SCIENCE ON STAGE
EUROPE

Index

Magic Tricks

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Magic for the youngest

Math tricks

How did it all start and who we are

Spectacular science demonstrations and magic illusions have many things in common. They involve practice, showmanship, audience interaction and suspense followed by a moment of astonishment. Magic "tricks" which are in fact demonstrations of hidden science.

They can be used as introductions to topics or simply as puzzles for students to solve.

It is important, as in all science, to observe carefully and ask the right questions if you want the correct answers**!**

Warning: some secrets are revealed!

Adrian Allan "I am a chemistry teacher at Dornoch Academy in Scotland, UK. I am interested in the use of magic illusions to teach science concepts to students."

David Featonby "David Featonby is an experienced teacher having taught physics at a UK comprehensive school for 35 years. Following retirement, he has worked for the Institute of Physics supporting physics teachers and in outreach activities.

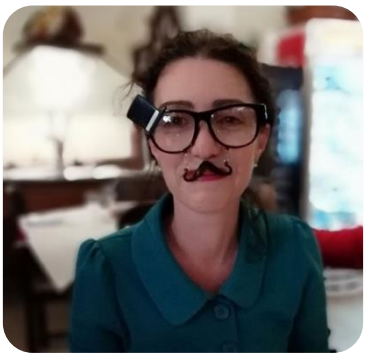
He has several published articles in Science in School and Physics Education, and now writes a regular column in the latter, (What Happens Next?) He has attended all International Science on Stage Festivals since 2005 and presented workshops at many conferences in the UK and throughout Europe."

Paul Nugent "Paul Nugent teaches science and maths in Dublin, Ireland. He is an Education Coach with the Institute of Physics Ireland (IOP) and an Associate with Oide the Irish Department of Education Development Service for Teachers.

He is co-chair of the Irish Science on Stage NSC. a board member of Science on Stage Europe.

In 2020 he was awarded Irish Science Teachers Association (ISTA) Science Educator of the Year.

He is a founder and leader of the Science Communication group Physics Buskers that entertains members of the public at many festivals."



Rute Oliveira "Because I love learning and I love science I'm a Chemistry and Physics Teacher in Nobel Algarve British International School, in Portugal."

Adrian, Paul, Rute and I, we have worked together to create this booklet, which contains a series of demonstrations designed to both bemuse and entertain audiences of all ages, from pre-school to adult. With contributions from members of Science on Stage Europe, this booklet brings together simple "magic" tricks that highlight different aspects of school science.

The booklet contain instructions and tips of how to demostrate the "magic experiments" as well as links to the science behind many of them. Many of them can be performed by children themselves, who enjoy either keeping the "science" a secret or revealing the story of the science behind the demonstrations.

David Featonby Science on stage Europe Vice Charman

We cannot assume responsibility for any accidents or injuries that may occur during the performance of these demonstrations. We strongly advise testing each demonstration in advance if it will be presented to an audience.

Magic Tricks

1. The Vanishing Liquid

Tutorial - How to perform

Effect

Water is poured into an opaque plastic cup. When the cup is turned upside down no water comes out. The water has mysteriously vanished.

Tutorial - Click

The Science behind

The plastic cup secretly has some hydrogel powder in from the start. This can be done using hydrogel powder extracted from nappies or you can buy a product called slush powder for about £5 from internet suppliers such as Amazon. When water is added to the hydrogel it forms a solid gel that stays in the cup when inverted.

The Science - Click

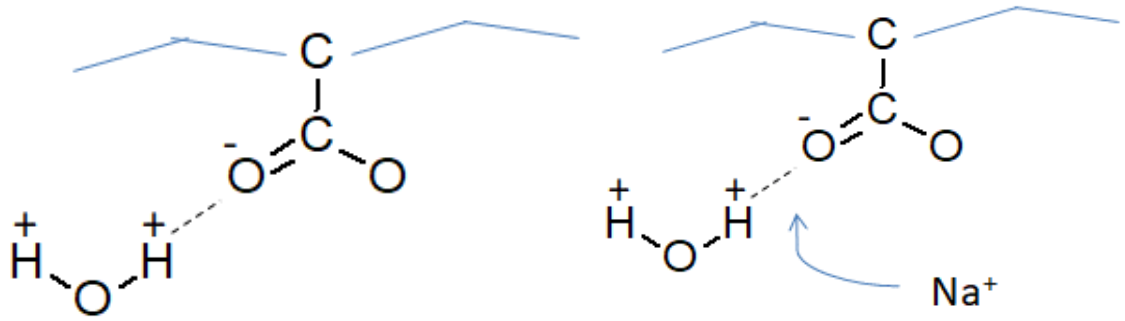
There are granules of sodium polyacrylate (with a molecular weight of over 1 million) in the hydrogel. There are sodium carboxylate groups along the carbon chain. When water is added to the polymer, the sodium ions migrate leaving negatively charged carboxylate groups on the chain. The negative charges repel each other so the chains unwind, and the polymer increases in volume (figure 1.1). At the same time, there is an electrostatic attraction between the ions and the water molecules. Many water molecules are attracted to the carboxylate groups and are electrostatically held to them (figure 1.2). The polymer absorbs water.

Figure 1.1: Polymer with water increases in volume.

Figure 1.2: Demonstration of water molecules attracted to the carboxylate groups and are electrostatically held to them.

The water can be recovered from the hydrogel using salt. The sodium ions take the place of the bound water molecules and release them from the polymer.

The addition of salt can be used as a magic powder to recover the vanished water if time allows.



What you will need:

- 3 polystyrene drinking cups

- The lining from a disposable nappy. (Cheap ones will do – remove plastic backing but the inner layer nearest the baby can be left).

- A measuring cylinder.

- A beaker of water.

Before the demonstration

Cut circles, the diameter of the bottom of a cup (about 4.5 cm), out of the lining.

Place one in the bottom of one of the cups. It should be a snug fit.

The demonstration

Measure out 10-15 cm^3 of water (no more or the nappy will not absorb all of it) and place it in one of the cups. Colour if desired with a few drops of food colouring.

Make a great play of switching round the cups (but making it obvious which one has the water) and asking the audience to say which one has the water in it.

Each time they get it right, pour the water from the cup into the second empty cup.

On one occasion, pour the water into the 'empty' cup that contains the nappy liner.

Then when they predict the cup with the water, take the others in turn and show they do not contain water by attempting to pour from one empty cup to the other. (It also gives time for the nappy to absorb the water). This should convince the audience they are correct in their prediction. Now attempt to pour from this cup into one of the empty ones. Heh presto! The water has 'disappeared'.

It is the responsibility of teachers doing this demonstration to carry out an appropriate risk assessment.

SDG

By using water as a medium for the magic trick, it provides an opportunity to discuss the importance of clean water and access to safe drinking water, which is a critical aspect of SDG 6. This trick can serve as a conversation starter to raise awareness about water-related challenges and the need for sustainable water management.

Access to clean water and sanitation is critical for poverty eradication (SDG 1), clean water and sanitation are essential for achieving food security (SDG 2), providing clean water and sanitation increased school attendance because fewer illnesses children get (SDG 4), because women and girls are disproportionately affected by the lack of access to clean water and sanitation. In many communities, women and girls are responsible for fetching water (SDG 5).

2. Coin through rubber

Tutorial - How to perform

Effect

A coin is seen on top of a rubber sheet which is stretched over a clear glass beaker (figure 2.1). A volunteer places their finger on the coin and proceeds to push the coin through the rubber into the beaker. No hole is left in the rubber sheet, solid has passed through solid!

Figure 2.1: Set up.

Tutorial - Click

Method

The coin through latex trick is marketed under various names, usually Pena Coin, which can be bought for about £5 from Amazon for 3 sheets. Your local dentist or an internet dental supplier may sell small rubber sheets called dental dams which may be cheaper. I got mine from Amazon.

Where to buy latex sheets - Click

Put 10p piece and rest it on a cork or bung. When the rubber is stretched over the coin is becomes transparent and clings to the coin, creating the illusion the coin is on top of the latex when it is gripped underneath (figure 2.2). Adding a coin tucked beneath this slightly enhances the illusion. Get a pupil to push to the coin through and they will get a pleasant shock. Check for latex allergies beforehand.

The Science behind

This article shows a real time application of polymers for potentially making smart windows, using a polymer like latex that becomes transparent when stretched. The premise is that the intensity of light passing through the polymer can be controlled by stretching.

The Science - Click

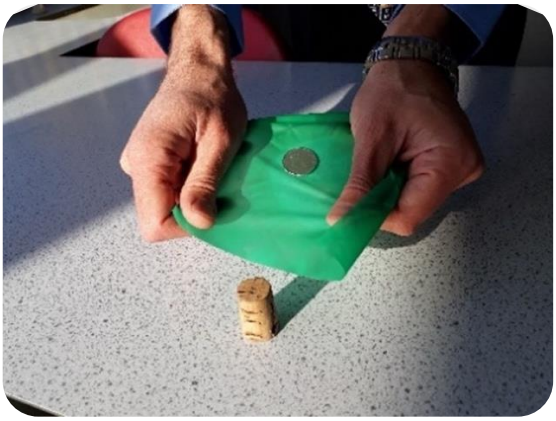


Figure 2.2: Put 10p piece and rest it on a cork or bung. Stretch the rubber over the coin until it becomes transparent and clings to the coin.

This article shows a real time application of polymers for potentially making smart windows, using a polymer like latex that becomes transparent when stretched. The premise is that the intensity of light passing through the polymer can be controlled by stretching.

http://news.mit.edu/2016/tune-polymer-material-transparency-smart-windows-0122

SDG

The magic trick involves the use of scientific principles, demonstrating how innovation and scientific knowledge can create awe-inspiring experiences. It emphasizes the importance of investing in research, technology, and infrastructure to foster creativity and discovery.

This magic trick can be linked with the study of smart windows made with polymers like latex. These windows can automatically adjust their transparency in response to external conditions, such as sunlight and temperature which can enhance energy efficiency in buildings.

Smart windows, on the other hand can reduce the need for excessive heating and cooling, leading to lower energy consumption and reduced greenhouse gas emissions.

3. Arc illusion

Tutorial - How to perform

Start the trick by presenting the two arches to the audience, one above the other vertically (figure 3.1). Alternatively, two bananas can be used (Figure 3.2). Ask a spectator to point out which arch (or banana) is smaller. After the spectator chooses, ask him to help you stretch the smaller arch until it is the size of the other one. Show the arcs vertically again, one on top of the other, but now switch the order (the one that was stretched and was initially on top is now on the bottom). Play with the audience and say, now I think we have stretched it too far. Tutorial - Click

Figure 3.1: Present the 2 arches, one on top of the other vertically.

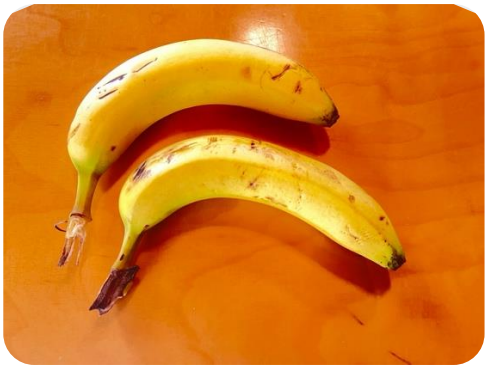


Figure 3.2

This magic trick demonstrates the crucial importance of measuring and comparing accurately. In science, relying solely on our eyes can be misleading. To obtain reliable results, it is essential to use rigorous measurements and appropriate tools.

The Science Behind

Explanation

This illusion is commonly known as the Jastrow illusion. It is an optical illusion where two identical figures are placed next to each other. Although they are both exactly the same size, one appears to be larger. When the positions of the two shapes are reversed, the impression of which is the larger is also reversed.

Scientists are not yet certain what causes one figure in the Jastrow illusion to appear larger than the other. The fact that the shorter side of one figure is next to the longer side of the other somehow tricks the brain into perceiving one shape as longer and the other as shorter, although it is unclear exactly why this is so.

The Science - Click

4. Metal bending

Tutorial - How to perform

Effect

Tutorial - Click

A card is selected by a volunteer and committed to memory (figure 4.1). The volunteer is a given a short piece of wire and is asked to think of their card and place it into a beaker of hot water. The wire starts to bend and form a shape that matches the card selected by the volunteer (figure 4.3).

Figure 4.1: A card is selected by a volunteer.

Figure 4.2: Place the wire in a glass of hot water.

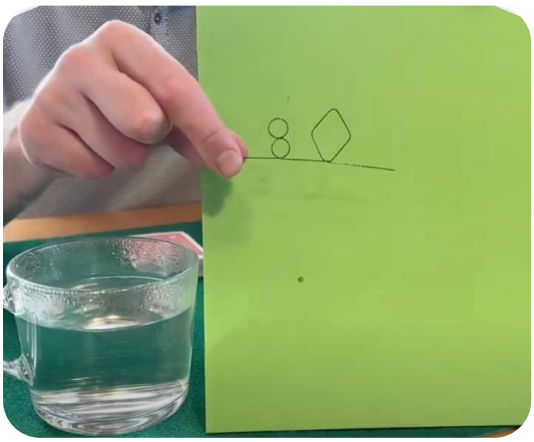


Figure 4.3: The wire starts to bend and form a shape that matches the card selected by the volunteer.

The Science behind

Method

[The Science - Click]

Various people, most notably Uri Geller, have claimed to have psychokinetic powers, claiming to bend metal with their minds. To create this illusion, wiregrams can be used which can change into the shape of a card when immersed in hot water (care with scalding). These are available from internet magic shops and eBay. You need to be able to force a specific card on a pupil which can be achieved in various ways, the easiest being having a pack with all cards the same. The wiregrams are made of nitinol, a memory metal which can 'remember' its shape heated or when an electrical current is passed through it. This makes it useful for stents in clogged arteries and robotic hands. Good memory metal resources are available from Mindsets, such as springs that uncoil in hot water.

SDG

The magic trick involves the use of scientific principles, demonstrating how innovation and scientific knowledge can create awe-inspiring experiences. It emphasizes the importance of investing in research, technology, and infrastructure to foster creativity and discovery.

5. Anti-gravity water

Tutorial - How to perform

Effect

A jar is filled three quarters full of water. A piece of laminated card is placed over the top of the jar and is tumed upside down. The card stays on under the jar (figure 9). When the card is removed the water stays in the jar, defying gravity! [Tutorial - Click]

Method

Preparation

1. Place a glass jar upside down on a piece of fiberglass insect screen.

2. Trace the mouth of the jar onto the screen.

3. Carefully cut out the circle of screen. Note: The circle of screen should be slightly smaller than the outside of the jar's rim.

4. Hot glue or superglue the screen to the top of the jar so that students cannot easily see the screen.

Procedure

1. Pour tap water through the screen until the jar is about three-quarters full.

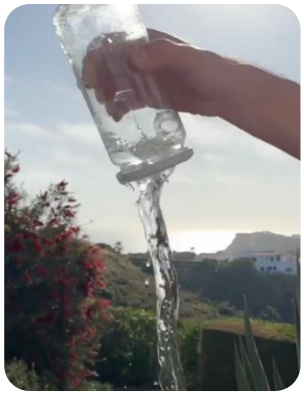
2. Place a laminated card over the top of the jar and hold the card down tightly with one hand. The water will form an adhesive seal with the laminated paper.

3. Quickly invert the jar 180° over a sink or other container, such as a plastic tub or bucket.

4. While holding the jar steady, remove your hand from the laminated card. The card will remain in place over the mouth of the jar! The water forms a tight adhesive seal and external air pressure holds the card in place.

5. Carefully slide the card out from under the jar with one hand while holding the jar steady with the other hand (figure 5.1). A little water may spill out, but most of the water will stay in the jar! The mesh screen provides a surface for the formation of hundreds of tiny surface-tension "membranes" that, in addition to air pressure, will support the weight of the water.

Figure 5.1: Carefully slide the card out from under the jar.



6. Tilt the jar a few degrees to allow air to enter the jar (figure 5.2). The water will immediately spill out of the jar—gravity still works!

Note: To ensure the success of the trick, the glass is typically pressed against the surface quickly to create the low-pressure zone before any significant amount of water can start to fall out.

Figure 5.2: Tilt the jar a few degrees to allow air to enter the jar and the water will spill out.

Tips and notes

There are variations that can be done on this demonstration. Rute has made jars with a metal lid that have a circle cut through it, with the insect mesh inserted in the top (figure 5.3) as shown in the video Anti-Gravity Water I. If the mesh holes are large enough, wooden toothpicks can be pushed through the mesh and floated to the top of the bottle when turned upside down.

Figure 5.3: Lid with a insect mesh cut to size.

Magic shop shops will sell glasses called hydrostatic glasses which have a plastic insert which can placed over the mouth of the glass and have a hole drilled in the side of the glass. The glass is filled with water, the plastic insert is secretly placed over the mouth of the glass covered with a card and the glass is inverted (the hole should be covered with the thumb). When the card is removed, the water stays in the glass and can be released when the thumb is removed from the hole. A performance of this can be seen in the video Anti-Gravity water II.

The Science Behind

The Science - Click

This trick relies on scientific principles and clever manipulation of air pressure and water tension.

When the glass is turned upside down and pressed against a flat surface (e.g., a plastic sheet or piece of cardboard), the surrounding air tends to stick to the curved surface of the glass due to the Coanda effect.

When the glass is pressed against the flat surface the air pressure inside the glass becomes lower than the atmospheric pressure outside.

The water molecules create a surface tension that helps keep the water inside the glass. This surface tension, along with the low-pressure zone created by the Coanda effect, prevents the water from falling out of the glass, despite it being upside down.

The forces acting on the water in the glass are balanced due to the combination of surface tension and low air pressure inside the glass.

SDG

By using water as a medium for the magic trick, it provides an opportunity to discuss the importance of clean water and access to safe drinking water. This trick can serve as a conversation starter to raise awareness about water-related challenges and the need for sustainable water management.

Because women and girls are disproportionately affected by the lack of access to clean water and sanitation, we can use this trick to promote the discussion around gender equality since in many communities, women and girls are responsible for fetching water.

Access to clean water and sanitation is critical for poverty eradication. Inadequate access to clean water and sanitation facilities can exacerbate poverty by affecting health, hygiene, and overall well-being. So we can also talk about the Sustainable Development Goal - No poverty, using this trick with water and its unique chemical and physical properties.

6. Cut and restored newspaper

Tutorial - How to perform

Effect

A strip of newspaper is folded in half and cut with a scissors and seen to be restored when opened out again (figure 6). Tutorial - Click

Figure 6: Fold the newspaper and cut in half with scissors.

Method

There is a good torn and restored newspaper demonstration from Flinn Scientific. This relies on rubber cement to keep the paper together and provides a context for intermolecular forces between molecules.

https://www.flinnsci.com/api/library/Download/5537422a07664d95a1213f2504eb536d

Preparation

1. Cut a 2-inch strip of newspaper from the length of a sheet of newsprint.

2. Coat one side of the strip of newspaper with rubber cement and allow it to dry.

3. Lightly coat the dry rubber cement with baby powder.

Procedure

1. Show the uncoated side of the strip of prepared newspaper to the students.

2. Bring the bottom edge of the newspaper up so that the two coated sides face each other. Note: Keep the uncoated side toward the students.

3. Keep a finger between the top edges of the newspaper but lightly press the bottom folded area together.

4. Cut above the fold with sharp scissors.

5. Let the back edge of the newspaper fall; this will keep the uncoated side toward the students. The strip of newspaper will stay connected giving the illusion of an uncut strip of paper.

6. Repeat as desired.

Note

Elmer's rubber cement is difficult to obtain outside the UK. A suitable alternative is spraying the newspaper with two coats of repositionable glue spray, this was used in the video shown.

Always check the risks and safety of the glue you use!

The Science behind

Timstar and Mindsets online sell auto heal or self-healing tape. This silicon polymer sheet embodies the remarkable property of almost instant self-healing. If two freshly cut edges are pushed back together, new bonds form and in seconds it becomes virtually impossible to pull the cut open. Similarly, if two clean surfaces are brought together, new bonds immediately form – making this one of the few known materials that can be welded to itself using pressure alone. It bonds to itself and only itself. The Science - Click

7. Magic is ...

Tutorial - How to perform

Effect: This trick creates the illusion of ink magically disappearing from a surface when subjected to heat, using a friction pen. Tutorial - Click

Materials:

- A friction pen available at most stationery or magic supply stores.
- A regular pen with the same colour of the friction pen.
- A piece of paper or any surface where you want to perform the trick.
- A heat source, such as a hairdryer.

Procedure:

To prepare the trick write a message with a normal pen. Hide this message using a friction pen. For example write random letters between the letters of the message. This way what is written is imperceptible to the public.

Ask someone in the audience to say the magic words: **"For the words to show, heat must bestow."**

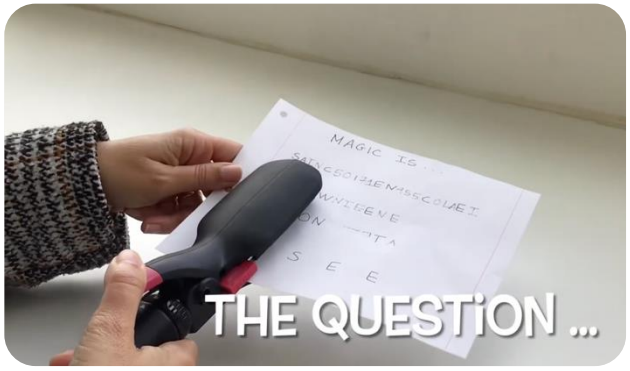


Figure 7: Use a hair plate to heat the paper.

As the heat is applied to the ink marks, they will "magically" disappear right before the audience's eyes! (figure 7).

The Science Behind

Frixion pens contain thermochromic ink which vanishes when the heat from the friction of erasing is used to make the ink disappear. This can be used to reveal secret messages as shown in the video, by using heat to make the thermochromic ink disappear and leave visible writing done in ink from a normal pen.The Science - Click

8. Water on fire

Tutorial - How to perform

Tutorial - Click

Safety First

This activity should only be carried out by a teacher.

Before performing the experiment please check the risks and safety of Lighter Fluid at the following link:
Zippo Lighter Fluid - Safety Data Sheet

There is a lot of interesting chemistry in this demonstration. You can discuss density, combustion, miscible and immiscible liquids, polar and nonpolar liquids as well as observation skills.
It is recommended that safety goggles are worn for this demonstration. Before the demonstration, a little lighter fluid is added to the bottom of the flask (less than a ml). The students should be unaware of this.
Drink from a bottle of water. Fill the flask to just below the lip with tap water, don't let the flask overfill and lose the lighter fluid. Light the liquid on top of the flask. Put the flask on the table. Let the students make observations and figure out what is happening as the lighter fluid is completely burned away (figure 8.1).

Figure 8.1: Let the students make observations.

The Science Behind

Water, of course, does not burn. The students should deduce that there is something other than water burning. The immiscible flammable liquid added before the demonstration is less dense than water, floats to the top and is flammable when lit.

1. Add the fuel.

2. Add water.

3. Wait a few seconds and bring a match close to the surface of the water.

Figure 8.2: Step by step preparation.

SDG

The trick symbolizes the transformation of water into fuel, illustrating the importance of clean and sustainable energy sources. Sustainable energy is essential for achieving SDG 7, which aims to ensure access to affordable, reliable, and sustainable energy for all.

In this trick the audience is made to think that the water is on fire. We can use this trick as an introduction to the discussion about fossil fuels, renewable and non-renewable energies and their impact. With this trick we can ask the question: Can we use only water as fuel? Then we can make a connection with these two SDGs.

Emphasise that the transition to cleaner energy not only benefits the environment but also leads to more resilient and inclusive urban communities, aligning with the principles of SDG 7 and SDG 11.

The Science - Click

9. The bottomless glass

How to perform – Tutorial

Tutorial - Click

Safety First

This activity should only be carried out by a teacher.

Before performing the experiment, please check the risks and safety of acetone at the following link:

Safety Data Sheet: Acetone

Tips for a Safe Performance:

- Perform the trick in a well-ventilated area to avoid inhaling acetone fumes.
- Use acetone sparingly to avoid excessive reactions.
- Dispose of any used acetone and Styrofoam responsibly and safely.

Figure 9: Press a piece of Styrofoam into an opaque container with acetone inside.

You'll need an opaque container that viewers can't see is acetone inside. This acetone cannot be the softened acetone that we often find in supermarkets and that is used to remove nail polish, as it is not pure and does not achieve the same results in this trick.
The lower the container and the higher the piece of Styrofoam, the greater the impact.
Start by showing that under the container there is nothing but the table where it is and that it has no hole through which it can get out.
If the table doesn't have a tablecloth so that viewers can see freely under the table, the greater the impact.

The Science behind

Expanded polystyrene articles are manufactured from polystyrene granules that incorporate a blowing agent – a substance which, when heated, gives off a gas. This may be a volatile liquid (such as pentane) or a carbonate. These granules are then steam-heated and the gas from the blowing agent expands to produce a foam plastic. This gas is eventually exchanged with air. Thus, the gas in the solid foam is largely air.

The expanded polystyrene does not actually dissolve in the propanone; it merely softens as it absorbs the propanone and allows the air to escape, thereby collapsing the foam. An interesting example of a gas formed not by a chemical process, but by a physical process. The resulting colloidal gel consists

of propanone molecules dispersed in a network formed by a tangle of large polystyrene molecules – a similar structure to ordinary jelly in which water molecules are dispersed in a network of protein molecules.

The Science - Click

SDG

Sustainable Cities and Communities: SDG 11 advocates for sustainable urban development, which includes creating resilient and resource-efficient cities. Styrofoam insulation in house walls can help reduce energy consumption and greenhouse gas emissions, promoting sustainability in the construction sector. In the magic trick using styrofoam we can explore its use in construction and we can also take the opportunity to discuss whether this is a sustainable material and possibly think about alternatives.

10. Magic strip

Tutorial - How to perform

Trace the Surface: Indicate that you are going to launch a challenge: Ask to trace on one side with one colour and on the other side with another colour. Emphasise that no matter where they start, they will end up back at the starting point without lifting the pen or crossing an edge. The audience will be amazed that they can't do it and end up where they started having used just one colour and not two as stated in the challenge.

Cutting the Möbius Strip: Ask the audience what will happen if you cut the Möbius strip down the middle. Wait for the answers.

Now, explain the surprising property of the Möbius strip when you cut it down the middle. Unlike an ordinary loop, which would yield two separate loops when cut, the Möbius strip produces a single, larger loop. This time, have a physical Möbius strip ready to demonstrate this by making a single cut along the strip.

How to prepare the **Möbius strip**:

If you have strips of paper available, you can invite the audience to create their own Möbius strip. Instruct them to take a long, thin strip of paper, give it a half-twist, and then glue or tape the ends together (figure 10.1).

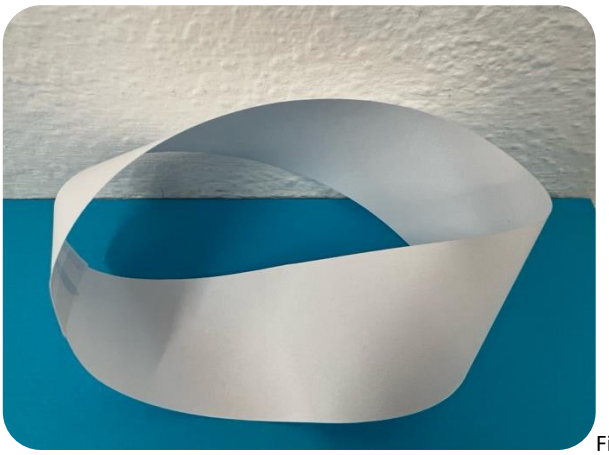


Figure 10.1: Möbius strip.

Tutorial - Click

The Science behind

A Möbius strip is a one-sided surface that can be constructed by affixing the ends of a rectangular strip after first having given one of the ends a one-half twist. This space exhibits interesting properties, such as having only one side and remaining in one piece when split down the middle. The properties of the strip were discovered independently and almost simultaneously by two German mathematicians, August Ferdinand Möbius and Johann Benedict Listing, in 1858.

If you cut it straight in half, (that would mean two cuts) you just get two strips half the original size. However, try to cut it lengthwise and you fail to separate the strip. You still get a ring with a couple twists that's not a mobius strip (figure 10.2). Cut that lengthwise again and you get that same shape with a mobius strip half the length interlocked.

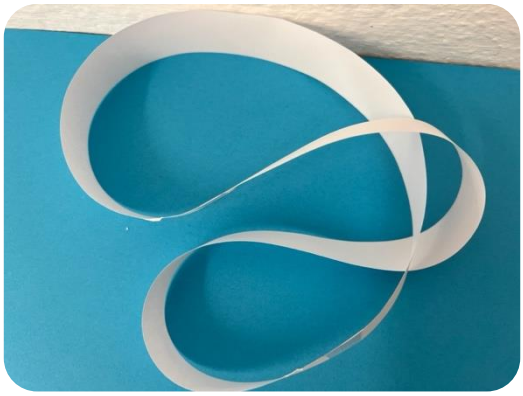


Figure 10.2: Tape resulting from the cut of Möbius strip lengthwise.

An animation of how this works can be found here:

Animation - How this works - Click

A nice explanation of how to do the effect can be found here:

Animation - Click

Applications: Möbius strips are found, such as in conveyor belts or certain types of industrial machines. This shows that even though the Möbius strip may seem like a curious mathematical concept, it has practical uses.

SDG

11. Teflon - Secret message

Tutorial - How to perform

Instructions

1. Cut a piece of Teflon Tape.
2. Place your strip of Teflon Tape on a flat surface.
3. Write your secret message on the Teflon Tape.
4. Stretch the tape from top to bottom, making your message taller until you cannot read your message anymore (figure 11.1).

To reveal the message, Pull firmly on the tape from end to end stretching your message longer (figure 11.2).

Tutorial - Click

The Science behind

Teflon Tape is a type of polymer called polytetrafluoroethylene (PTFE). If you try to stretch the tape end to end before stretching it from top to bottom, you won't be able to stretch it much at all. That is because the polymers are bonded to each other very tightly. But, there are lots of chains stacked on top of each other. These stacks make it possible to pull the tape from top to bottom and stretch your secret message. When the polymer chains are pulled from top to bottom they slide over one another and reduce the number of chains in a section without breaking the chains themselves. When the tape is pulled back end to end, the chains are realigned and your message is legible again.

Figure 11.1: Stretch the tape from top to bottom.

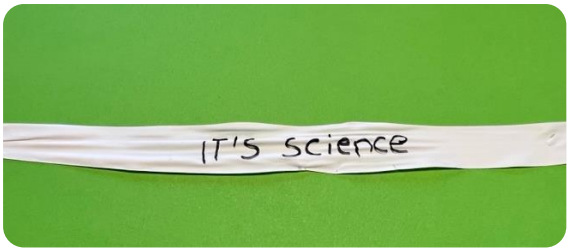


Figure 11.2: To reveal the message, Pull firmly on the tape from end to end stretching your message longer.

12. Euro millions Number

Tutorial - How to perform

Effect

A message is placed behind or underneath a transparent glass filled with hydrogel spheres (figure 12.1).

After this set up ask the audience to read the message we have for them.

Tutorial - Click

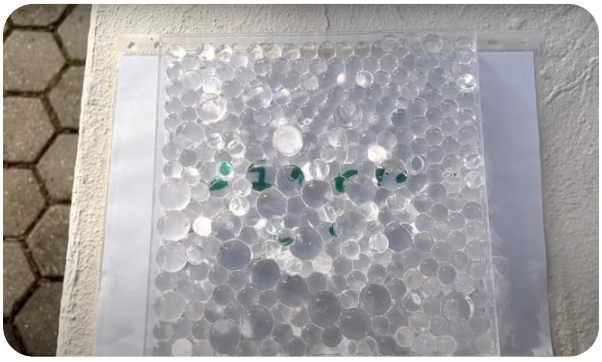


Figure 12.1: Hydrogel spheres in a plastic container above the message.

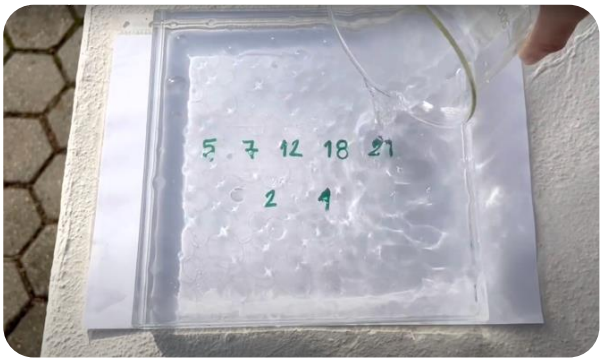


Figure 12.2: Message revealed after adding water to the spheres of hydrogel.

The Science behind

Aqua water beads when hydrated overnight, they have the same refractive index as water so are virtually invisible when covered with water. I like to put a beaker of beads on each bench and ask them to test the temperature, so they get a surprise when the feel the gel beads. Hydrogels are virtually invisible in water.

A similar effect can be obtained with Pyrex and vegetable oil or glycerol as they have the same refractive index. We only see things when is a refraction, when the light changes direction.

The message looks scrambled under the hydrated spheres because the light reflected off of the message is scattered in every direction by the water-filled hydrogels (figure 12.1). It's like trying to read through broken glass, in other words, impossible! When water is added to the dish, the light rays pass straight through the water and the spheres into your eyes without being scattered (figure 12.2). This is due to the hydrogels identical index of refraction with the water. So, it seems like you're looking through a cup of plain water and can easily read the message.

These demonstrations can be used to link this with invisibility cloak technology developments.

Figure 12.3: You can take advantage and do this trick at Christmas.

13. Linking Paperclips catalyst demo

Tutorial - How to perform

With this trick we can demonstrate how a catalyst acts as a surface for reactants to come together and form a product. Based on an old magic trick, this idea came from Paul Nugent from @SonS_Ireland. The ending is a nice surprise for students!

Tutorial - Click

Effect

Two paper clips are shown. They represent two different reactant molecules. If molecules (paperclips) have the correct orientation and energy (energy greater than activation energy) to collide, they will link with other and from a chemical bond. This is shown the performer links the paperclips.

The paperclips are unlinked and put on a folded piece piece of paper which represents a catalyst. A catalyst speeds up a reaction, provides a surface for the reactants and lowers the energy required to

perform the reaction. The paper is pulled, the paperclips (which were unlinked) jump off of the paper and are now linked showing the catalyst has worked!

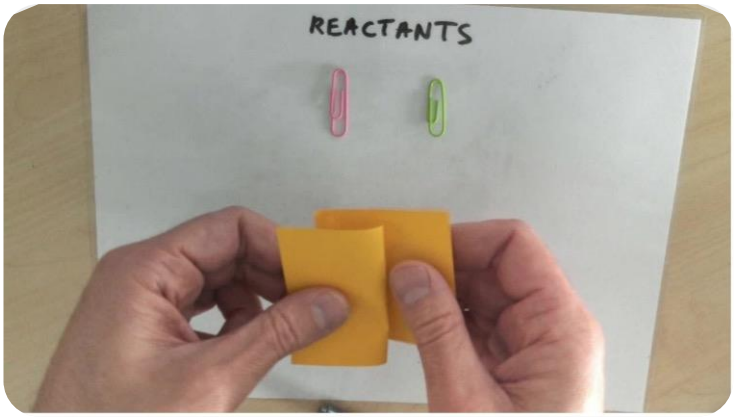


Figure 13.1: Take a piece of paper or money note (which is often smooth and easier to use) and fold into an S shape.

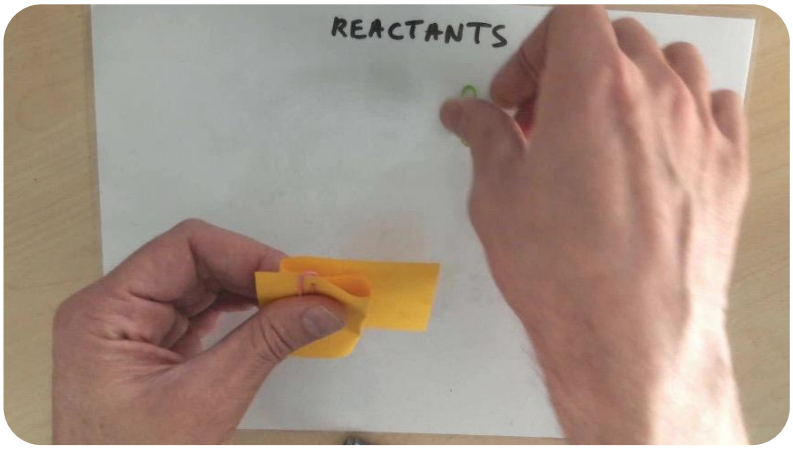


Figure 13.2: Place the first paperclip onto the note like shown in the picture below You want to join the front of the paper with the first 'fold' of the 's'-shape.

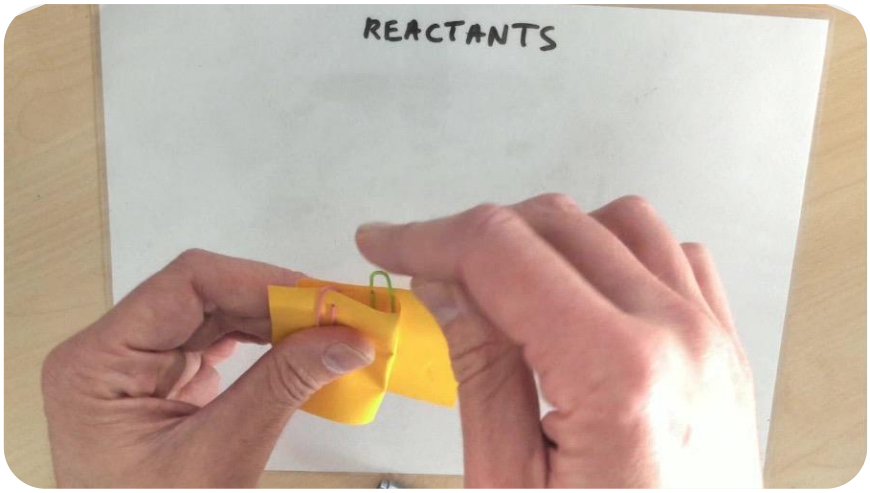


Figure 13.3: Place the second paperclip on the note like shown in the picture below, joining the second fold of the 's'-shape with the back of the paper.

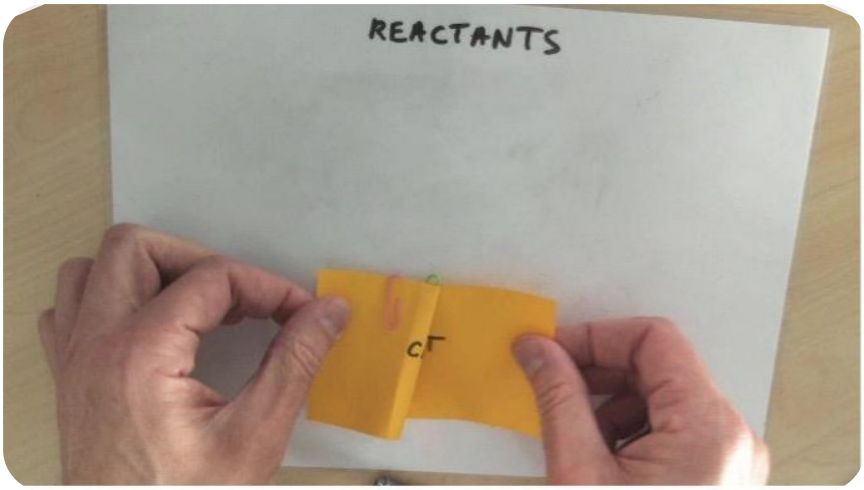


Figure 13.4: Time for the **magic moment**. Holding the ends of the note or piece of paper between your forefingers and thumbs (see the picture below, pull the ends in opposite directions as to 'unfold' the note).

Credit should go to Ireland's Paul Nugent who performed this at a Science on Stage webinar in 2021.

SDG

The paperclips catalyst trick can show how less energy is needed when using catalysts and they can be reused.

Energy efficiency measures help reduce energy consumption and contribute to SDG 7's goal of ensuring sustainable energy use.

14. Invisibility

Tutorial - How to perform

Preparation of the trick (must be done before the audience is present): Prepare a container with vegetable oil. Inside this container should be a Pyrex glass test tube.

Show small pieces of Pyrex glass and point out that they are from a test tube that has broken, something that often happens in a school laboratory. Point out that we can, with a magic liquid, get our test tube back in one piece. Insert the small pieces of Pyrex glass into the container with vegetable oil. The audience will see the pieces 'disappear'. You can then ask the audience to help you with a magic word to get the tube back intact. Then remove the test tube that was inside the vegetable oil.

Tutorial - Click

The Science behind

By adding vegetable oil to these Pyrex glasses, we will witness the light changing direction, also known as refraction.

When light travels from one medium (like air) to another medium with a different refractive index (like pyrex glass or vegetable oil), its speed changes, causing the light rays to bend, change direction. This bending of light is what we refer to as refraction. Refractive index is a measure of how much light slows down when passing through a particular material. The higher the refractive index of a material, the slower light travels through it, and the more it bends.

The index of Pyrex glass is similar to the refractive index of vegetable oil, so the light will have the same speed in both media, it will not bend when passing from the Pyrex glass to the vegetable oil and vice versa, which gives us the feeling that there is no other Pyrex glass inside of vegetable oil (figure 14).

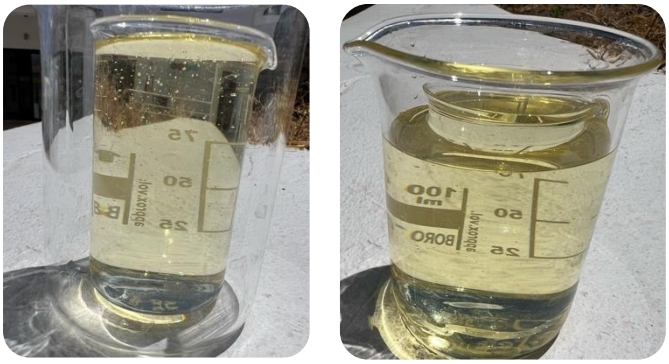


Figure 14: Two pyrex cups inside each other with vegetable oil.

15. The ketchup trick

Tutorial - How to perform

To prepare the trick, simply place a ketchup packet inside a plastic bottle of water. Check that the ketchup packet floats in the water. Close the bottle tightly with the cap.

Tell the audience that you will get the ketchup packet down with your mind power. However, as you can see in the video below, the ketchup packet doesn't move (because you're not doing anything).

Next, involve the audience, ask them to help you. Ask them with the power of their mind to make the ketchup packet go down. Now squeeze the base of the bottle, without the audience realising, everyone will see the ketchup packet go down (figure 28). Thank the audience for their support.

Note: Asking the audience for support is always a good idea, make them feel involved in the magic trick.

Figure 15: squeeze the base of the bottle, without the audience realising.

Tutorial - Click

The Science behind

The ketchup packet has some gas inside. Squeezing the bottle with water increases the pressure and the gas in the ketchup packet is compressed. This compression leads to a decrease in the volume of the packet, thus an increase in its density, because the mass remains the same. The density of the ketchup packet becomes greater than the density of the water and it sinks. When you let go of the bottle, the pressure decreases, returns to its initial value and the packet becomes less dense than the water in the bottle, causing it to float again.

This experiment can be performed with other solid objects which have an airspace that can be compressed. ….an inverted weighted test tube or pen top for example (the space is part filled with water leaving an airspace in the tubes)

Note: Sometimes the ketchup packet doesn't float, it sinks when placed in water. This is related to the density of the water used (which is not the same everywhere) and the density of the ketchup. Sometimes adjustments have to be made to the density of the water. If the ketchup sinks, we have to increase the density of the water, for example by adding salt.

16. The head that lost its body/Flying man

Tutorial - How to perform the head that lost its body

A table is prepared with a hole just off set from the centre through which the assistant can put his/her head by standing/sitting below (figure 16.3).

The table has underneath a large Perspex mirror across a diameter between opposite legs.

16.1 Photo showing construction of table .

16.2: Note similar legs and position of mirror and hole for head

Figure 16.3: How to set up the table.

The assistant (or member of the public) sits below the table with head protruding.
The full table is revealed , showing the head just on top and the empty space of a table with 4 legs below.
(Key is the position of the table, I find a total clear floor is best, so that no extra items are caught in the image in the mirror).

Figure 16.4: Adrian and Rute showing the effect.

The Science behind

This is just a simple reflection of light creating this illusion.

The large plane mirror across half of the underside of the table gives the illusion of an empty underneath. The body is hidden behind the mirror.

(This is an excellent demonstration to take to a parents display evening or summer /winter fayre)

Tutorial - How to perform the flying man

The assistant /child or member of the public stand in such a way that the appear to raise two legs to fly across the room.
The mirrors used need to be suitable for the size of the demonstrator.

The large mirror (about a metre and a half long) is fixed vertically on a plain floor surface (figure 16.5).

Figure 16.5: Large mirror fixed vertically on grass. Mirror supported vertically on plane background

The assistant steps forward and moves astride the mirror with a leg on either side (figure 16.6).
He/she then raised the leg in front of the mirror and appears to be flying (figure 16.7).

Figure 16.6: How to perform.

Figure 16.7: Student standing astride mirror, then raising one leg only. The assistant appears to be flying.

(The performance can be enhanced by having some costume for the assistant. e,g, Harry Potter, Superman , Peter Pan , …for extra effect).

The Science behind

Here is another image in a plane mirror example. The raised leg in front of the mirror has its image in the mirror giving the impression of two legs raised at the same time. The body is of course held aloft by the second leg behind the mirror

17. The wildest race

Tutorial - How to perform

Show two tubes of the same size, one made of copper or aluminium and one made of plastic (not telling the public what material they are made of).

Drop a magnet through the aluminium or copper tube. The magnet falls much more slowly than if it were in free fall.

Drop the magnet again but now bring a ferromagnetic ring on your finger close to the tube. The magnet stops falling. Repeat but now with a plastic tube, the magnet will fall in free fall (figure 17).

To perform this trick we can ask for a volunteer to run a race, whoever takes the longest to get through the tube wins. We give the metal tube to the volunteer and keep the plastic one, count to 3 and drop the magnet at the same time. We congratulate the winner for managing to slow down the fall.

The Science behind

This magic trick is related to the Lenz's Law, a fundamental law of electromagnetism that explains the direction of an induced current in a conductor in response to a changing magnetic field, with the

induced current creating its own magnetic field to oppose the change. This law is named after the Russian physicist Heinrich Lenz, who formulated it in the mid-19th century.

Lenz's Law tells us that the direction of the induced current is such that it opposes the change in the magnetic field that caused it. In other words, the induced current creates a magnetic field that counteracts the change in the original magnetic field.

A common example used to illustrate Lenz's Law is the experiment with a magnet and a conducting tube (e.g., a copper or aluminium tube). When you move the magnet towards the tube, the changing magnetic field induces an electric current in the tube. According to Lenz's Law, the induced current creates a magnetic field that opposes the motion of the magnet.

This opposition between the induced current's magnetic field and the original magnetic field is the reason why objects, like the magnet, experience resistance or "drag" when moving through conductive materials.

Figure 17: Two tubes, one plastic and the other metal, with equal length.

18. Ambiguous cylinder illusion

Tutorial - How to perform

Place the cylinder it on a flat surface, such as a table. Stand directly above the cylinder and tilt your viewpoint at approximately a 45-degree angle. Now, begin slowly rotating the cylinder. As you do so, observe the shape closely, and you'll notice that it alternates between appearing as a circle and a square. Finally, complete the experiment by rotating the cylinder 180 degrees to observe the captivating transformation (figure 18.1).

Tutorial - Click

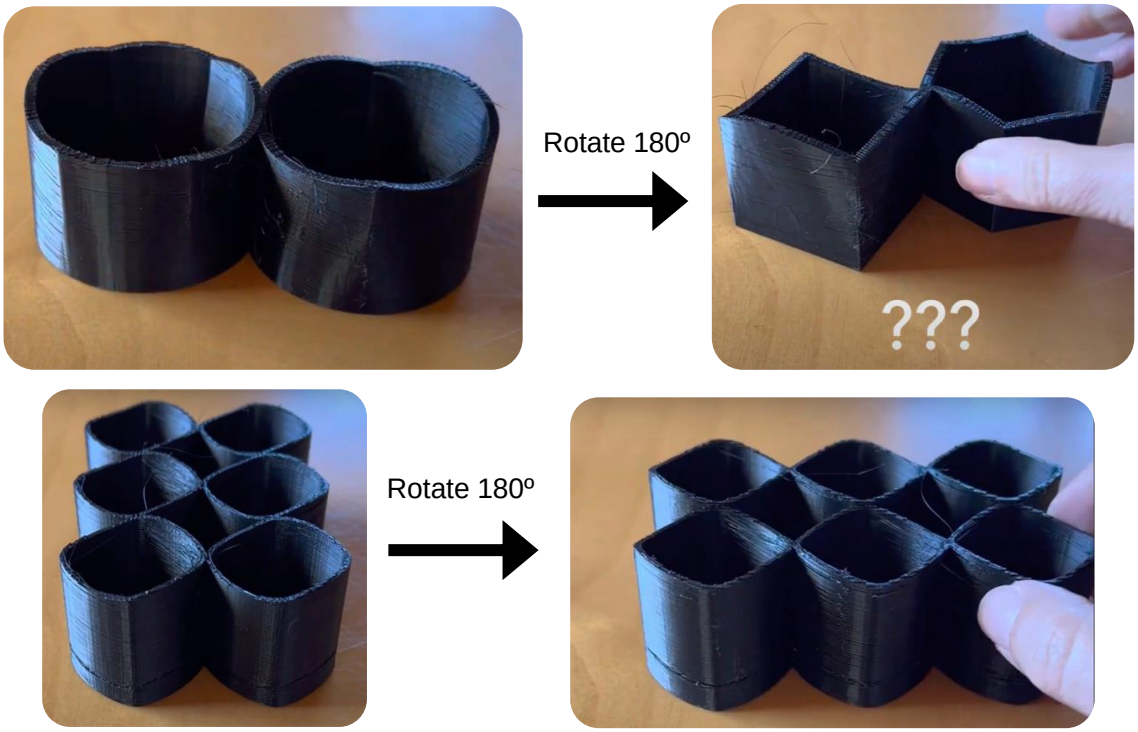


Figure 18.1: Ambiguous cylinder. Photograph showing cylinders rotated by 180 degrees, a circle changes to a square cross section.

The same mysterious effect can be shown with the aid of a plane mirror, placed behind the object . The image in the plane mirror is of the object viewed from behind, so that the circles seen directly will appear as squares in the mirror (figure 18.2).

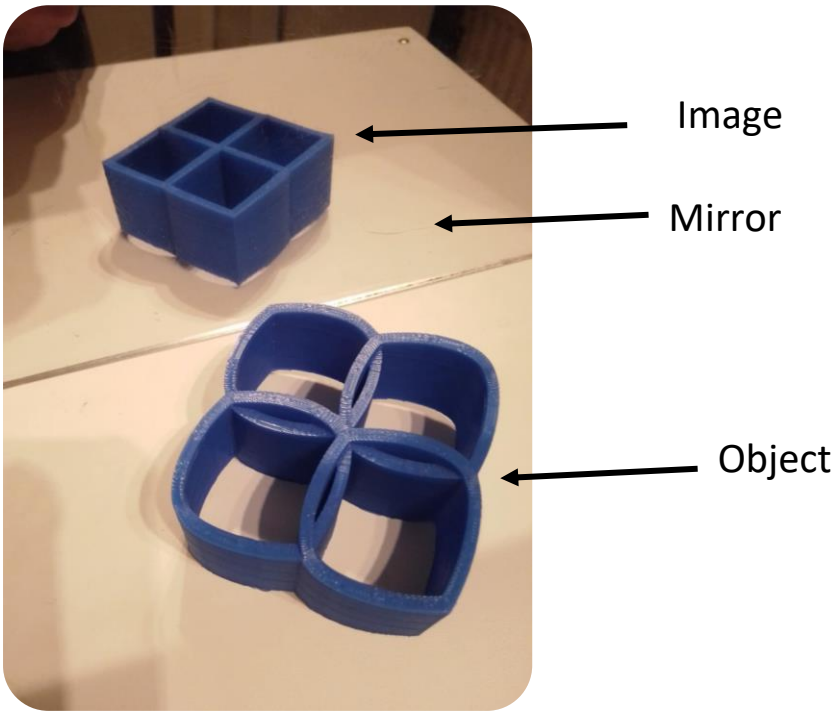


Figure 18.2: Ambiguous object seen in the mirror. Ambiguous solid in plane mirror , the image is viewed from the back of the solid creating the change.

The Science behind

This enigmatic cylinder defies logic! From one angle, it presents itself as a square, but shift your perspective, and it magically transforms into a circular shape. Astonishingly, when you place it before a mirror, you witness both sides simultaneously—the circle before you, and its reflection in the mirror as a square, or vice versa. However, this bewitching illusion only unfolds when viewed from a specific angle.

The cylinder is carefully made to create an amazing trick. It looks like a square from one side and a circle from the other, but only when you look at it from a special angle - albeit exclusively when viewed from an elevated 45-degree angle. Nevertheless, a true revelation awaits those who choose to look directly down upon it, exposing its actual form. The top and bottom of the cylinder are not flat; they are curved. When you look at it from a certain angle, your mind gets confused and thinks

the curves are flat. This makes your brain tricked into seeing either a square or a circle, depending on which side you look at the cylinder from. It's like a cool magic trick!

See the explanation in the next video and take the opportunity to make the connection with the constellations.

https://youtu.be/GfOcBwOwssw

19. The Liquid of Invisibility

Tutorial - How to perform

Begin by creating a drawing or using a small picture (depending on the context of the trick, in the following video are several examples). Tutorial - Click

Another idea: Tutorial I - Click

Insert the drawing into the plastic bag, ensuring that it is fully sealed inside. Draw or write, on the outside of the bag, with an acetate pen what you want to see when you submerge the plastic bag in water (figure 19.1).

Fill a container with Water.

Submerge the Bag in Water.

Observe the Illusion: As you lower the bag into the water, you will notice that the drawing inside the bag seems to disappear, and we can only see what has been drawn or written in acetate pen on the outside.

Figure 19.1: Put the drawing we want to disappear into a plastic bag.

Figure 19.2: Seal the bag tightly to prevent any water from getting in.

The Science behind

The trick involves a simple optical illusion that demonstrates the concept of total internal reflection.

The illusion occurs due to a phenomenon called total internal reflection. When light travels from a denser medium (in this case water) to a less dense medium (in this case the air inside the plastic bag), the light can undergo reflection at the boundary between the two mediums. However, if the angle at which the light strikes the boundary is too shallow, the light does not escape but reflects entirely back into the denser medium.

In this trick, the plastic bag acts as a boundary between the water and the air inside the plastic bag. When you submerge the bag in water, light from the drawing inside the bag encounters the bag's surface at a shallow angle. Due to total internal reflection, most of the light reflects back into the water, making it difficult to see the drawing clearly.

Figure 19.3: It looks like the Harry Potter drawing disappears.

It gives the impression that the drawing on the inside of the bag has disappeared (figure 19.3).

Idea: This illusion can be performed with children to demonstrate the importance of hand washing.

SDG

This illusion can be used to demonstrate the importance of hand washing.

Washing our hands is not just a simple task – it's a powerful way to keep ourselves healthy and well.

This connects to "SDG 3: Good Health and Well-Being."

20. The magic number

Tutorial - How to perform

Give a volunteer from the audience an envelope with a prediction.

Show 9 cards numbered from 1 to 9. Ask a member of the public to choose 3 cards.

Write the chosen numbers on a board or sheet of paper. For example, if the numbers 2, 5 and 8 have been chosen, the rule is to put the largest number on the left (but this instruction should not be communicated).

Write down the number 852.

Now ask them to subtract the inverse, i.e. 852 - 258. Write the result 594 and add the symmetric.

Write down the result 1089.

Now ask the person you gave the envelope to open it and ask them to read the number written on it: it's 1089.

Tutorial - Click

The Science Behind

Let us assume that the initial number is the larger and has digits a, b and c. So, when we reverse and subtract we will have (100a + 10b + c) – (100c + 10b + a)

This is the same as 100a + 10b + c – 100c – 10b – a = 99a – 99c = **99**(a – c)

Because a and c are integer numbers, at the end of the first part of the process we will always end up with a multiple of 99.

The three digit multiples of 99 are: 198, 297, 396, 495, 594, 693, 792 and 891.

Now, note that the first and last digits of each number add up to 9.

So, when we reverse any of these numbers and add them together we get 9 hundreds from the first digit, 18 dozens from the second digits and 9 units from the third digit.

So we get **900 + 180 + 9** = 1089.

21.Phoenix from the ashes

Tutorial - How to perform

Safety First

This activity should only be carried out by a teacher.

Before performing the experiment please check the risks and safety of experimental activities with fire.

This torn and restored demonstration involves setting fire to some craft tissue paper rolled into a tube. Tutorial - Click

Figure 21: How to set up.

The Science Behind

This causes the air inside the tube to become less dense and rise, carrying the ashes with as they float. The ashes can be caught and restored using a duplicate piece of paper hidden in the catching hand.

This can be done with certain types of teabags or a special type of craft paper found in packets of flying wish paper. Ordinary tissue paper is too heavy, craft paper from florists is the paper that was used in the video. The Science - Click

22. Elastic and paper clip

Tutorial - How to perform

The ring or paperclip is placed at the lower end of the elastic and the lower hand holds the band just below the ring.

The magician scientist then streches the band with the upper hand so that the ring is at the bottom of a gradient of elastic. The remaining elastic in the hand holding it , is hind in the hand behind the fingers (figure 22).

The audience totally focuses on the ring and at a word of command "up" ..the ring begins to climb the band .

This is simple apparatus to give out ..a paper clip and some elastic and a whole class can attempt to move the clip (if they are well behaved !).

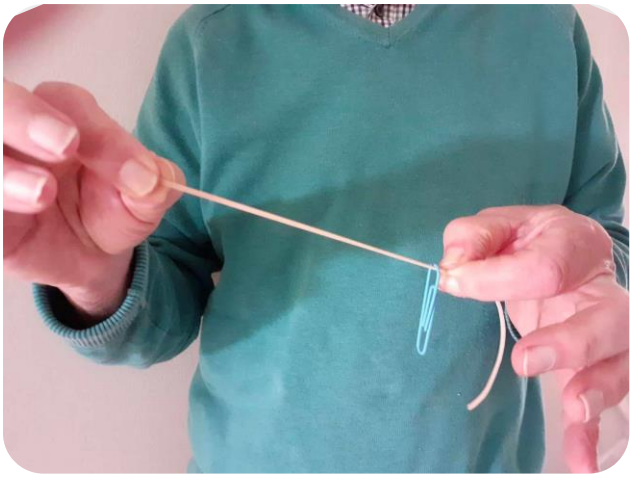


Figure 22: How to hold the elastic band with clip at the bottom.

Hold the upper end tightly, as the elastic is stretched, and gradually ease the unstretched elastic through your fingers of the lower hand. The paper clip will appear to ride up the elastic but in reality, it is the band holding the clip that rises.

The Science Behind

This is an example of how asking the wrong question inevitably leads to the wrong answer, whether it is science or life in general.

The ring or paper clip only appears to move halfway up the elastic. The reason is that the lower hand secretly eases its grip of the elastic so that more elastic is allowed in between the two hands ..i.e. the tension in the elastic changes. The ring appears to climb, but what is happening is that more elastic is released but the ring stays stationary on the elastic, but moves up relative to the hands.

This is a good example of asking the wrong question…. better is “what does the paper clip move in relation to”? The clip remains on the same piece of elastic throughout.

23. Matchbox and Coin

Materials Needed:

- A matchbox (preferably filled with matchsticks to make it look ordinary)
- Two coins of magnetic material, e.g. UK pennies, canadian cents, euro cents.
- A small strong magnet e.g neodymium

Tutorial - How to perform

Preparation:

Secretly tape a small magnet to the underside of the matchboxes inside compartment, beneath the matchsticks. Ensure the magnet is strong enough to attract the coin, through the matchbox.

With the matchbox half open, place a coin wedged between the two parts of the matchbox on top of the matches, so that it is not seen when the matchbox is only half open (figure 23.1) and when you close the box the coin falls into it, coin stays on top of the matches inside the box, hold the other magnetic coin in your hand, making sure it is visible to the audience.

Figure 23.1: Set up.

The Performance:

Open the matchbox halfway so the coin is not seen.

Close the matchbox and place it on top of the coin that's in your hand.

Gently lift the matchbox off the hand. The coin on the hand has disappeared!!

Finally, open the matchbox to reveal the coin has magically appeared inside!

Figure 23.2: Step-by-step setup of the magic trick using coins, a matchbox, and a magnet.

The Science Behind

This magic trick cleverly uses **magnetism**, a fundamental force of nature, to create the illusion of a disappearing and reappearing coin. Here's the scientific explanation:

The coins you use are magnetic, meaning they can be attracted to a magnet. UK pennies, for example, contain steel, which is magnetic. The small magnet hidden inside the matchbox creates a magnetic field that can attract the coin in your hand.

An important characteristic of magnetism is that it can pass through non-magnetic materials, such as the cardboard of the matchbox. This allows the coin in your hand to be attracted to the magnet inside the matchbox without the audience noticing anything unusual.

24. The Dry –Erase Dancers

Tutorial - Click

Tutorial - How to perform

The Effect

When some water is added to the two figures, they mysteriously start to dance and float until they disappear.

Method

You will need:

-some dry-erase white board markers

-a clean white bowl, plate or a flat glass

-a dropper

-some water

Draw your figures on the clean dry surface (figure 24).

Add drops of water to the figures. They will appear to float.

Rock the container to create movement.

The Science Behind

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

Experiment with:

-Different marker brands and colours

-Different amounts of applied ink

-Different surfaces drawn on

-Different temperatures of water used

Figure 24: Drawing made with whiteboard markers on a non-porous surface

Credits: Paul Nugent, Booklet Science on Stage 2022, Ireland

25. Nutty nuts and bolts

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

Material:

A film cannister or another suitable container

3 nuts and bolts

3 different coloured tapes

Tutorial - How to perform

Prepare the Bolts:

Take the three bolts and place a piece of different colored tape on each one. This will make it easier for your volunteer to identify and choose one later (figure 25).

Volunteer's Choice:

Ask a volunteer to select one of the bolts. Once they've made their choice, instruct them to place a nut in the middle of the selected bolt's thread.

Into the Canister:

The scientist (you) then takes all three nuts and bolts — including the one the volunteer chose — and places them inside the canister.

Magical Movement:

With a mysterious air, rotate the canister in your hands. The trick happens here, but the audience is unaware of what's really going on inside the canister!

The Big Reveal:

Empty the contents of the canister into the volunteer's hand. Magically, only the chosen bolt has its nut in the middle, while the other two bolts remain unchanged!

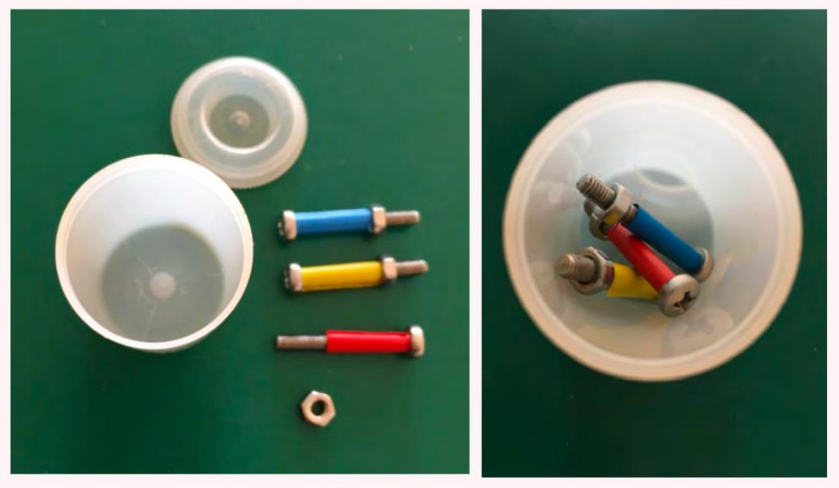


Figure 25: Bolts placed in canister, all holding a nut. Three bolts, each marked with a different coloured tape, allowing the volunteer to easily identify and select one during the trick.

The Science behind

This magic trick works thanks to a clever use of friction and orientation.

When the volunteer is distracted, the scientist places the two unselected bolts in the canister with the nuts facing downward. However, the chosen bolt is placed with the nut facing upward. This subtle difference is key to the trick's success.

As the magician rotates the canister, the nuts on the bolts placed downward remain tightly in place. However, friction comes into play with the chosen bolt that is nut-side up. As the canister rotates, the nut on the chosen bolt gradually loosens due to the friction.

Credits: Paul Nugent, Booklet Science on Stage 2022, Ireland

Next level

Stepping into the Next Level of Magic

Remember that as always behind these "tricks" there is an application of science, often science the magician hides. So, get ready to take your skills further, as we explore the magic that sometimes requires a little extra preparation and careful thought as to how the science is to be demonstrated and maybe a touch of the professional.

26. Joining Scarves

Tutorial - How to perform

Begin by showing the audience the empty tube. To make it more convincing, you can even blow through the tube to show that it is "empty."

Figure 26.1: Placing the separate scarves one by one into the tube.

Then, show the separate scarves to the audience. Hold each one up and explain that you'll be placing them inside the tube one by one.

Place the scarves into the tube, but do so carefully so that you don't accidentally expose the knots or how they're tied together.

Once all the scarves are inside, say a few magic words or give the tube a little shake to "activate" the magic.

Begin to slowly pull the scarves out from the tube. As you do, the audience will be surprised to see that instead of separate scarves, they are all connected together, forming one long chain of scarves!

Fully extract the scarves from the tube, showing that they are now magically joined together.

To enhance the effect, you can toss the scarves into the air or twirl them to show how long the chain is.

An alternative presentation is to blow the scarves out of the tube …this I actually find a safer way as you are unlikely to pull the scarves apart,

The Science Behind

The scarves are pushed separately into the tube and come out joined!

This little demonstration is an excellent introduction to some physical properties that are part of junior physics syllabuses. The scarves appear to join in knots within the tube, Is it possible to tie a knot within the tube ...or must another force be present? What properties of that force are needed? Is a knot tied ...or is that an illusion? This is another demonstration where you don't get to examine the scarves themselves but just must observe from a (short) distance.

Figure 26.2 Removing the joined scarves from the tube

Small neodymium magnets in small knots in the corner of the silk handkerchiefs can find each other in the tube when the handkerchiefs are pushed in. Always make sure that the magnets are at the free end as you push the silk into the tube and make sure that they join inside, out of view of your audience!! Silk is used as this gives the knots their small size.

27. Cube explosion

Figure 27.1 Cube explosion as purchased in toy shop.

Tutorial - How to perform

Preparation:

Start by placing the eight small white plastic dice inside the hollow black steel cube. Make sure the open side of the cube is facing down so that it appears to be a solid black cube.

Place the cube inside the cylindrical container. The magnet hidden in the lid of the container should be strong enough to attract and hold the steel cube when the container is shaken.

The Performance:

Show the audience the cylindrical container with the black cube inside. Let them observe that it looks like a solid cube.

Next, shake the container gently. As you shake, the magnet in the lid will attract the steel cube, pulling it upwards and holding it in place at the top of the container.

As the steel cube is lifted by the magnet, the eight small white plastic dice will be released and will appear to explode out of the cube and fill the bottom of the container.

Open the container to reveal the eight small white dice, seemingly replacing the black cube.

The Science Behind

The "Exploding Dice" trick is a clever use of magnetism and material properties to create a surprising and visually impressive effect.

Magnetism:

The trick works because steel is a magnetic material, while plastic is not. The black steel cube has five closed sides and one open side, making it hollow and capable of holding the eight small plastic dice inside. When the container is shaken, the strong magnet hidden in the lid of the cylinder attracts the steel cube, pulling it upwards and holding it against the lid. This allows the plastic dice to be released from the hollow cube.

Material Properties:

The key to the trick is the different properties of the materials used. The steel cube is attracted to the magnet, while the plastic dice are not affected by it. This allows the steel cube to be lifted and held by the magnet, leaving the plastic dice to fall freely into the container, creating the illusion of an "explosion" of dice.

Figure 27.2: The trick performed. The black steel dice changes into the white plastic dice.

28. Magnetic attraction of coins /"magnetic Rings"

Materials Needed:

- A magnetic ring (or a regular ring with a hidden neodymium magnet underneath)

- A selection of coins, including both magnetic and non-magnetic coins

Tutorial - How to perform

Preparation: Wear the magnetic ring on your finger. If using a regular ring, discreetly attach a small neodymium magnet beneath the ring.

Lay out a small pile of coins on the table, making sure to include a mix of magnetic and non-magnetic coins.

The Performance: Show the audience the pile of coins, emphasizing that they are ordinary coins.

Slowly pass your open hand, with the magnetic ring facing down, over the pile of coins.

As your hand passes over the coins, the magnetic coins will be subtly attracted to the magnet in your ring and will stick to it. After a few passes, casually remove your hand and show that some of the coins have "disappeared" from the pile. The coins are now secretly attached to your ring.

Figure 28.1. Passing hand over coins, (note number of dark coins).

Figure 28.2. Hand covering (but not touching) coins.

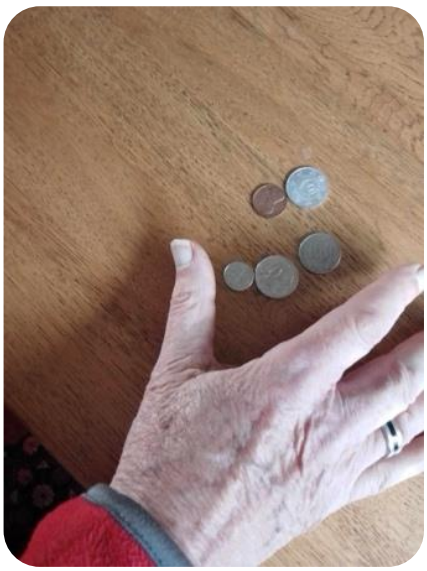


Figure 28.3. Coins re revealed but some are missing.

Figure 28.4. Hidden coins revealed.

The Science Behind

The "Magnetic Coin Vanish" trick cleverly exploits the properties of magnetism and the changes in the materials used to make certain coins.

Magnetism:

The trick hinges on the fact that some metals are magnetic, meaning they can be attracted by a magnet. The magnetic ring or hidden neodymium magnet provides a strong enough force to lift the magnetic coins from the pile without the audience noticing. Since not all coins are magnetic, only specific coins will be attracted to the ring.

Changes in Coin Composition:

UK coins have changed over the years, with many now being made of steel and therefore becoming magnetic. For example, 10p and 5p coins minted after January 2012, as well as 1p and 2p coins minted after 1992, are magnetic due to their steel content. Older coins, made of copper or nickel, are not magnetic and will remain in the pile.

29. Coloured Discs

Tutorial - How to perform

Present two prepared discs to the audience showing different colours. Simply bring the discs together and then apart and amazingly without any particular skill or sleight of hand the two colours have changed.

Figure 29.1: Colours discs black centre on left, blue on right.

The Science Behind

The discs are in two sections. A holder which has within itself small magnets of different strengths. The disc with two dots has a stronger magnet. The holders can attract the separate coloured steel discs. A coloured steel disc on the weaker holder can easily be transferred to the stronger holder disc when the two docs are placed together. Thus, it appears that the disc has changed colour, but in fact only one steel disc has been transferred.

Figure 29.2: Disc showing separate movable steel centres.

Note: These special discs are obtained from a magic shop.

30. Ring through shoelace

Materials Needed:

A steel ring

A hallow shoelace (or string) with a small neodymium magnet hidden inside the lace

Attention: Take care, safety instruction, do not let small children handle the magnet.

Tutorial - How to perform

Before starting the trick, insert a small neodymium magnet inside the hollow part of the shoelace. Ensure that the magnet is not visible to the audience.

Hold the shoelace vertically. The metal ring appears to thread the lace through the ring, but in fact just let the magnet inside the lace attach to the ring. pull the lace on the side of the ring to the centre of the lace, then let the ring hang, the ring should appear to be freely hanging on the lace, as if it's just resting there.

Figure 30.1 The apparatus, a steel ring, a hollow shoelace and a small neodymium magnet.

Create the Illusion: you can slowly move the ring on the lace. The audience will see the ring moving along the lace, creating the illusion that it's sliding down freely.

Magnet Action: As you move the ring down, the hidden magnet inside the shoelace is actually attracting the ring, so the ring is moving because of the magnetic force, not because it is looped through the lace. The magnet moves inside the lace as the ring moves.

At the right moment, remove the ring by detaching it from the magnet. Show the audience the ring and the shoelace to demonstrate that the ring has "passed through" the lace.

Let the audience inspect the ring and lace, if you like. The magnet hidden in the lace will remain unseen, leaving the audience amazed at how the solid ring passed through the lace.

Figure 30.2: The ring hanging (?) on the shoelace

Figure 30.3: The ring is easily separated from the lace

The Science Behind

The trick known as ‘swing a ring’ consists of a small neodymium magnet hidden inside a hollow shoelace. A steel ring appears to hang on the lace but is in fact held there only by the magnet inside it and the ring can be removed at will, giving the illusion of passing through the lace. The clever part is that the ring is able to move the magnet inside the lace from one end to the other as if the ring is actually looped onto the lace. This can be made for the price of a small neodymium magnet, a shoelace and a key ring! Perhaps there is some deceit by the performer here, but it does show the strength of a small magnet, the fact that magnetic forces can pass through materials like the lace and illustrates well the importance of questioning whether what you think you see is what is actually happening.

31. Find the force

This presentation is about forces. It is a good introduction to challenge students as to which forces are acting. Maybe an initial thought will be magnetism, but that would be wrong.
The little man works on the same principle as the note.

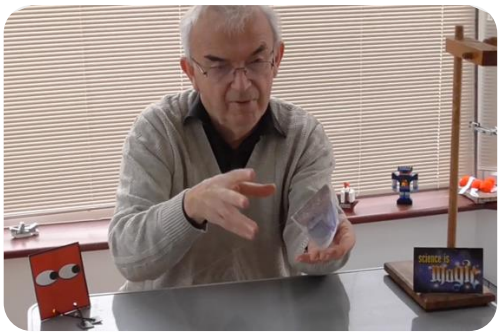



Figure 31.1: (Folded) paper note suspended in mid-air.

Tutorial - How to perform

The puppet needs to be set up beforehand using the invisible thread to hold it and a free end of thread that can be held by the science magician.

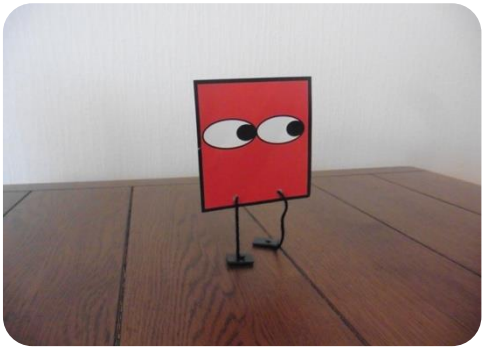


Figure 31.2: Card model suspended in mid-air and is able to dance without anything touching.

The background is important ...preferably some striped (Black and white) paper that makes the "invisible thread" even more difficult to see.

Unseen by the audience slip the small "paperhook" over the line of invisible thread so that the puppet is supported. It then can be moved at will by the thread in your hidden free hand. The second hand can be made to make gesticulations over the puppet to distract the audience and make them think there are hidden magenta of forces at work.

The Science Behind

The invisible thread is obtained from magic and other shops. It is very thin making it almost impossible to see with the naked eye (so don't lose it!). Seeing the thread is even more difficult if the line of thread follows a pattern in the background.

The question to ask is "Which forces are there? and which forces could move the puppet? Most initially think it must be magnetism, some may go for electrostatics but eventually "hidden strings " maybe an answer. The point to make is Newton's 1st Law ...if it moves and changes direction something must make it move.

Why is the thread invisible ...because it is too thin to be seen. You may discuss revolution of the eye and the smallest angle it can resolve. Take two sticks held then a mm apart. Gradually move away from an observer until the tow appear as one ...then try with each eye separately!

A good little idea for a parents meeting or demonstration.

32. Under Pressure – Jar of India and Fun Funnel

Water provides us with several demonstrations, including some that with unexpected results. Depending on how they are presented, we either have "magic tricks" or a scientific experiment.

Tutorial - How to perform

Fun Funnel:

The nice thing about this is that the principle can be easily demonstrated with a plastic bottle with two holes. Holding the fun funnel in one hand with your thumb or finger over the hole ask someone from the audience to come and place their hand over the lip of the funnel. The other hand is to be the "handle" of the imaginary pump. Place a bucket under the nozzle of the funnel. Next for the performance take the volunteers free hand and move it up and down, at the same time moving your thumb from the upper hole. The water comes our below as the pressure is equalised. You can stop the flow and start it again as you move your thumb on the hole.

Jar of India:

The magician holds the jar which has previously been filled, "This jar has an undendinfg suply of water ....!" por the water out into a bucket below keeping a finger on the hole. The audience will hear what seems like a lot of water . Place the beaker down and get on with something else. (you have removed the finger from the hole) . Pick up the jar again , placing your finger carefully on the hole again , (Don't make this obvious) You can then pour our a second amount of water . You can then repeat tjis several times ...(note : each time the amount of water gets less , but the audience are unlikely to notice this)

The Science Behind

The principle is of course the equalisation of the pressure ...with your finger on the hole as soon as some water leaves the funnel the pressure above the water in the sealed container is reduced, and so the atmospheric pressure is able to hold the water in, with the help of a little surface tension at the hole.

The need for air to replace water being poured from a sealed container, evidenced by the glug-glugging when you pour from a bottle quickly, can be used to control the flow of water. Using one plastic bottle with two holes, one hole at the top and the other at the bottom, can give you the ability to control the flow from the lower hole. This is applied directly in the so called 'fun funnel'. The funnel is held in a suitable position, and at the signal water flows out of it. This is achieved by simply holding one's thumb over a small hole in the top of the funnel and raising it very slightly to allow water to flow from it at the appropriate moment.

Figure 32.1: Fun Funnel and plastic bottle that can mimic the funnel.

Figure 32.2: Fun funnel showing operation , when the hole is covered the water stays inside , but will come out of the second hole when the first hole is uncovered.

Can you see the small hole in the funnel?

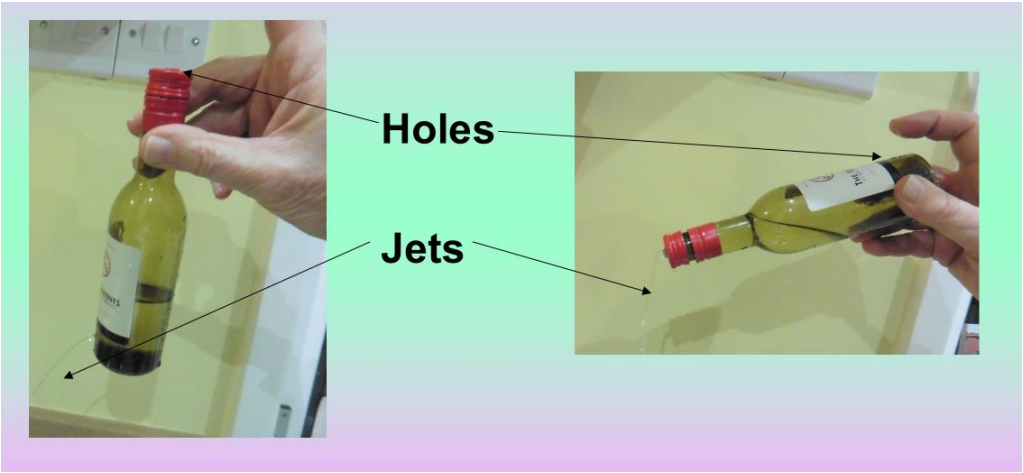


Figure 32.3: The bottle can be similarly used , with two holes. The second hole must be uncovered to release the contents of the bottle.

You can make your own with a vinegar botle.

The Jar of India is a 'trick' vessel, which appears to refill itself continually. It operates in exactly the opposite way to the fun funnel. The jar consists of a central chamber surrounded by hollow walls, which are filled with water. When left, the jar's walls partly empty into its main inner vessel, leaving a considerable proportion of the water still hidden. If the jar is lifted with the secret hole covered, no more water flows out of the hollow walls, so the jar can apparently be emptied. Putting the jar down again with the secret hole uncovered enables water to refill the inner vessel. The process can be repeated again and again until all the water in the hollow walls is used.

Figure 32.4: Jar of India, large magicians vessel ..has two holes, one to cover and one to release water into central chamber.

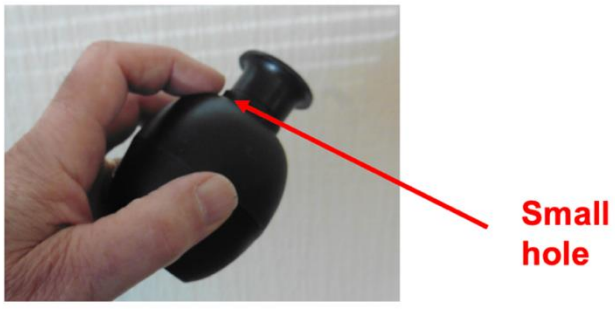


Figure 32.5: Jar of India : Small children's magic works with same principle.

33. Disappearing Head

Tutorial - How to perform

Materials Needed:

- A large box with an opening for a person's head and a viewing window to see head and holes for skewers
- Two mirrors cut to fit the interior sides of the box
- Skewers (to create the illusion of piercing through the head)
- A scarf

Preparation:

Construct a large box with an opening at the top for a person's head. The box should be tall enough to cover the upper body of the person sitting inside, with only the head sticking out.

Fix the two mirrors on either side of the interior of the box. These mirrors should be positioned so they can swing towards each other when needed forming a triangular space front the head.

The bars or skewers, which will be used later, should be attached to the front of the box in such a way that they appear to be penetrating through the box, giving the illusion of going through the head.

There should be holes in the side of the box so that the skewers can be inserted and appear to pass through the hidden head.

The Performance:

An assistance puts a box on his/her head and while covered the magician makes the head appear to disappear, before inserting some skewers through the box (and through the head?).

An empty box with a prepare hole for the head, and open window at its front is shown to the audience.

The assistance places the box on his/her head so that the audience can see the head in the box.

The magician covers the window of the box and mutters the magic words.

The magician then reveals that the head no longer appears to be in the box, and the prove this inserts some skewers through the box, as if through the head (if it was still there).

Their head still in position on the assistant's body can then be revealed.

Figure 33.1: David's head shown clearly in the box.

Figure 33.2: The box appears empty.

The Science Behind

Inside the box are two mirrors fixed with hinges (tape) to the sides of the box, in such a way that they can be moved from the sides across in front on the head at 45 degrees. This gives the illusion of an empty box, i.e no head!! Again, this is based on the well learnt fact that the image in a plane mirror is the same distance behind a mirror surface as the object is in front.

The skewers appear to fill the box because of the extra images are seen in the mirrors.

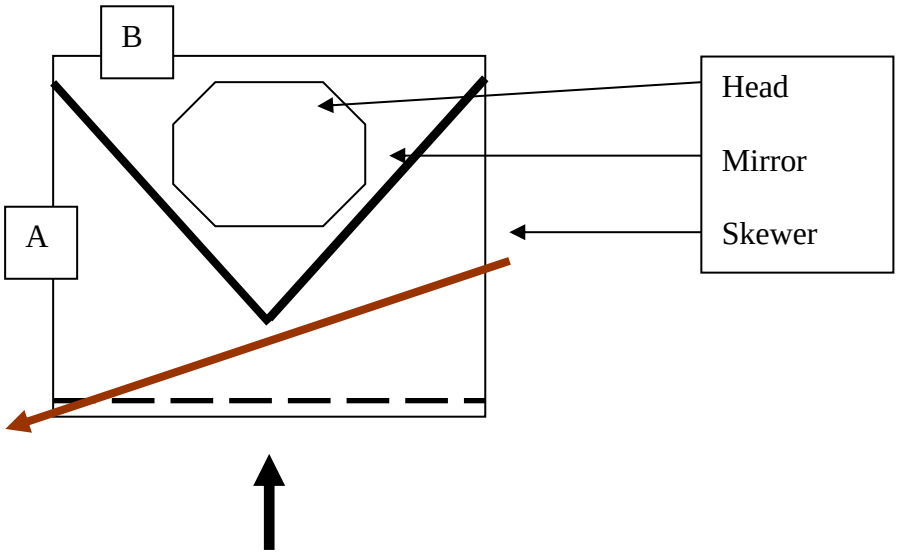


Figure 33.3: Schematic diagram showing mirror positions.

At the beginning of the last century the same principle was used on stage to make even larger objects disappear. (See the book Hiding the elephant by Jim Steinmeyer, Heinemann)
https://youtu.be/ihQyEkLYtP8?si=kgXmmh1REnJlkZGz

34. Mirror writing

The simple images in plane mirrors provide many opportunities to amaze, yet many of these can be understood in simply in terms of the positions of the image. In the past we used to teach reflection with ray diagrams, but maybe an approach with images is simpler and easier to understand.

Principle:

We are all familiar with " mirror writing" in that letters often seem distorted when viewed in a mirror (sometimes called lateral inversion) . Here we mislead the observer by distracting them to look at colour rather than the shape of letters Xadding colour etc those letters and carefully selecting themX. Note the symmetry of the letters, whether about a vertical axis , or horizontal axis.

Tutorial - How to perform

Show a card showing different words carefully printed . You can mislead the audience by referring to the colour . Then show the card's image in the mirror. One colour seems unaffected and one colour seems to be inverted....magic ?!?!
Another card showing carefully draw pictures can be changed using a plane mirror. The image of the inside of half a box creates the illusion of a totally empty box and objects can be made to appear from behind the mirror

The Science Behind

Images in a plane mirror are laterally inverted, that is right to left and left to right. Depending on the symmetry of the letters ..symmetry vertically or horizontally.. and depending on where the mirror is placed some letters will appear to be inverted and others unchanged because of the symmetry of the letters. Which of these letters are changed when the mirror is placed above them or at the side? The

second example of the words WHAT A COOKIE can have both vertical symmetry (e.g. WHAT A with symmetry vertically through the centre of each letter) and horizontal symmetry) e.g. COOKIE. With the symmetrical axis, horizontally through the centre of each letter).

Until the observer realises what is happening this can be mysterious. The two different colours are just a distraction, (common in magic performances) especially if something has been done recently on refraction as a similar experiment can be done using a rod of solid glass placed over the words, eg MAGNESIUM DIOXIDE works well. But what about this reflection exercise? Does colour have anything to do with it other than identifying the words? perhaps it is more about individual letters here...and the positions of the mirrors

Carefully selected words appear to be inverted whilst others do not. You can cause a little puzzlement by using different colours, even though the colours have nothing to do with what happens.

Figure 34.1: Mirror images (All the letters are laterally inverted but only the red ones appear to be!).

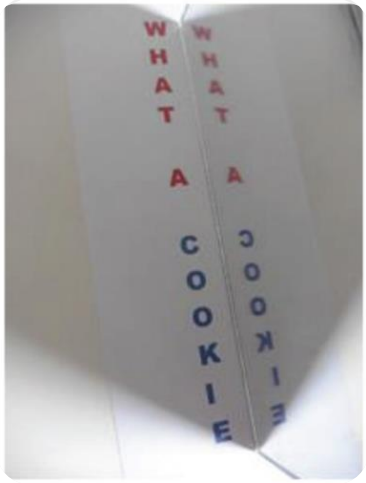


Figure 34.2: WHAT has vertical symmetry, COOKIE does not.

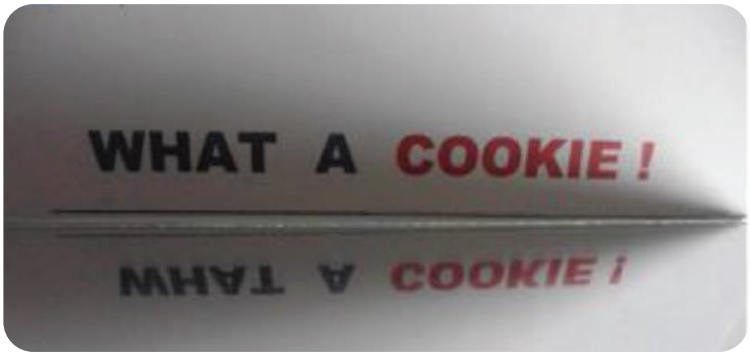


Figure 34.3: The explanation is of course not in the colour of the objects but in their lines of symmetry.

35. Half objects which produce a “whole image” when viewed

You can change an object into something else using a mirror. The picture shown changes from the two children into a symmetrical child and telescope with the mirror in place.

Figure 35: Showing transformation of a picture into a symmetrical one

Principle: A whole image in a plane mirror will create a mirror image which replicates what is in front of the mirror. We are all familiar with the image of a room in the window when it is dark outside ...it appears like an extra room. We also can use a full wall plane mirror to make a room appear twice the size. Here are some applications that can be used in the laboratory space.

36. The empty box

Tutorial - How to perform

Small money boxes are readily available which appear to accept coins which then disappear. I usually ask someone to provide me with some small coins and insert them into the box. The box appears to be empty whatever coin is inserted.

The Science Behind

A mirror is at 45 degrees across the centre of the box. Coins fall behind the mirror, whereas the image of the box in front of the mirror gives the appearance of a whole box which is empty (Figures 63 to 65).

Figure 36.1: Mirror box

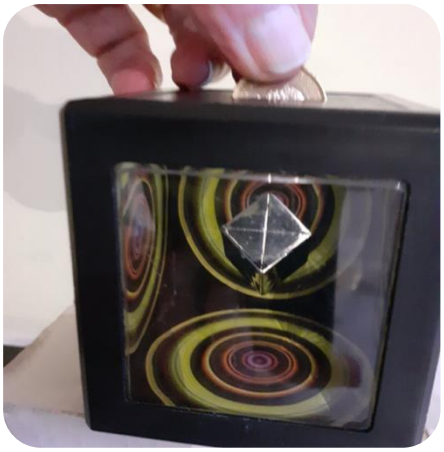


Figure 36.2: Front view as seen by the audience, creating the illusion that the box is empty.

Figure 36.3: Mirror box - Note the line of the mirror at 45 degrees across the left-hand face.

A larger version of the box can be easily made using a plane mirror wedged inside a large cardboard box at 45º. The image of the space in front of the mirror is behind the mirror making the box appear to be empty.

37. Mysterious appearing scarves

(The previous examples in reverse!!)

Empty containers (apparently) can be made full in an instant

Tutorial - How to perform

The empty glass or tube is shown to the audience. Either by being covered and then revealed again, or by a very quick movement the glass/tube suddenly appears filled with a silk handkerchief.

The Science Behind

Each item has a plane mirror placed at its centre, and therefore is in two distinct halves, an empty half (shown initially to the audience) and the side behind the mirror packed with whatever you wish (silk handkerchiefs). With a little practice the glass /tube can be twisted from one side to the other. The empty view gives the impression of an empty glass/tube, (of course it is just half a glass/tube and its image)

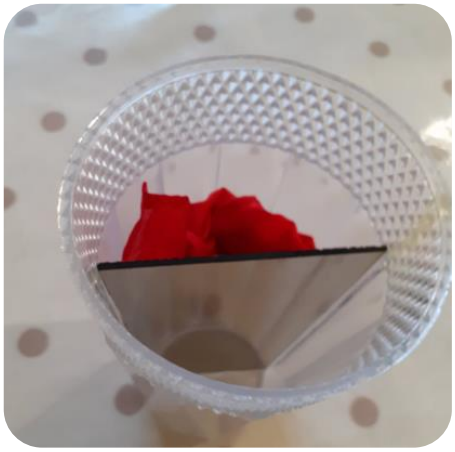


Figure 37.1: a. Empty Glass b. Glass with handkerchief c. Glass shooing dividing mirror

Figure 37.2: a. Empty tube b. Tube containing handkerchief c. Tube shooing dividing mirror

38. Tipping bird!!, Origami style

This magic is all about the centre of mass. So how can a folded origami model arrange for movement of its centre of mass?

I hope you will try this …

https://www.youtube.com/watch?v=_Qd6oocK21M

WARNING The effectiveness of this demonstration is highly dependent on the paper you use, not thick but not too thin.

Tutorial - How to perform

The origami bird is placed on the table in front of the audience as in figure 38 on the right, after a while the bird tips up as shown on the left. IF you know your paper models well you can estimate the length of time before the bird tips.

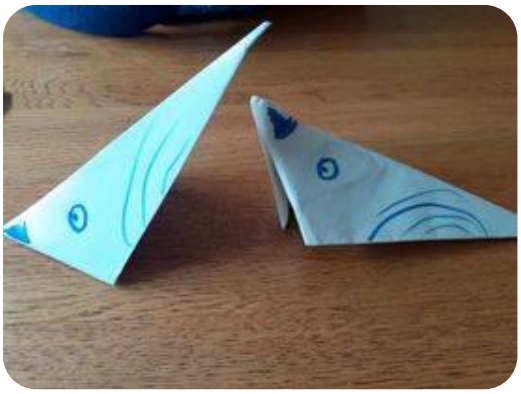


Figure 38: Photograph shown the bird in the two positions.

The Science Behind

This is a trick based on the movement of the centre of mass of the origami model. Originally the centre of mass is to the right of the left-hand end of the base of the model, and this keeps the model as shown. Over the next few seconds, the bird's sides move slightly apart, and this movement moves the centre of mass forward to the opposite side of the base…thus tipping the bird forward.

Magic
for the youngest

When children see a magic trick, they are enchanted and motivated to understand how it works. This natural curiosity is a great starting point for introducing scientific concepts.

39. The power of the mind

Concept: Density

Tutorial - Click

This magic trick is great for children to choose or create their own role-play.

The bottle of water may represent the seabed and the ketchup packet may represent a submarine or a fish. The water bottle could be down the rabbit hole and the ketchup packet could be Alice. These are just two examples of stories that can be used as context for the trick.

The bottle itself can be animated with children's drawings.

This is the same trick on page 34 that can also be used by primary school teachers to explain the concept of density and how submarines work.

Figure 39: We discreetly squeeze the bottom of the plastic bottle, unnoticed by the audience.

40. The liquid of invisibility

Concept: Straight-line light propagation and refraction.

This illusion can be performed with children to demonstrate the importance of hand washing.

Instructions:

- Start by asking children to draw what they think are germs on our hands.
- Insert the drawing into the plastic bag, ensuring that it is fully sealed inside.
- Children should now draw their hand on the bag with a permanent pen.
- Fill a container with Water.
- Submerge the Bag in Water.

Observe the Illusion: As you lower the bag into the water, you will notice that the drawing germs to disappear and we can only see what has been drawn in acetate pen, a clean hand.

Figure 40.1: We can see the drawing on the paper inside the bag as well as what we drew on the plastic bag.

Figure 40.2: When placing the bag in water and viewing from the right angle, the drawing inside the bag becomes invisible.

The trick involve a simple optical illusion that demonstrates the concept of total internal reflection. Although this is a complicated concept for young children, it can be explained in a very simple way: - Imagine you are playing with a flashlight. When you shine the flashlight on a mirror, the light bounces back, right? That's called reflection. What happens in this experiment is that the light is reflected without letting you see the drawing that is inside, we call this total reflection.

Tutorial - Click

SDG

This illusion can be used to demonstrate the importance of hand washing. Washing our hands is not just a simple task – it's a powerful way to keep ourselves healthy and well. This connects to "SDG 3: Good Health and Well-Being."

41. Secret messages

Concept: Light and its characteristics.

This very simple activity can be performed by children in Pre-School and Primary as a simple magic trick, the magic paper that reveals secret messages and much more! An opportunity to talk about light and colour.

Figure 41.1: By placing the drawing behind a red filter, the blue markings stand out clearly, revealing the hidden message.

Tutorial - Click

INSTRUCTIONS

1. The child should draw his/her message or drawing on the paper using only a blue pencil.

2. Then, they should hide the message/drawing with a red, orange and yellow pencil, using circular movements (do not paint evenly, as the result will not be the same).

3. Use red cellophane paper (which can easily be replaced by some candy wrapping paper) to reveal the hidden message/drawing.

This activity can also be carried out using red gelatine. Just make sure that the container containing the gelatine is transparent so that you can see the message behind it.

Gelatine and secret message - Click

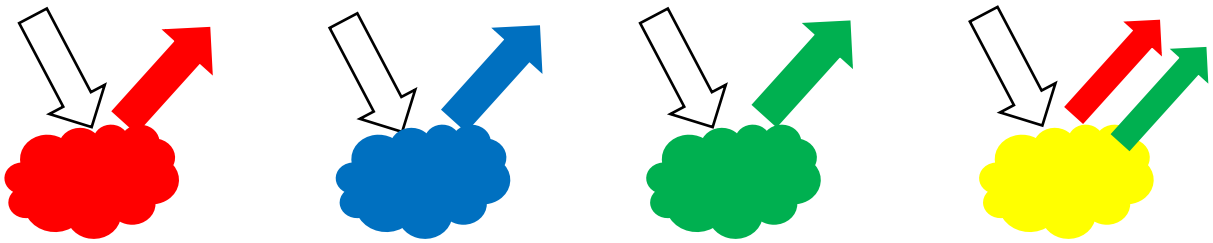
SUGGESTIONS

This activity can be done at festive times, such as a card with a Christmas message, it could be an activity carried out on St Valentine's Day or to hold an exhibition where children draw what they think, inspired by Laurent Moreau's book "What do you think about?". They can draw what they think in blue and hide it with red, orange and yellow, and only with very special glasses (with red filters) will we be able to see what they've drawn (figure 41.2).

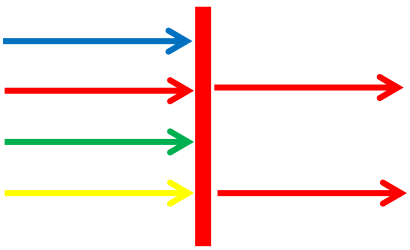
Figure 41.2: Christmas message.

The science behind

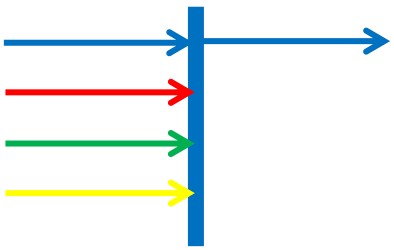
Our eyes see objects through the light they reflect.



Filters absorb some light and transmit other light. So using filters to observe objects causes them to be observed in different colours.

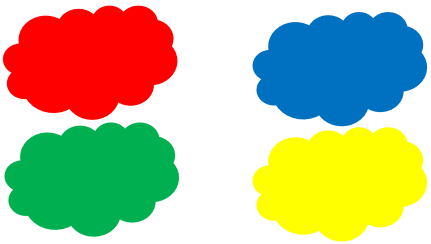


Red filter



Blue filter

Using the red filter



No filter

With red filter

A red filter absorbs all lights but the red light it transmits.

So, as the colour white reflects all lights, when we use a red filter we will only observe the colour red.

A white cloud will look red.

The colour **red** reflects red light, so using a red filter a red cloud will look red.

The colour **blue** reflects blue light, so using a red filter a blue cloud will look "black" (although scientifically speaking black is the absence of colour) as the filter does not let blue light through and no light reaches our eyes.

The colour **yellow** reflects red and green light, using a red filter a yellow cloud will appear red because the filter lets through only red light.

The colour **green** reflects green light, by using a red filter a green cloud will look black (no colour) as the filter does not let green light through and no light reaches our eyes.

So, as the colour white reflects all lights, when we use a red filter we will only observe the colour red.

A white paper will look red.

The colour red reflects red light, so using a red filter a red drawing will look red.

The colour blue reflects blue light, so using a red filter a blue message/drawing will look "black" (although scientifically speaking black is the absence of colour) as the filter does not let blue light through and no light reaches our eyes.

The Science - Click

42. Curve or square?

This trick can be used in Pre-School and Primary to talk about shapes using a story.

For older students we can use this trick/illusion to talk about perspective.

How about using this story for the little ones and adding this illusion?

"Once upon a time there was a square named Claire. Claire liked to play and explore. One day, something magical happened. Claire started to change. She became a curve, Claire giggled with joy, rolling like never before. She discovered a new way to play. Bute as the sun began to set, Claire wanted to be a square again. With a wish and a twist she turned back."

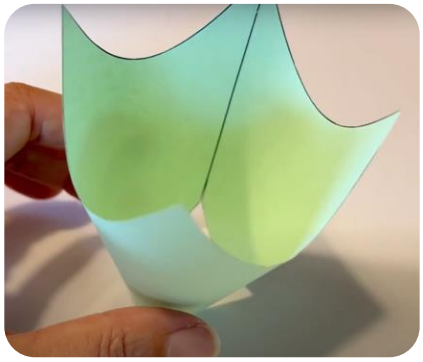


Figure 42.1 a Side view.

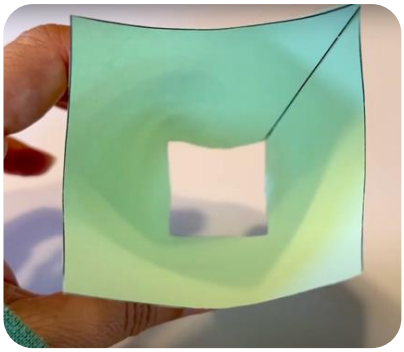


Figure 42.1 b Top view.

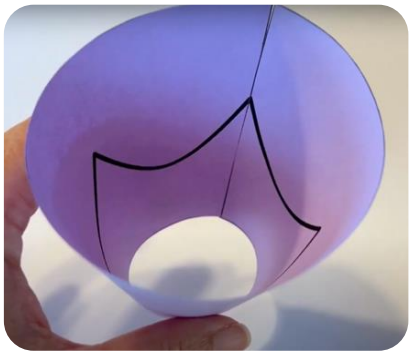


Figure 42.2 a Side view.

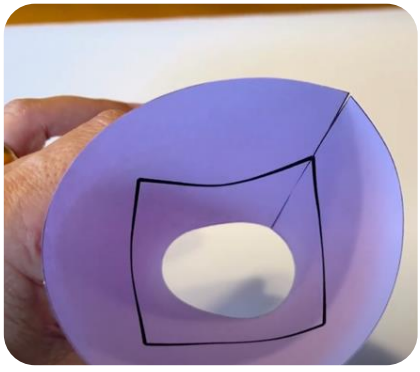


Figure 42.2 b Top view.

43. How to transform 2 circles into a square?

Concept: Geometric shapes

Tutorial - Click

This trick can be used in Pre-School and Primary to talk about shapes using a story.

For older students we can use this trick/illusion to talk about perspective, point of view and to talk about our differences and how we can try to eliminate what divides us.

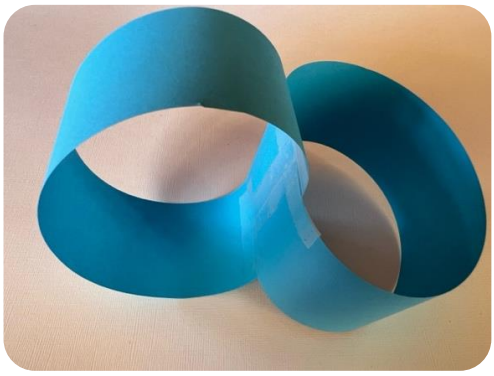


Figure 43.1 Cut two strips of paper, form each into a ring, and then secure them together with tape, as shown in the figure.

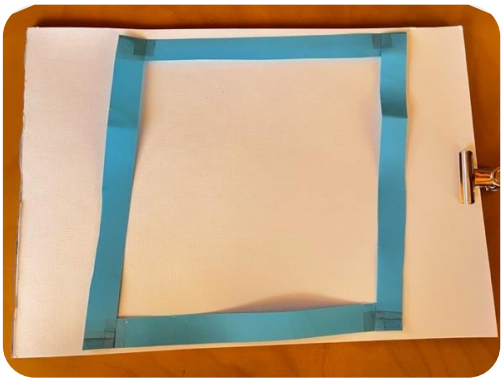


Figure 43.2: After cutting, as shown in the tutorial video, we obtain a square.

How about using this story for the little ones and adding this illusion?

“Once upon a time, there were two intertwined circles called Twirly and Whirly. They always saw things differently and neither could understand the other's point of view.

One day, they realized that these differences were tearing them apart. They decided to take some time to understand each other and work together.

With patience and some tweaking, counting their differences, they found a way to align their views. In doing so, they magically transformed themselves into a frame and both of them, at the same time, could understand each other because they were looking to the same thing at the same time.

We learn from Twirly and Whirly, we can overcome differences and that we can find a way to see the world in the same way and understand each other's point of view.”

Math Tricks

44. The magic number

Tutorial - How to perform

Give a volunteer from the audience an envelope with a prediction.

Show 9 cards numbered from 1 to 9. Ask a member of the public to choose 3 cards.

Write the chosen numbers on a board or sheet of paper. For example, if the numbers 2, 5 and 8 have been chosen, the rule is to put the largest number on the left (but this instruction should not be communicated).

Write down the number 852.

Now ask them to subtract the inverse, i.e. 852 - 258. Write the result 594 and add the symmetric.

Write down the result 1089.

Now ask the person you gave the envelope to open it and ask them to read the number written on it: it's 1089.

The Science Behind

Let us assume that the initial number is the larger and has digits a, b and c. So, when we reverse and subtract we will have (100a + 10b + c) – (100c + 10b + a)
This is the same as 100a + 10b + c – 100c – 10b – a = 99a – 99c = **99**(a – c)
Because a and c are integer numbers, at the end of the first part of the process we will always end up with a multiple of 99.
The three digit multiples of 99 are: 198, 297, 396, 495, 594, 693, 792 and 891.
Now, note that the first and last digits of each number add up to 9.
So, when we reverse any of these numbers and add them together we get 9 hundreds from the first digit, 18 dozens from the second digits and 9 units from the third digit.
So we get **900 + 180 + 9** = 1089.

45. Perfect Ten Paperclip Paradox

Tutorial - How to perform

Tutorial - Click

The Perfect Ten Paperclip Paradox is a mathematical puzzle that was published in the book, The Art of Astonishment- Volume 3 by Paul Harris. A new paperclip is added to the outside of a square composed of paperclips three times, but the mysteriously, the number of paperclips on each side remains the same.

Get 29 paper clips and arrange them on a table as shown below as shown in figure 45.1.

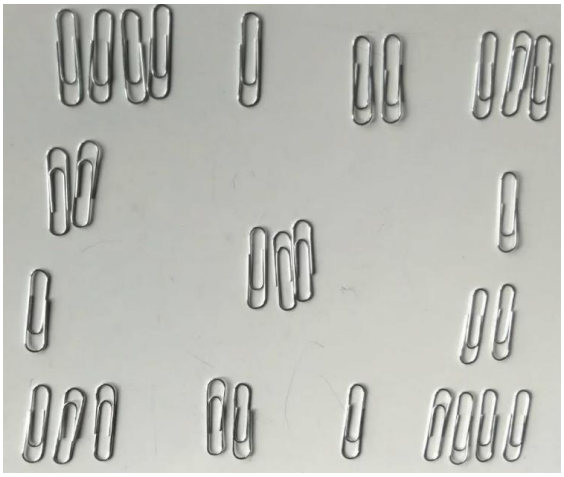


Figure 45.1

The square is a perfect ten on all sides. Count the top rows, left side, right side and bottom row to check.

Pick up a single clip from the pile in the middle and move it to the right row as shown in figure 45.2.

Move one clip from the lower right corner to a middle spot on the bottom row as shown in figure 45.3.

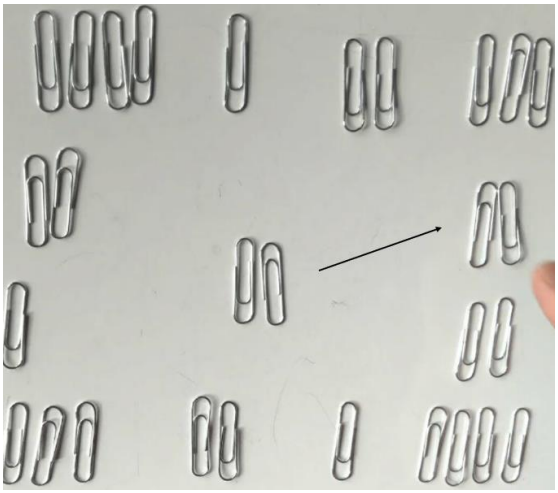


Figure 45.2

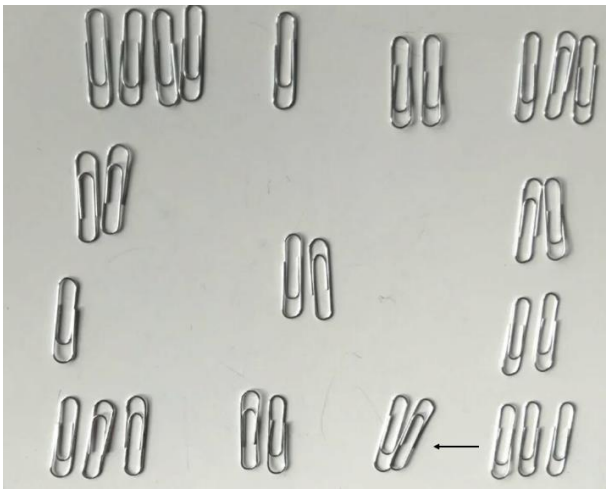


Figure 45.3

Count the rows. Each row has ten clips even though have just added one. It appears that a paper clip has vanished!

Take another clip from the pile in the middle and put in the top (figure 45.4). Now move one clip from the upper left corner to the left side (figure 45.5).

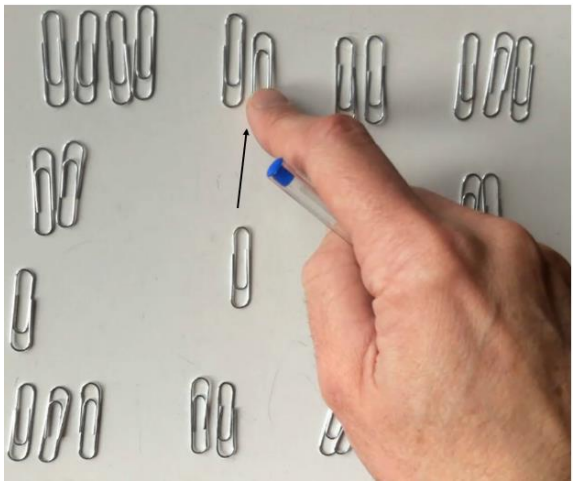


Figure 45.4

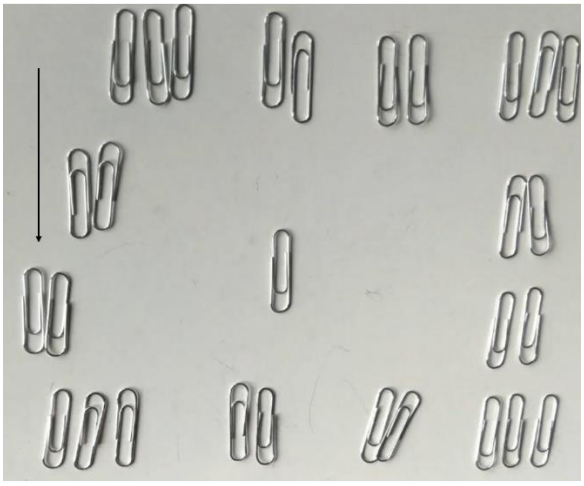


Figure 45.5

Count the rows again, there should ten clips in each row. Another paper clip has mysteriously vanished.

Pick up the final clip in the middle. Put it in the top right corner as shown in figure 45.6. Move two clips from the same corner - one goes in the top row, and the other in the right side row as shown on figure 45.7. Count the four rows again. Where did the clip go?

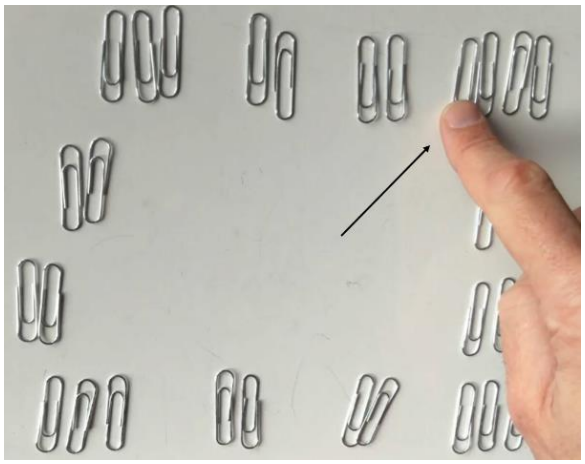


Figure 45.6

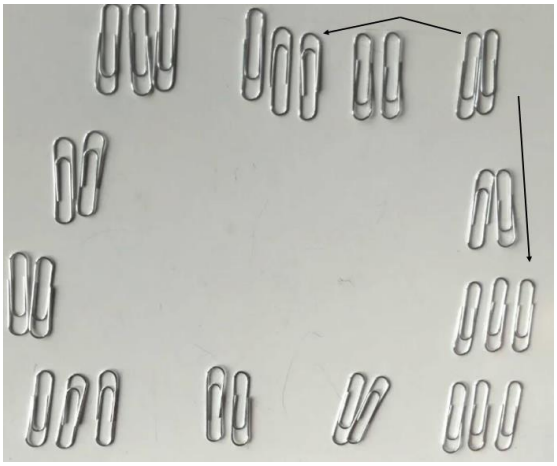


Figure 45.7

The Science Behind

[The Science - Click]

The explanation for this puzzle is due to the arrangement of the clips. When counting the clips, the ones in the corner are counted twice, as they are part of a horizontal row and a vertical side. The clips between the corners are counted only once during the counting process. When a clip is added to a row or side, there are initially eleven clips in the row or side. However, when a clip is then moved from a corner to a place between the corners, it is only counted once, which keep the numbers of clips at 10 when counted for each row or side. A video explanation is also available for this puzzle by using the link.

46. Vanishing square puzzle

Tutorial - How to perform

This magic puzzle was presented by Dieter Kadan from Austria, at the 2019 Science on Stage festival. It is based on a magic puzzle invented by a New York Magician named Paul Curry, although the principle of this paradox has been known since the 16th century (https://en.wikipedia.org/wiki/Missing_square_puzzle).

The instructions are shown below.

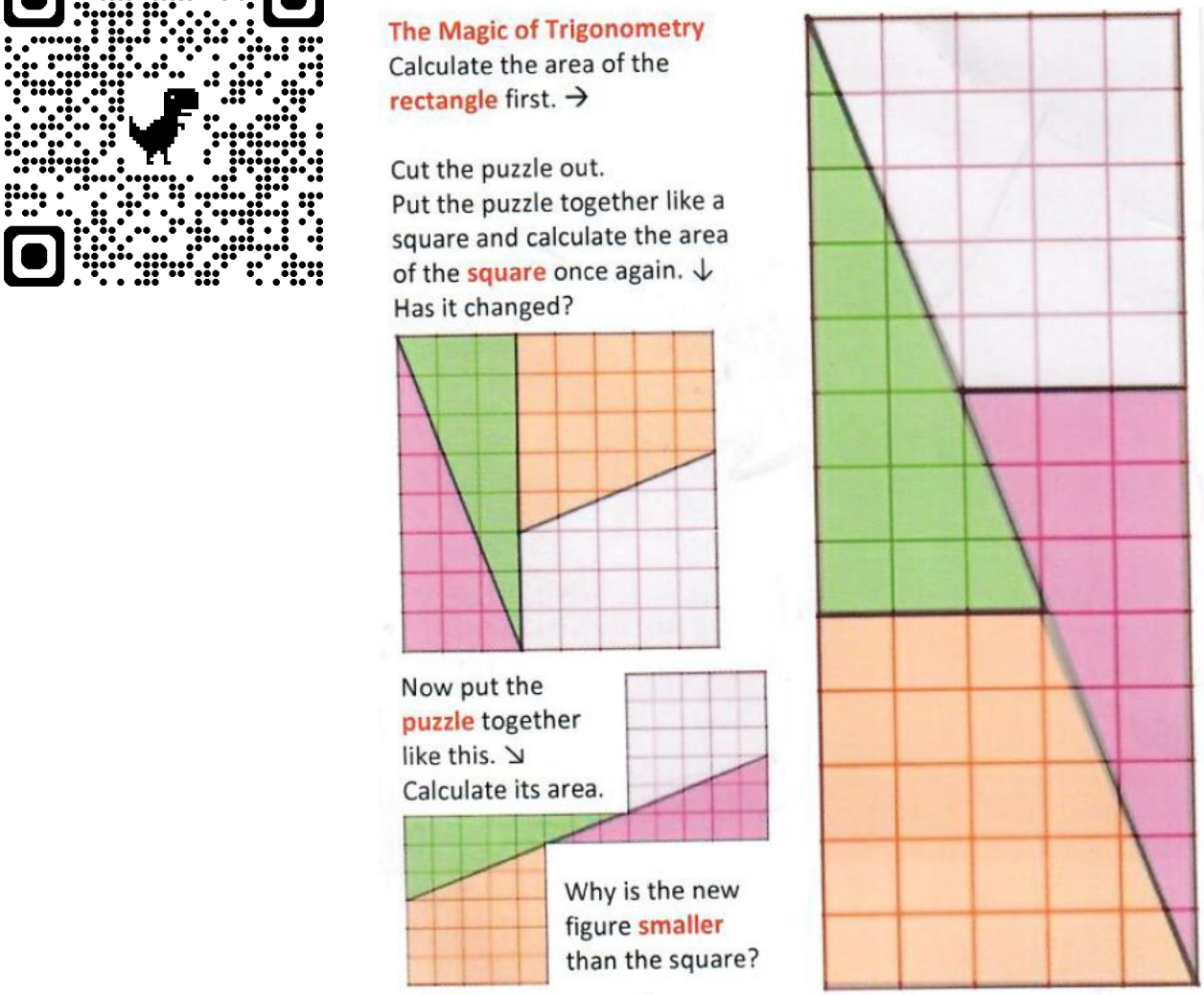


Figure 46.1: Cutting template.

When the shapes are assembled, the number of squares in the rectangle is 65, the square has 64 squares, and the final shape has sixty-three squares. It appears the squares are vanishing each time the pieces are reassembled!

Tutorial - Click

The Science Behind

Explanation

The true number of squares is 64 as seen in the square shape. When the shape is assembled into a rectangle, the pieces don't align completely. There is a small amount of space from the top left to bottom right diagonal. This space is equivalent to the area of one extra square, giving the illusion of 65 squares in this shape. When the other shape is reassembled, there appears to be 63 squares, as the pieces have to overlap each other slightly to form the shape. The area of overlap is the same as one whole square, so it appears there is one square less.

This is a nice way to show how care and precision are required in science to generate accurate data. If care isn't taken when gathering data, then the results can be variable as shown when trying to count squares in shapes if the pieces aren't aligned properly. [The Science - Click]

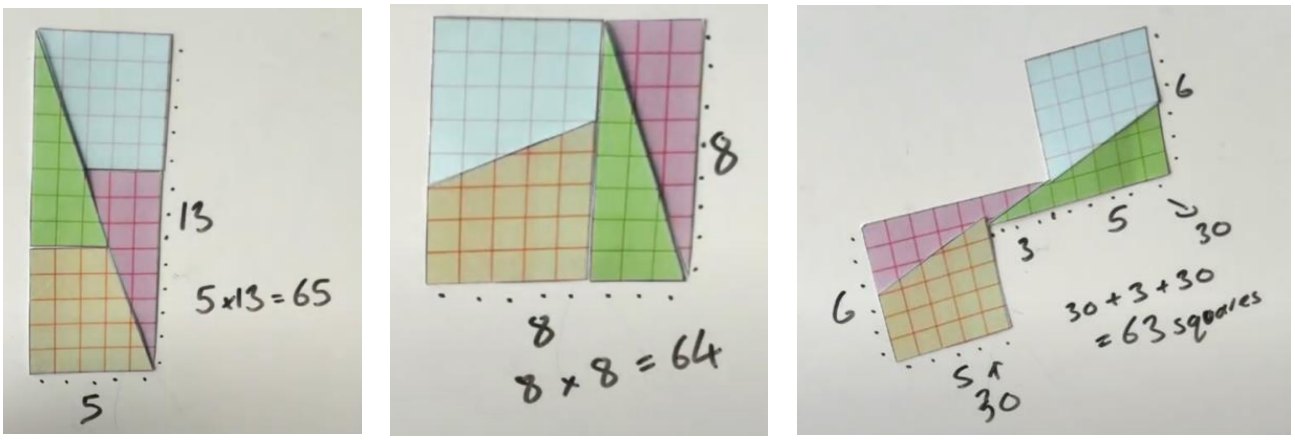


Figure 46.2: Various Ways to Assemble.

47. Mathematical mind reading

Tutorial - How to perform

Tutorial - Click
Try this!
1: Think of a number from 2 to 10
2: Multiply your number by 9
3: Add the two numbers of your total together
4: Take 5 away from your answer
5: If your answer is 1, it equals A; if it's 2, it equals B; if it's 3, it equals C; if it's 4, it equals D (no need to go any higher, as the answer will of course always be D)
6: Think of a country in Europe beginning with your letter
7: Think of an animal, not a bird or a fish, beginning with the second letter of your country
8: Think of the colour of your animal
Most of you will be thinking of a grey elephant in Denmark!

The Science Behind

This is a self-working maths trick. Any single digit number multiplied by 9 will give two-digit number. If you add the digits of the two-digit number, it will always add up to 9.
So, if you choose 7, 7 x 9 = 63, 6+3 = 9. If you subtract 5 from 9 you will get 4.
D is the fourth letter of the alphabet. The country most people will think of is Denmark. Don't give people too much time to think or they may come with Djibouti or Dominican Republic. The second letter of Denmark is E so most will think of elephant when asked for an animal beginning with E. The colour of an elephant is grey which you announce to the class as evidence of your mindreading abilities.
The Science - Click

48. Water math answer

Concept: Refraction of light

Tutorial - How to perform

1. Draw the following numbers, on your piece of paper:

Figure 48.1: The paper with the sum should be securely placed in a vertical position.

2. Find a way to keep your paper standing;
3. Put the glass in front of your numbers;
4. Pour water into your glass until the level of the water is above the numbers;
5. Move the glass towards and away from you until you find the spot where the numbers are reversed;
6. Once you've worked out where that is you are ready to perform the trick.
7. To perform the trick, cover the glass with a small card or handkerchief before adding water to create a greater effect.

Figure 48.2: After Pouring Water into the Glass.

Tutorial - Click

The Science Behind

When we add water to the glass instead of spreading out in straight lines, the light changes direction both when it enters and leaves the glass of water. This change of direction is called refraction, and it happens because the light slows down as it enters the glass and speeds up again as it leaves.

Without water in the way we see the numbers as they are. This is because light spreads out in all directions and some of it will travel in a straight line to our eyes. When there's water in the way the light bends.

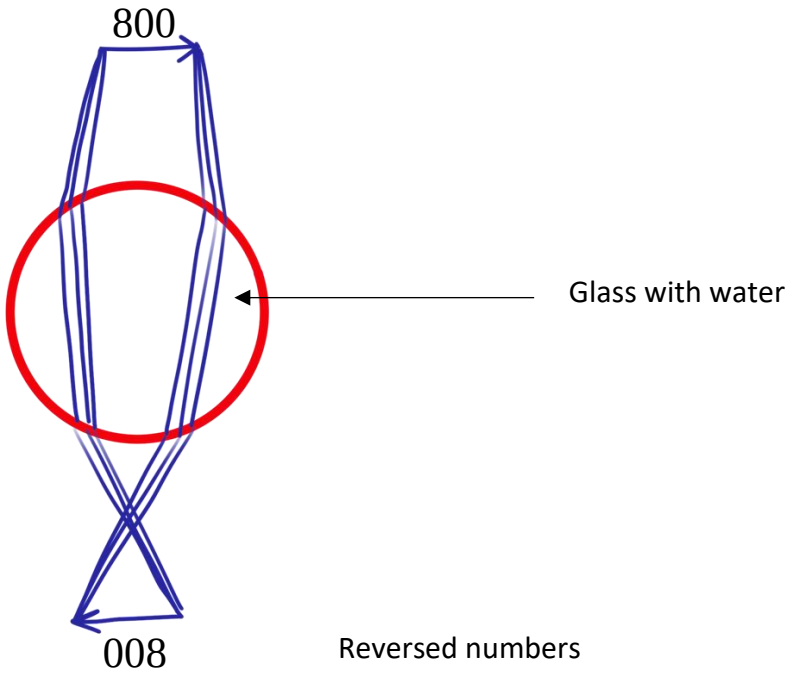


Figure 48.3 Diagram showing light refraction in a glass of water.

[The Science - Click]

Final Thoughts

This project has brought us immense joy and satisfaction. Working together from different countries, we shared ideas, knowledge, and a part of ourselves in this collaborative effort. We created this resource to share with teachers, including videos that explain both the magic trick and the science behind it. These videos are available through easily accessible QR codes and links.

Additionally, we organized a science fair where our students presented the magic tricks to the school community. You can see a glimpse of this science fair dedicated to magic in the following link.

The Science Fair Video - Click to watch

We hope you enjoy this material as much as we enjoyed creating it!