles

Follow these steps:

1. Each group researches their assigned region, identifying key artistic and architectural features (e.g. styles, materials, patterns). Students sketch their area of the installation (a section of the 3D map). Brainstorm how the LEGO EV3 “tourist” will travel through the region (straight path, ramp, turntable, etc.). Identify which simple machines (gears, pulleys, levers) will help move or animate elements of the design.
2. Build the landscape and landmarks for each region using mixed materials. Assemble and program the EV3 robot to follow a path through the installation using sensors or timed movement. Add moving parts to certain landmarks (e.g. rotating windmills, drawbridges lifting etc.).
3. Test and refine the robot’s journey so it moves smoothly from region to region.

So what happened?

Through the process, students applied mechanical and programming concepts to solve design challenges. They also observed practical outcomes: adjusting robot programming for accuracy, testing friction and balance as well as refining artistic details to enhance realism.

What next?

Possible extension ideas include:

Art connection: Design posters or digital portfolios explaining how art influences engineering design today (e.g. modern architecture, robotics aesthetics).

Engineering extension: Challenge students to modify their EV3 robots to respond to sensors eg. pausing or turning automatically at specific landmarks.

Mystery box

Latvia

Background:

The mystery associated with a hidden object always increases curiosity and acts as motivation in the problem solving process. Critical thinking allows some options to be eliminated at different stages.

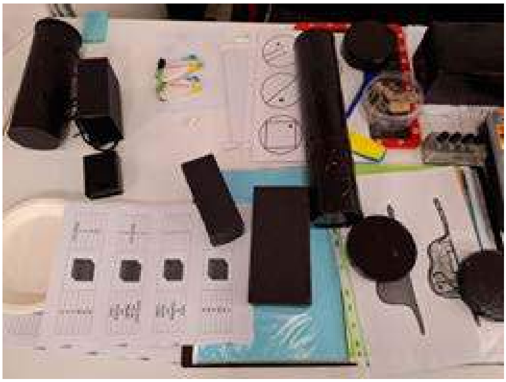
You will need

Black boxes, electrical components, hypothesis sheet with list of contents, Information cards

Follow these steps:

1. Students study hint cards with 4 or 5 options for contents of boxes.
2. Read information sheets listing properties of components
3. Choose tests to be carried out to identify content without opening box
4. Carry out diagnostic tests to confirm predictions

Sample of electrical components



So what happened?

Students really consider the properties of materials prior to making predictions or designing tests.

With electricity components, measurements of voltage , current and resistance are far more meaningful than normal calculations.

What next?

More complex systems can be set up within boxes e.g. Parallel, series circuits.

Making a convex mirror

Bulgaria

Background:

Curved mirrors (and lenses) offer the opportunity to explore reflection (and refraction) of light and to learn to use ray diagrams and the thin lens formula to predict the behaviour of images of objects placed at different distances from the mirror. This demonstration, from Bulgaria, describes how students can make their own convex mirror using some basic materials.

You will need:

✓ Laboratory watch glass
✓ Aluminium tape

Follow these steps:

1. Lay the watch glass on a table top with its central bulge in contact with the table top.
2. Cut several small pieces of aluminium tape (~1cm2) and stick them to the upper surface of the watch glass such that the surface is completely covered. Try to flatten the pieces of tape against the glass surface. Try to make sure there is no overlap or gaps between pieces of tape.
3. Shine a beam of light at your newly-manufactured mirror and see how well it reflects the light.
4. Use a ray box and wire mesh to create an object and see if you can form an image of it by reflection in the mirror.

So what happened?

The aluminium tape is reflective and so when it is made to form a concave shape by placing it on the watch glass, it acts as a mirror. The smoothness of the reflecting surface will affect the quality of the image formed by the mirror.

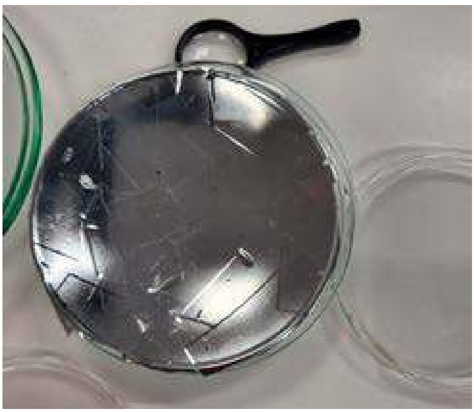
What next?

Explore the shapes you use for your pieces of aluminium tape (tesselation).

The method you used to manufacture your mirror is similar to that used when constructing mirrors you use in the lab and mirrors used on telescopes. A piece of glass is forced into the desired shape (there are a number of ways to do this) before being coated with a reflective surface.

Try coating a watch glass using a different reflecting material - e.g. reflective spray paint. How does the quality of the image formed compare to the first mirror you made?

The VERITAS telescope located in southern Arizona, USA, detects light which comes from high energy gamma radiation crashing into the earth's atmosphere. These gamma rays come from some of the most extreme environments in the universe, including black holes. VERITAS is operated by a group of scientists from America and Europe, including astronmers from Ireland. The VERITAS telescope's mirror is large but is not a single solid piece of glass, rather it is made up of smaller hexagonal pieces which are coated with a reflective aluminium surface - just like the mirror you made.



Low-Cost Experiments in STEM Education

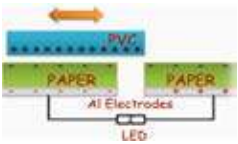
SCIENCE ON STAGE TURKU 2024

Alan Casey| Coláiste an Chroí Naofa | Cork | Ireland

FROM STATIC TO LIGHT

Let‘s illuminate the charge.

A set of hands-on activities that guide students through the concept of static electricity emphasising how static electricity can be transformed into a viable source of energy by constructing a Triboelectric Nanogenerator(TENG) - capable of powering an LED.



Triboelectric Nanogenerators (TENGs) operate on the principle of the triboelectric effect, where specific materials become charged upon contact with others, effectively converting mechanical energy into electrical energy.

Students follow a path that includes:

a) Exploring Static Electricity: Electron transfer and charge creation via material friction and Induced charges.
b) The Triboelectric Series: Experiment with material combinations to understand electron affinity.
c) Build and Test: TENGS of different geometries and actions(tapping, sliding and shaking) are built and their output is measured.
d) Illumination: Direct conversion of mechanical energy into light.

Additionally, Students

- Investigated the different methods of how electricity is created (Nuclear, Fossil Fuels, Hydro and Wind)
- Understood how electrical generators operate.
- Developed Lab Skills in testing strategies, recording data, analysing data and forming conclusions.

Conclusion: Students of all ages (12-18) engaged in this activity: Creating a generator out of cheap everyday materials that does not involve a magnet and coil and using it to light an LED.

Scan for Resources

Low-Cost Experiments in STEM Education

SCIENCE ON STAGE TURKU 2024

Denis McCarthy| Hazelwood College | Limerick | Ireland

Building Stem Connections

Play well, Inquire well

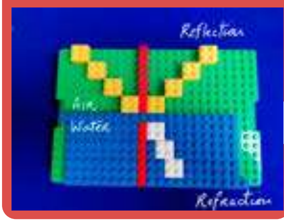
Building bricks are often used to model ideas, like the atomic theory. There is also huge potential to exploit their adaptability in carrying out experiments, and graphing data in the STEM area.

Students tend to be more comfortable expressing ideas using physical models. This allows for common misconceptions to be identified and teased out at a very early stage in the learning process. The therapeutic element of manipulating building bricks cannot be underestimated. Students with additional educational needs show greater levels of motivation.

Light …

Model

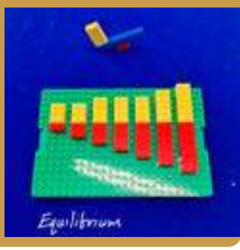
Expressing ideas, misconceptions



Equilibrium…

Experiment

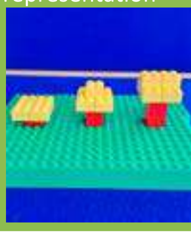
Variety of variables



Patterns……….

Represent

Choice of 2D, 3D representation



Graphing experimental or other data often represents the least stimulating part of the investigation process for students in the STEM subjects. Even with the aid of the technology, there can be a challenge to draw a conclusion or find patterns. Building bricks allow for a more personal, relevant method of presenting results. Modelling chemical reactions adds greatly to the understanding of chemical equations.

Conclusion: Using physical models gives greater opportunities for inquiry in topics not ideally suited to conventional experiments. The chance to return to a box of building bricks, abandoned years earlier, can be nostalgic and bring a playful, creative feeling sometimes absent in STEM classrooms.

Joint Projects

SCIENCE ON STAGE TURKU 2024

Jane Shimizu, Scoil Chaitríona Junior
Galway, IRELAND

Geneviève Cueff, École Notre Dame de la Charité
Saint-Pol-de-Léon, FRANCE

Looking After Our Oceans

Our joint Irish-French project aimed to engage our students in STEM education and in the theme of Ocean Sustainability through the medium of art and drama.

Our project included:

- **Music** - songs relating to the ocean
- **Drama** - original musical dramas with a message of ocean sustainability
- **Recycled art** - made from rubbish found during beach clean-ups
- **Board games** focusing on biodiversity
- **Beach safaris** - learning about marine life
- **Beach clean-ups**
- **International cooperation** between our schools in Ireland and France

Our STEAM focus was on

- Active Learning
- Collaboration
- Curiosity
- Creativity
- Critical thinking
- Communication
- Inquiry-based learning

STEAM Learning
Through International Cooperation and the ARTS

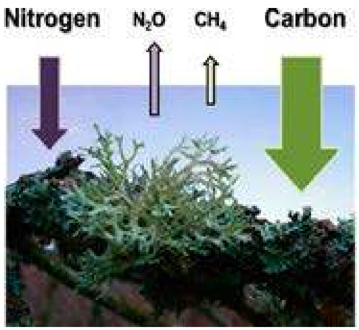
Working together for a sustainable future

STEAM in Education

Tracey Mason | St Mary's Academy CBS | Carlow | Ireland

The Power of Lichens and Moss

The students engaged in an air quality campaign to assess traffic-related pollution levels. The project prioritised raising awareness of air pollution around the school and the local community. The students placed monitoring tubes to measure nitrogen dioxide levels in different areas around the school and conducted ecological surveys on the diversity of lichens and moss. From biological and chemical analysis of air quality, the students created poems based on their observations of Lichens and moss in their local environment.



From learning about air pollution as an art-science project, students engaged in the scientific process, promoted action around clean air, and showcased the potential of citizen science to gather unique data and insights into our environment.

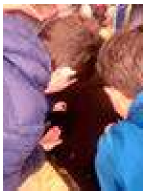
STEM for the Youngest

Veronica Ward | Dublin 7 Educate Together National School | Dublin | Ireland

How does your garden grow? With green practices and sustainability!

The pupils engaged in sustainable gardening, striving to create a greener urban landscape within the local community. The project prioritised conservation and advocacy for sustainability, integrating lessons on plant life, carbon sequestration, and biodiversity.

From organic farming to green living, the pupils applied knowledge in designing and constructing urban community garden planters, while also assessing local sustainability impacts.



During the project the pupils developed the following life-long skills:

- Communication
- Collaboration
- Creativity
- Critical thinking
- Problem solving
- Ethics
- Global Awareness
- Citizenship

Conclusion: Through hands-on activities, group projects and presentations, this interdisciplinary endeavour seamlessly wove together various subjects uniting the broader community to address a real-world challenge.

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ERASM

Science on Stage 2024

Demonstrations and teaching ideas selected by the Irish team

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