SCIENCE ON STAGE EUROPE

THE EUROPEAN NETWORK FOR SCIENCE TEACHERS

MONEY MATTERS

SIMPLE SCIENCE EXPERIMENTS

David Featonby, Rute Oliveira

IMPRINT

Published by

Science on Stage Europe e.V.
Am Borsigturm 15
13507 Berlin, Germany

Authors

David Featonby (UK, Science on Stage Europe)
Rute Oliveira (Portugal, Nobel Algarve British International School)

Design

WEBERSUPIRAN.berlin

Illustration

Arnaud Braibant

Credits

The authors have checked all aspects of copyright for the media and texts used in this teaching material to the best of their knowledge.

About Science on Stage Europe

Science on Stage Europe brings together science teachers from across Europe to exchange best practices and teaching ideas and concepts with passionate colleagues from over 30 countries. Science on Stage Europe believes that the best way to improve science teaching and to encourage more schoolchildren to consider a career in science or engineering is to motivate and inform their teachers. The non-profit organisation was founded in 2000 and reaches 100,000 teachers Europe-wide.

Science on Stage offers teaching materials developed by European STEM teachers for teachers. All materials are free open educational resources and can be downloaded here: https://www.science-on-stage.eu/teachingmaterials

Learn more about Science on Stage Europe – The European Network for Science Teachers

Newsletter

www.science-on-stage.eu
www.science-on-stage.eu/newsletter
www.science-on-stage.eu/socialmedia
Contact: info@science-on-stage.eu

TABLE OF CONTENTS

Safety Notice

This booklet contains activities involving lasers, magnets, and coins. Care must always be taken when handling these materials. Never shine a laser into anyone's eyes, as this may cause serious injury. Keep all small items, such as coins and magnets, out of the reach of young children, as they pose a risk of swallowing or choking.

By carrying out any of the activities described, you accept full responsibility for your own safety and for the safety of others. The authors and publishers of this booklet cannot be held liable for any accidents, injuries, or damages that may result from attempting these activities.

INTRODUCTION

Welcome to our selection of experiments, some developed by us, others shared by various teachers, or inspired by activities we have discovered through our research and exchanges of ideas with colleagues from across Europe. Our aim was to find experiments related to money and bring them together in a booklet that teachers can find useful.

The idea was developed for Science on Stage in London in 2015 by Niloufar Wijetunge " whose initial project was "Money matters " This idea was developed by David in 2019 ," in his article for the Science in School Journal in 2019 "Fantastic Feats – Magic with Money" (https://www.scienceinschool.org/article/2019/fantastic-feats-magic-money/) which then led to the inspiration of this project and extended booklet.

For the others .... whose ideas and encouragement have been useful to us, as we compiled the booklet, we are also indebted to each other for continued patience in compiling these experiments.

The booklet consists of several sections, most of which relate to different aspects of the science curriculum throughout Europe and beyond. The booklet is intended for use by all ages from the youngest enthusiast to the elderly teacher (and even those who may by now have retired!!) It can be used as a resource for the classroom, or simply as a bit of fun and enjoyment to puzzle others.

We all have some money in our pockets /wallets (we hope so anyway) and therefore carry with us a scientific laboratory. As we don't employ laboratory equipment, many of these experiments can be performed spontaneously, and impressively. But beware, many of our familiar coins and notes are quickly disappearing from general use and the materials used changing, for example paper notes are being replaced by plastic, and coinage changing to more economic use of metals e.g. magnetic steel is much cheaper than copper, nickel which were at one time the popular metals. The intrinsic value of coins now bears little relation to their value as a lump of metallic material, which was historically the case. An example in the UK is the latest 10p which recently changed ...its intrinsic value going from 4.5p to 0.5p in 2011. There are now over 500 coins around the world which have become magnetic with the increased proportion of steel used.

So, enjoy the next few pages, I am sure that there will be many experiments you already know, so I hope we can give them a new twist! We hope that many teachers will find the insights we give into the science behind them useful, and most of all that you will try as many as you can for yourself.

A special thank you to:

Niloufar Wijetunge (England), Nuria Muñoz Molina (Spain), Paul Nugent (Ireland), Kim Christiandson (Denmark)

David Featonby (UK, Science on Stage Europe)

Rute Oliveira (Portugal, Science on Stage Portugal)

1 INERTIA AND NEWTON

Newton's laws of motion underpin our understanding of almost all mechanical motion, whether expected or unexpected. These experiments illustrate different examples of the laws.

1.1 Paper Bridge

The Science

Newton's first law of motion, impulse and inertia.

Description - What to do

Material needed:

- 2 identical coins
- 2 glasses (or beakers)
- 1 strip of paper or a €10 banknote

Setup:

- Lay the note flat between the two glasses, forming a bridge, but not too tight.
- Place one coin on the note above the rim of each glass, positioned horizontally as shown in the photograph (photo 1).

Photo 1: Set up with 2 glasses.

The Challenge:

- Remove the paper strip quickly without knocking the coins into or off the glasses.

How It Works:

- Strike the paper sharply down at its centre (photo 2).
- The paper will slide out quickly, while the coins stay balanced on the glass rims (photo 3).

Photo 2: Applying the force.

Photo 3: Challenge complete.

Explanation - Science in context

According to Newton's first law of motion (inertia), an object at rest stays at rest unless acted on by an external resultant force. Inertia is the tendency of an object to resist changes in its state of rest or of motion so the paper moves, but the coins remain in place due to their inertia.

The speed of movement will free the paper and leave both coins still sitting on the edge of the beakers, undisturbed. To move the coins requires a significant impulse from the paper. So, if the force isn't very large and the time is short then the impulse (*Fxt*) will be small.

Note: It is important the note is pulled downwards as any upwards force will dislodge the coins.

Extensions

An extra from the same activity.

Description - What to do

Balance a few coins on the lip of the bottle underneath the €10 note.

The challenge: pull the note away leaving the coins balanced on top of the bottle (photo 4).

Photo 4: Bottle and coins

Photo 5: Removing the note

Solution:

Hold the note horizontally in your hand just below the bottom coin and bring the edge of your other hand down sharply on the note, pulling it away (photo 5).

It is important that the note is pulled downwards as an upward force dislodges the pile.

1.2 €10 and the Bottle

The Science

Centre of mass, friction, inertia and impulse.

Description - What to do

Place the €10 bank note flat on a dry table and a dry inverted glass bottle on top (photo 1).

The challenge:

Remove the €10 without touching or toppling the bottle.

Solution:

There are two distinct solutions:

1. **Remove the note as quickly as possible**. Place the bottle near the edge of the table with the note overhanging. Hold the note near horizontally with one hand just below the table surface and, with the other hand, strike it suddenly to pull it out (photo 1).

Photo 1: Ready to strike

Photo 2: Challenge completed

Explanation - Science in context

Inertia is the tendency of an object to remain in its state of motion (at rest or in motion) unless an external force acts on it.
The bottle is initially at rest on the table (almost in between stable and unstable equilibrium, so that it can be easily toppled). When you pull the note quickly, the force you apply acts on the note.
There is also friction acting between the bottle and the note as the note is dragged away, but over the short time that the note takes to slip out this provides insufficient impulse (*Fxt*) to move the bottle.
It is important that the note is pulled downwards as any lift given to the bottle will cause it to fall.

2. **Remove the note as slowly as possible**. Roll the note and use it to gently push the bottle off (photos 3 to 5).



Photo 3, 4 and 5: Rolling the note to remove it.

Explanation - Science in context

There is a frictional force between the bottle and the banknote. If you pull the note quickly, the applied force is large, and the bottle is dragged along. If you pull it slowly, the frictional force is small, and the note slides out without moving the bottle.

Even when upside down, the bottle's centre of mass lies vertically above the neck. As long as the friction is not enough to disturb this balance, the bottle remains standing. The bottle tends to remain at rest. When the note is pulled slowly, not enough impulse is applied to set it in motion.

Neither method will work very well if the table is wet (though it is a way to prevent someone else from achieving the challenge!!).

Extensions

This is a variation of the famous table cloth trick (see Science in School article "Fantastic Feats" in 2017 in the section "Money Grab – Explanation - Trickier Tricks"
https://www.scienceinschool.org/article/2017/fantastic-feats/)

For those who like a challenge you can extend this using two bottles, one on top of the other, neck to neck as shown. The same principle applies except that this set up is far less stable than the single bottle. Any hint of an upwards force will cause the upper bottle to fall. Good luck!!

Photo 6: Two glass bottles and dollar bill

Photo 7: About to move the dollar

Photo 8: Yes!!!

As a further extension, ask "What happens if we try to do this with empty plastic bottles? And what happens next if the bottles are both filled with water (and sealed of course!!!)?".

1.3 Inertia Challenge

The Science

Inertia, acceleration and free fall.

Description - What to do

Two coins are balanced horizontally and diametrically opposite each other on the rim of a wine glass, preferably with near vertical sides (photo 1).

The challenge is to use one hand to remove both coins simultaneously and hold them without moving or touching the wine glass itself, using no additional apparatus.

The second challenge is this: Holding three coins together between thumb and finger (photo 2). Can you hold on to the outer coins whilst removing the inner one, without using your other hand?

Photo 1: Two coins are balanced horizontally and placed diametrically opposite each other on the rim of a wine glass.

Photo 2: Holding the coins

Explanation - Science in context

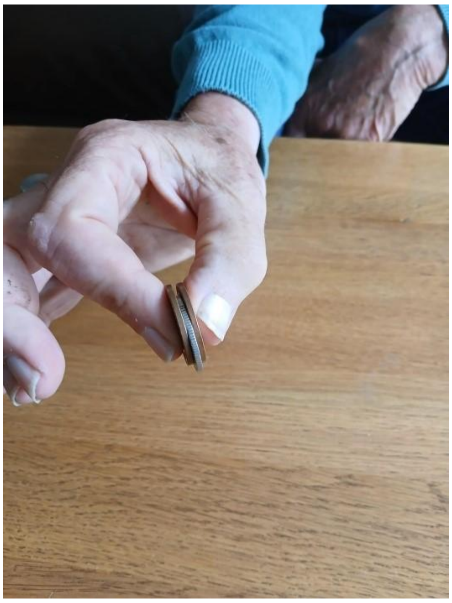
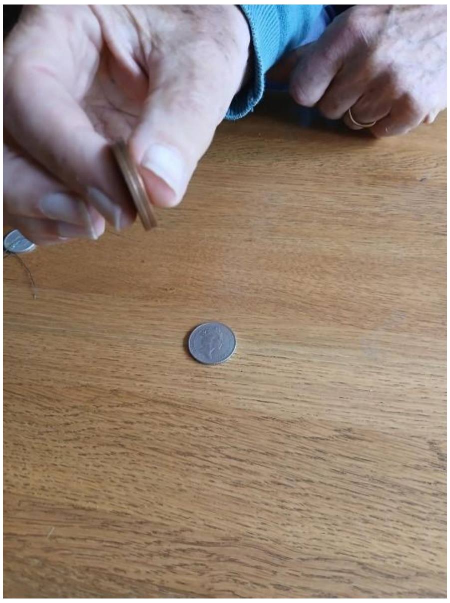
These are about free fall and acceleration. When a body is released, its initial speed downwards is zero. In the absence of other forces, it accelerates downwards at 9.8 m/s^2, but that means in the first fraction of a second the object falls a very short distance. The distance is further reduced here by the slight dampness of your finger which provides an extra resistive force to movement.

In the first experiment the first thing is to move the coins so that they rest vertically on the sides of the glass (photo 3). Then there is sufficient time to bring your fingers holding the coins on the glass together (photo 4).

Photos 3 and 4: Step-by-step demonstration of how the coins are caught using inertia.

In the second experiment the fingers hold the outer coins almost stationary for sufficient time for the inner coin to slip out, and the outer coins be brought together again (photo 5 and 6).

Photos 5 and 6 – The fingers are moved apart and then quickly back together between the photos 5 and 6.

1.4 First Newton Law with Credit Card

The Science

Newton's first law of motion and inertia.

Description - What to do

- Materials needed (photo 1).
- Place a credit card on top of a glass (photo 2).
- Place a coin on top of the credit card, in the centre (photo 2).
- With a quick movement, pull the card horizontally, or flick it away from the glass (photo 3).
- The coin falls almost vertically, remaining inside the glass when the card is removed.


Photo 1: Materials needed


Photo 2: Set up


Photo 3: Challenge complete

Explanation - Science in context

According to Newton's first law, the coin which is at rest will remain at rest unless acted upon by an external resultant force.

When we pull the card quickly, the coin does not follow the movement of the card because there is little friction between the card and the coin, and that acts for a very short time. Therefore, the coin falls in a straight line, downwards due to the force of gravity. Demonstrating that an object at rest remains at rest unless a significant external force acts on it.

When the coin is resting on the card, the resultant force is zero, as the gravitational force acting on the coin is equal but opposite to the normal reaction. When the card is removed, the only force acting on the coin will be the gravitational force, so the coin falls vertically down.

1.5 Stack Strike Surprise ...an Application of Newton's Laws Using a Stack of Coins

Description - What to do

- Make a pile of coins (photo 1), placed horizontally one on top of another, higher than the diameter of a single coin.
- Place one coin at the side balanced vertically and flick it sharply into the pile, so that the rolling coin makes contact with a few coins from the bottom.
- Flick the vertical coin into the tower of coins

Photo 1: The pile and striker coin

Photo 2: After the strike

A single coin will emerge from the pile at a height equivalent to the radius of the coin (photo 2).

Explanation - Science in context

The rolling coin exerts a sharp force on the pile only at a height equal to its radius (photo 3). The coin in the pile at this height is therefore the only one that is moved as shown in photo 4, the rest remain in the pile. When the coin strikes the pile it transfers its momentum to this coin only, the others remaining almost at rest above and below.

Photo 3: Before the strike

Photo 4: After the strike

Extension

Try with more coins in the pile.

- Do the extra coins make the pile more stable because of their extra mass? or just more difficult to eject the one coin because of increased friction?
- How is the experiment affected by the number of coins above the striking point?
- What happens if you use a smaller/larger coin as a striker?

1.6 Straws and Coins

The Science:

This experiment demonstrates both Newton's first law of motion (inertia) and the relationship between linear velocity, kinetic energy, and potential energy.

Description - What to do

Place two coins as shown in photo 1, one is 1 unit from the pivot the other 3 units. When the loose end of the balance is struck, the coins are thrown upwards ...but by how much?

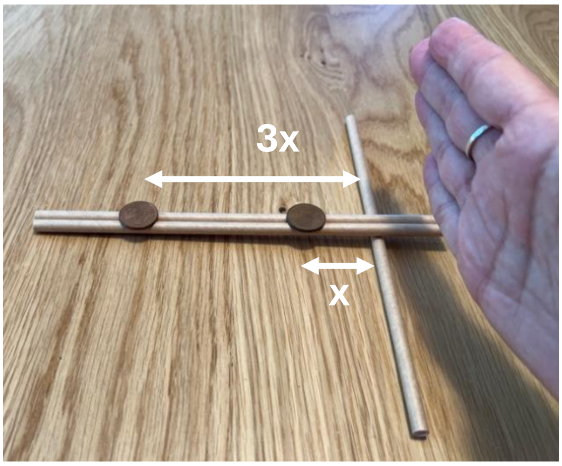


Photo 1: Set up

Will both coins leave the straws? Will the coins rise by the same distance? Will the coin furthest from the pivot rise most if the rise is different? Will there be a link between the distances the two coins rise?

Now try it for yourself ... use coins and pencils if you don't have straws.

Explanation - Science in context

When the board (made of paper straws in this example, or pencils) swings upwards and suddenly stops, the coins keep moving forward because of inertia. Their speed depends on their distance from the pivot:

- The coin at distance x from the pivot has a certain linear velocity v.
- The coin at distance 3x moves with a velocity 3v, because velocity increases with distance from the pivot when the board rotates.

Now consider the energies:

- Kinetic energy is proportional to the square of the velocity ($E_k = ½mv^2$).
- Therefore, the coin at 3x has not just 3 times, but 9 times more kinetic energy than the coin at x since $(3v)^2 = 9v^2$.

As the coins fly upward, their kinetic energy is converted into gravitational potential energy ($E_p = mgh$). With 9 times more energy, the outer coin rises to about 9 times the height of the inner one.

1.7 Newton's First Law and the Disappearing Coins Trick

The Science

This activity explores Newton's first law of motion — an object remains at rest or in motion unless acted on by an unbalanced force — from the forces and motion unit in the physics curriculum. It also introduces critical thinking and observation skills by mixing scientific principles with an element of illusion.

Description - What to do

Begin with observing a stack of UK 10p coins, two identical containers (seemingly empty), and a ring placed on the surface.

- Place one container over the coins, hiding them from view.
- The second container is then placed at one side by the ring.
- The first container (now containing the coins) is next moved and placed on the ring, "Wow the coins have disappeared!" (see photos 1 to 4).
- With a dramatic pause, prompt the audience with: "What do you think happens to the coins?"
- "Wow the coins are now under the container on the ring."

The rest of the routine is left to the performer's imagination ...but the coins seem to be transferred at will between the two containers.

Photos 1 to 4: The disappearing coins experiment.

Note: These containers are obtained from a magic shop commercially and are made to exactly fit the local coinage.

Explanation - Science in context

Newton's first law tells us that objects at rest stay at rest unless acted upon by an external resultant force. The trick blends physical principles with a magician's misdirection, making the viewer question what they actually saw versus what they assumed. It demonstrates how expectations can obscure understanding — an important concept in scientific observation.

Extensions

The trick's conclusion is intentionally left unseen, encouraging students to predict outcomes based on physics and logic. (The pile of 10ps appears to have moved into the empty container).

2 FREE FALL

There are several experiments which are related to the free fall of objects that are falling under gravity with no other external forces acting. Sometimes understanding free fall is expedited by considering the situation both with and without air resistance.

2.1 Free Fall and Reaction

The Science

It takes about 0.5 seconds for us to react to a visual stimulus which is longer than it takes for a note to fall by its length.

Description - What to do

You need two people. The first holds the note as shown in photo 1 and the other has finger and thumb on either side of the note as shown. When the first suddenly drops the note the second tries to catch it between the fingers. Inevitably they fail (photo 2).

Photo 1: How to set up the challenge

Photo 2: Too late to catch the falling note

Explanation - Science in context

The normal reaction time before the fingers can grasp the note is too long. So, the note falls to the ground. The second person can catch the note if they aim to catch it just before it reaches the ground, as this gives them enough time to move down, bending knees and moving hand rapidly (photo 3).

Photo 3: The note is caught near the ground

Extension

How does reaction time vary with the method by which a signal is given? What happens if instead of using sight the “catcher” is tapped on the head or told that the note is dropping (sound). Both these methods give shorter reaction times than sight, which can be proved by dropping a half metre ruler. But is that reduction enough to catch a note?

Try the experiment again this time signalling the drop by either a tap on the head or an audible call. It will turn out that “sight” is by far the slowest signal to react with, i.e. the longest reaction time.

2.2 Falling Coins ... Faster than “g”

The Science

Newtons laws, rotational motion.

Description - What to do

Can an object in free fall "faster than g", that is with an acceleration greater than the acceleration due to gravity?

The set up is a horizontal ruler pivoted at one end so that it can swing downwards to the vertical. What is the acceleration of different parts of the ruler and how would that affect the coins resting on it? Will they not all slip down the ruler and into the pot below? How will the coins' weight and the friction between the ruler and coins affect the result? What affects the number of coins that reach the pot below?

Photo 1: The set up; notice the coins placed along the length of the ruler, and the empty container below.

Photo 2: Close up showing the coins

Explanation - Science in context

When the ruler rotates downwards in this experiment the initial acceleration of the centre of mass will be "g"...however the end of the ruler near the pivot will accelerate linearly at less than "g" and the other end at an acceleration greater than "g".

Thus, the coins away from the pivot will be left behind the ruler and fall freely at "g", whereas the coins nearer the pivot will remain in contact with the ruler and therefore will fall into the box, when they slide down the ruler.

The end of the ruler furthest from the pivot moves downwards with an acceleration greater than the acceleration due to gravity. So, coins near this end will leave the ruler straight away and fall vertically. Coins nearer the pivot will, depending on the value of the friction, stay on the ruler and may slip down into the pot.

Photo 3: Note that only half of the coins reached the container, those on the floor are roughly below their starting points.

2.3 Guinea and Feather Experiment

(Modified for the 21st Century)

The Science

Curriculum area: Forces, air resistance, gravity.

In the famous version of this experiment (by Geoge Adams for a demonstration for King George III of England in 1671) a feather was placed with a guinea (a former British coin) and dropped in an evacuated tube. The experiment can (has) also be performed with various objects in the evacuated tube. The contrast is marked when air is introduced. A cheaper version illustrated here is simply to use a small piece of torn paper and a medium sized coin (photo 1). How can the two items be dropped together so both reach the ground at the same time?

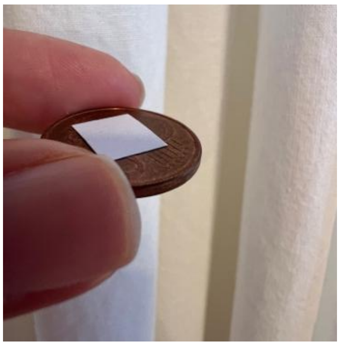


Photo 1: The set up

Photo 2: Drop the coin with the paper on top.

Description - What to do

- Take a medium-sized coin.
- Tear a small piece of paper, smaller than the coin.
- Place the paper flat on top of the coin (photo 1).
- Make sure the paper doesn't hang off the sides — it should lie entirely within the coin's surface.
- Drop both together — as one unit — from a height (photo 2).

Explanation - Science in context

When dropping a coin and a small piece of paper from the same height at the same time, the coin ends up falling with greater acceleration than the paper. This is due to air resistance, which has a greater effect on the light paper compared with the heavier coin. When you place the paper on the coin and drop it you create a mini “evacuated” zone, (partial vacuum) for the paper, (behind the coin) so the coin takes the brunt of air resistance. The paper “hitches a ride” and falls as if there were no significant air resistance.

2.4 Coin Snatch

The Science

Acceleration, reaction time, velocity and distance.

Description - What to do

Balance a pile of coins on your elbow as shown below (photo 1) … as many as you can!

By rotating your arm in the direction of the arrow, can you catch the coins before they fall? (Photo 2)

Photo 1: Ready to catch coins?

Photo 2: Success! Got them!

Explanation - Science in context

The instant the coins are released they begin accelerating downwards at 9.8 m/s^2. They speed up downwards from their initial velocity of 0 m/s, so that initially the coins cover a small distance, and therefore can easily be caught by your hand as it comes round.

Of course, over the short distance and small velocity air resistance is insignificant. How many can you catch without dropping any?

Extensions

We can try with a ruler on your arm to support a row of coins (photo 3).

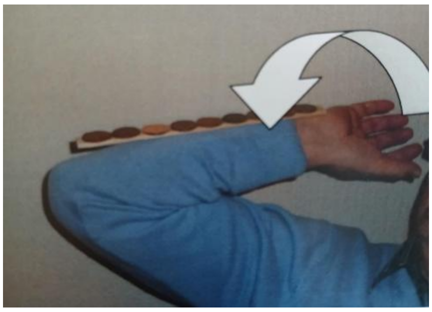


Photo 3: Coins balanced on a ruler.

3 CHEMISTRY

Money is not only about numbers and values – it is also about **materials and chemistry**. Coins and banknotes are made from special substances that give them strength, durability, and sometimes surprising scientific properties.

3.1 The Magic Solution

The Science

Redox reaction.

Description - What to do

- Look for two rusty coins (photo 1).
- Fill a glass with vinegar and add a teaspoon of salt.
- Stir the solution until the salt dissolves completely.
- Place the coin in the solution and let it soak for a few minutes (photo 2) (the time may vary depending on the concentration of the vinegar solution and the state of oxidation of the coin, but a few minutes are usually sufficient) (photo 3).
- Observe that the coin begins to change colour and shine.
- Remove the coin, wash it under running water and dry it thoroughly (photo 4).

Photo 1: Two rusty coins

Photo 2: Solution of vinegar and salt

Photo 3: Add the coin to the solution.

Photo 4: Compare the 2 coins.

Explanation - Science in context

Copper, which is found in some coins, reacts with oxygen in the air over time, forming copper(II) oxide (CuO), which gives the coin a darker and more rusty appearance.

Vinegar, an acetic acid solution, reacts with the copper oxides present on the surface of the coin, forming water-soluble copper salts (copper(II) acetate). The acid solution removes the oxide layer, exposing the shiny metallic copper underneath.

The salt (sodium chloride) helps to solubilise these copper salts, accelerating the cleaning process. The sodium chloride provides chloride ions (Cl^-) that help to form soluble compounds with the oxidised copper. This helps to solubilise the copper salts, so they are more easily removed from the surface of the coin. Salt also increases the conductivity of the solution, which facilitates chemical reactions because it increases the number of charged particles (ions) in solution. Thus, the reactions between the acid in the vinegar and the copper oxides happen faster.

After cleaning, the coin will be brighter and have the original colour of copper, as the oxides that made it opaque have been removed.

Extensions

Repeat the test using cola and tomato sauce and observe whether these substances are also capable of cleaning the coins.

3.2 Coin Battery

The Science

Batteries use a chemical reaction to produce electricity. They need two different metals (electrodes) and an acidic solution (electrolyte).

Description - What to do

Make a pile using 5-euro cent coins (or alternative coins with copper surface) and aluminium circles cut from a soft drink can of the same size as the coins. Also cut circles of absorbent paper with the same diameter as the coins and soak them in a solution of water with a few drops of acid, such as lemon juice or vinegar. Stack them alternately, starting with a 5-cent coin, then place the absorbent paper soaked in the electrolyte on top. Now place an aluminium circle on top and repeat the sequence in this order until you have used up 10 of the coins.

Explanation - Science in context

A battery, or electrochemical cell, consists of two electrodes (anode and cathode), and an electrolyte. The anode is the electrode where oxidation (loss of electrons) occurs, and the cathode is the electrode where reduction (gain of electrons) occurs. The electrolyte is a substance that allows the movement of ions, ensuring the flow of electric current between the electrodes.

The aluminium will undergo oxidation (the anode), the copper will undergo reduction (the cathode), and the electrolyte will allow the directed movement of charges between the two elements.

We can use water with vinegar and salt as an electrolyte.

Extensions

- Test the voltage using a voltmeter.
- Compare the voltage as the number of coin/paper/foil units (cells) increases.
- The challenge: Light up an LED.

An extra activity will be the construction of a fruit battery.

What to do

- Cut a small slit in each lemon (orange or tomato) with a kitchen knife.
- Insert a coin (5-euro cent) halfway into the slit.
- Push a zinc-galvanized nail into each lemon, on the opposite side of the coin. Make sure the coin and the nail do not touch.
- Use alligator clips to connect the nail of one lemon to the coin of the next lemon.
- Repeat until all four lemons (oranges or tomatoes) are connected in series.
- Attach one free clip to the open penny and the other free clip to the open nail.
- Connect these last clips to the legs of a mini-LED bulb. If it does not light, reverse the connections.

Explanation: Science in context

Inside each lemon (orange or tomato), a chemical reaction happens:

- **Oxidation** occurs at the zinc nail.
- **Reduction** happens at the copper coin.

This flow of electrons from zinc to copper creates an **electric current**.

By connecting several lemons (oranges or tomatoes) together, the voltage adds up and becomes strong enough to power the LED.

https://www.scienceinschool.org/article/2025/building-a-simple-voltaic-pile/

4 SURFACE TENSION

Water may look soft and fluid, but its surface hides an invisible "skin." Thanks to it, drops form into spheres, and even some animals, like water striders, can walk on water — making many fun science tricks possible.

4.1 Water Pile-Up – Testing the Strength of Surface Tension

The Science

This simple experiment highlights surface tension, a key concept in fluid mechanics and molecular interactions. It demonstrates how molecules at the surface of a liquid stick together tightly, forming a sort of "skin" that can hold water in place — even on a small, curved surface like a coin.

See the section "Feat 2 Water Pile up" in Science in School, Summer 2019

https://www.scienceinschool.org/article/2019/fantastic-feats-magic-money/

Description - What to do

Materials

- One small copper coin (such as a euro one-cent coin)
- A dropper (pipette or syringe)
- Clean water
- Flat surface (e.g. table)
- Soap or detergent (optional, for the extension)

Steps

1. Clean the coin thoroughly using hot, soapy water. Rinse and dry completely to remove any grease or detergent residue.
2. Fill the dropper with clean water.
3. Hold the dropper slightly above the coin — do not touch the coin — and place a drop of water in the centre (photo 1).
4. Continue adding one drop at a time, counting each drop.
5. Watch as the water "piles up" into a dome shape on top of the coin (photo 2).
6. Stop when the water spills over the edge — that's your total!
7. Repeat the test and try to beat your own score — or challenge classmates to a surface tension showdown.

Photo 1: The first few drops

Photo 2: Full coin with about 40 drops

Explanation - Science in context

Water molecules attract each other, creating cohesive forces at the surface that form a strong, flexible film — this is surface tension. It's this tension that allows the water to "dome" on top of the coin without spilling, even though the surface is small and curved.

The clean surface of the coin is crucial: any grease or dirt breaks the molecular bonding, reducing how much water can be held. When soap or detergent is added, surface tension is disrupted. The molecules spread out more easily, and water spills sooner.

This demonstrates how even small molecular forces can affect the behaviour of liquids in a visible, measurable way.

Extensions

Explore further with these ideas:

- **Soapy Surprise**: Add a drop of soap to the water dome and observe the collapse. Discuss how soap molecules interfere with surface tension.
- **Temperature Test**: Compare how many drops fit when the water is cold vs. warm. Does temperature affect surface tension?
- **Coin Size Variation**: Try the experiment with larger or smaller coins. Predict and measure how coin size affects water pile-up.
- **Slow Motion Science**: Record the process and watch the water dome grow. Observe the final moment when it bursts and analyse what causes the spill.

4.2 Tension on the Card!

The Science

Surface tension of water.

Description - What to do

If we balance a bank card on the rim of a glass and try to place even a single coin on it, it will fall. However, if we fill the glass with water, we will get a different result.

1. We start by filling a glass with water until it cannot be filled any further without spilling.
2. Next, we balance a bank card on the rim of the glass.
3. We now try to balance as many coins as possible on the outside of the bank card (photo 1).

Photo 1: Set up.

Explanation - Science in context

Water molecules' attraction stabilizes the setup until the weight of the coins exceeds the surface tension.

The surface tension of water is a physical phenomenon that occurs on the surface of a liquid, causing it to behave like an 'elastic film.' This effect is caused by the attraction between water molecules (cohesive forces), which are more intense inside the liquid than on the surface.

Why does this happen?

Water molecules are polar (they have positive and negative charges) and attract each other through hydrogen bonds. Inside the liquid, the molecules are pulled equally in all directions. But on the surface, however, the molecules are pulled only downwards and sideways, creating a tension that forms an invisible 'skin'.

Credits to Paul Nugent

https://youtu.be/GYEEmA0HiBo?si=J1E5UfzflAFsriI7

Extensions

Investigate whether the water temperature or the addition of a drop of detergent to the water influences the maximum number of coins that can balance on top of the card.

4.3 Coins in a Beaker of Water

The Science

Surface tension forces hold the surface together even when it is above the edge of the beaker.

Description - What to do

4. Make sure your beaker has a smooth brim without spout etc. and the brim is clean and free from grease.
5. Fill the beaker with clean water right up to the brim.
6. Next take a clean coin and slip it over the brim into the glass of water.
7. Keep repeating with more and more coins. How many can you get into the glass without spilling?
8. Watch closely what happens to the water surface as more and more coins are added.

Photo 1: Adding the coins one by one.

Explanation - Science in context

Surprisingly, in this attempt it was possible to add 16 coins without spilling a drop of water.

Obviously, the answer to "How many can you get into the glass without spilling?" depends on just how full and above the rim you start, the exact shape of the glass and how carefully you slip the coins into the beaker ... but maybe it is the basis of a nice competition. ...or consideration of how fair your fair test is!?

The surface tension in the clean water is able to hold the water above the rim .... (try next a drop of liquid soap and it will overflow immediately).

The surface tension holds the water together even when it is above the brim of the glass, so that more coins can be added. After the experiment remove the coins and see what extra volume has been added.

5 ELECTRO AND MAGNETISM

Electricity and magnetism are two sides of the same coin. When an electric current flows through a wire, it creates a magnetic field around it. Likewise, moving magnets close to a coil of wire can produce electricity. This close relationship is called **electromagnetism**, and it is the science behind many everyday technologies — from electric motors and loudspeakers to generators and MRI machines.

5.1 Matchbox and Coin

The Science

Magnetism.

Description - What to do

Materials Needed

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

Preparation

Secretly tape a small magnet to the underside of the matchboxes inside compartment, beneath the matchsticks (photo 1). 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 (photo 2) 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.

Photo 1 and 2: Set up.

The Performance

1. Open the matchbox halfway so the coin is not seen.
2. Close the matchbox and place it on top of the coin that's in your hand.
3. Gently lift the matchbox off the hand. The coin on the hand has disappeared!!
4. Finally, open the matchbox to reveal the coin has magically appeared inside!

Photo 3 to 6: Step-by-step setup of the magic trick using coins, a matchbox, and a magnet.

Explanation - Science in context

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 and 5-euro cent coins, 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.

5.2 Moving apparently "Non-Magnetic" Money with a Magnet

The Science

Paramagnetism, Electromagnetic induction, Lenz's law.

Description - What to do

Hold a neodymium magnet beside an aluminium Japanese "yen" suspended on a fine thread and observe the very slight attraction (photo 1).
Hold the magnet beside the suspended coin and move it away rapidly then towards the yen when stationary again. Observe the attraction and repulsion (photo 2).

Place a neodymium magnet on top of a pile of yen and lift it rapidly (photo 3). Observe how many yen can be removed (photo 4).

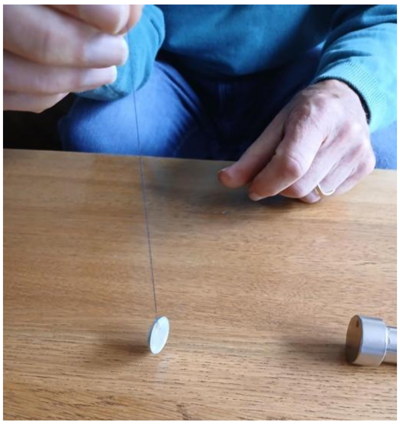


Photo 1: Aluminium Japanese "yen" suspended on a fine thread

Photo 2: The yen is slightly attracted.

Photo 3: Neodymium magnet on top of a pile of yen.

Photo 4: Lift the neodymium magnet rapidly and observe

Explanation - Science in context

Aluminium is a paramagnetic substance, that is it is very weakly attracted to a strong magnet. (Ferromagnetism is significantly stronger than paramagnetism. Ferromagnetic materials exhibit a strong, lasting attraction to magnets, even after the external field is removed, while paramagnetic materials show only a weak, temporary attraction to magnets and lose their magnetization when the external field is removed).

When a magnet is moved beside a conducting material, electric currents are induced in the material which oppose the motion producing them. Thus, moving the magnet away from the yen induces currents which attract the yen towards the magnet. Moving the magnet towards a suspended yen will repel the yen.

When a magnet is removed rapidly from a pile of yen the top few yen are attracted and removed from the pile. The faster the magnet is moved the more yen can be removed. The small forces induced are sufficient to move the very light yen, (they have a mass of 1 g). A nice illustration of Newton's second law, $F = ma$.

Extensions

If you don't have access to yen, aluminium ring pulls on drinks cans can be used instead or simply try aluminium wrapping foil.

5.3 Induced Magnetism

The Science

Induced magnetism.

Description - What to do

You will need at least one strong magnet and a selection of magnetic coins. Simply arrange the coins in the magnetic field in various "sculpture like" patterns (photos 1 to 4).
Utilise the fact that magnetism is a none contact force so that "sculptures" can be moving creations.


Photo 1: Tower of coins


Photo 2: Bridge of coins


Photo 3: Suspended coins


Photo 4: Coin sculpture

Explanation - Science in context

When placed in a magnetic field, certain coins become magnetised themselves and can therefore experience the magnetic attractive and repulsive forces. Many recent coins are now made of magnetic material (like steel) because they cost less than previous metal combinations. Examples can be found in UK, the Netherlands, Germany, France and Italy.

Extensions

Can you devise a method to measure the size of the force between hanging coins ...does it decrease linearly as you move away from the permanent magnet. What device could you use? (It must not be magnetic itself to ensure a fair measurement).

5.4 More Magnetic Mystery

The Science

Magnetic forces, induced magnetism

Description - What to do

Material

- A selection of coins made with magnetic material, e.g. UK 2p or 10p (there are over 500 magnetic coins now around the world).
- A flat plastic ruler
- A strong magnet

Experiment

1. Place the ruler between two improvised pillars and the magnet on top between them.
2. Raise the coin to the underside of the ruler such that the magnetic field holds it (photo 1) and the face of the coin is clearly seen

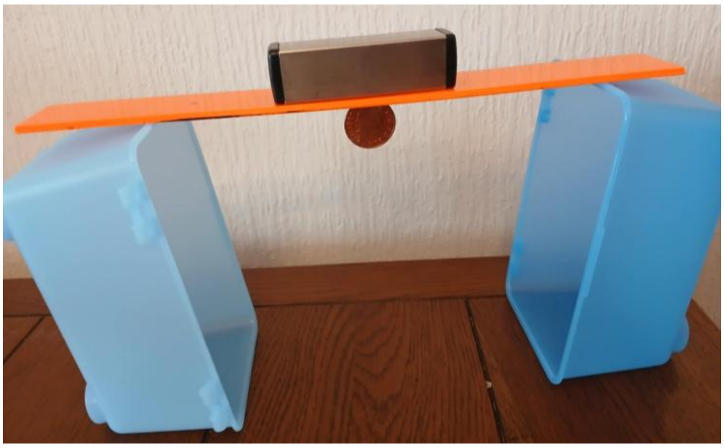
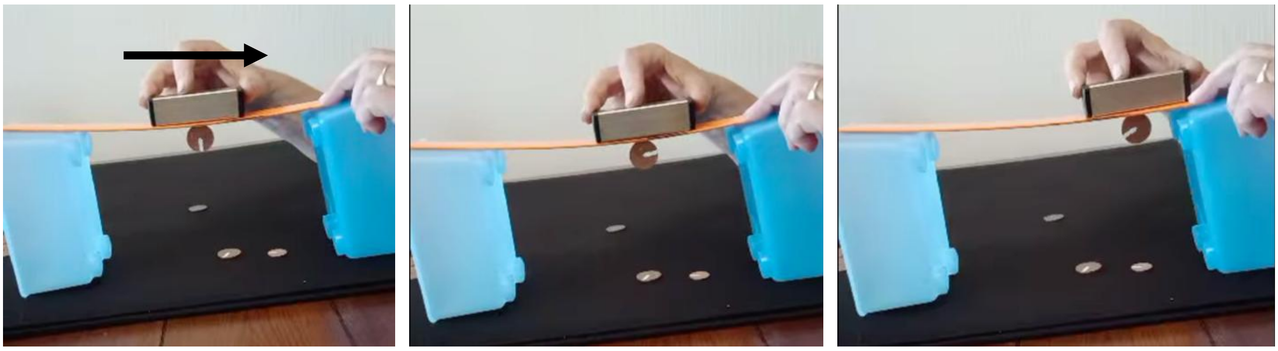


Photo 1: Set up.

3. Slide the magnet gently to the right along the rule.
   What will happen to the coin? Will it
   a) fall off
   b) rotate clockwise
   c) rotate anticlockwise
   d) slide
4. Add a second coin. What will happen to the second coin? Will it
   a) fall off
   b) rotate clockwise
   c) rotate anticlockwise
   d) slide

Explanation - Science in context

The answer is it rotates anticlockwise when we have a coin and the magnet is slid to the right.



Photos 2 to 4: The movement of the coin is anticlockwise.

The answer is that the second coin rotates clockwise and the first one anticlockwise when the magnet is slid to the right (photo 5).

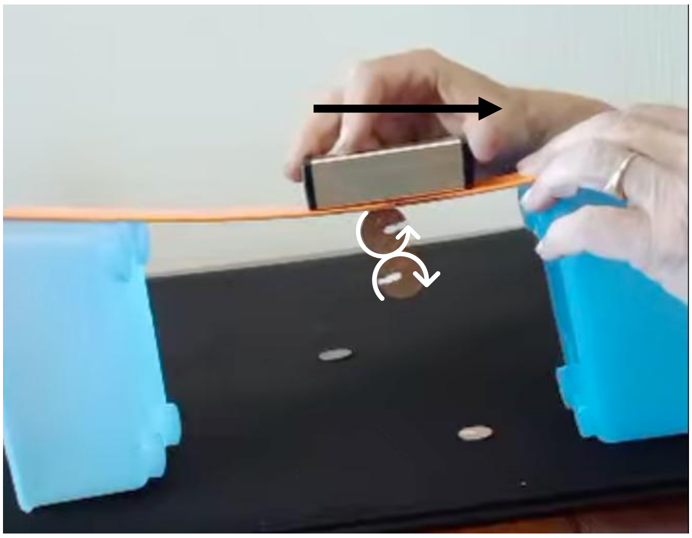


Photo 5: Add a second coin and move the magnet to the right.

Photo 6: Magnet holding coins, note white marks.

Photo 7: After sliding magnet to the right.

Extensions

Add more coins to the hanging coin and investigate further movements (photo 6).

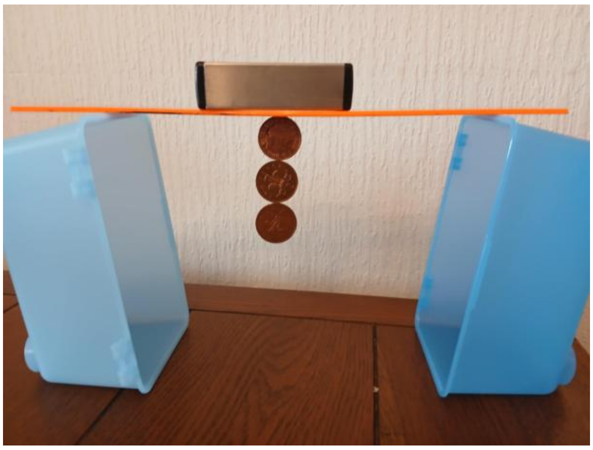


Photo 8: Which coins rotate in the same sense?

More rotation! Add a further coin until you almost reach the limit of what the magnet will hold.

Flick the last coin so that it spins, once more demonstrating the nature of the magnetic force, i.e. that it is non-contact (photos 7 to 9).

Photo 9: 4 coins held by magnet

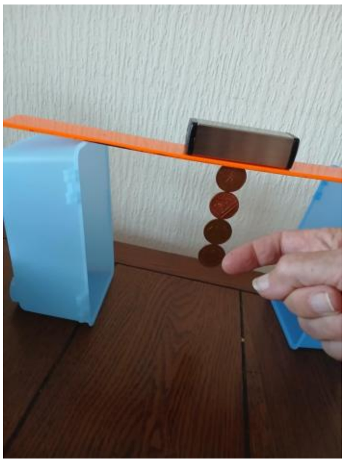


Photo 10: Flicking bottom coin

Photo 11: Bottom coin spinning

The bottom coin spins easily as there is little friction between it and the 3rd coin and the induced magnetism just holds it loosely.

5.5 Induced Magnetism II

The Science

Induced magnetism and no-contact forces.

Description - What to do

Material needed

- At least one strong magnet
- A selection of magnetic coins.

Place two coins vertically on top of the magnet. The coins balance because of the induced magnetism, which passes the magnetic field upwards (photo 3).

Now attempt to lift the coins vertically holding on only to the uppermost coin. Will the two coins lift together, or will the coins separate with the magnet holding onto the lower coin?

The coins pull away from the magnet, but stay together in the pair, i.e. holding together rather than the lower coin being held by the strong magnet.

Photo 1: Induced magnetic field holds coins in position

Photo 2: Induced Magnetic field holds coins together

Explanation - Science in context

When placed in a magnetic field our coins become magnetised themselves. Because magnetism is a non-contact force the magnetic field exerts forces through non-magnetic materials as the magnet does not need to be touching that which is to be magnetised.

The coins stay together because the concentration of the magnetic field is greater between the two coins than it is between the coin and magnet where the field lines are more spread out (See photo 3)

Showing the lines of magnetic force through the two coins being held together by the magnetism from the magnet.

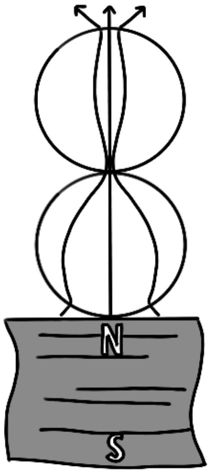


Photo 3: Lines of magnetic force

Extensions

The experiments can be tried with more than two or three coins and with different sized coins if they are magnetic. But note a small non-magnetic coin can still be used in the line, because the magnetism in one magnetised coin can be passed on to a coin below if it isn't too great, magnetism acts at a distance!

5.6 Yen and Neo Magnet

The Science

Density, matter.

Description - What to do

1. Place the yen on a plate filled with water.
2. Hold the neodymium magnet close to the water but next to the yen.
3. First hold the magnet stationary beside the yen and secondly move it beside the yen.

Photo 1: Holding a magnet beside the floating yen.

Explanation - Science in context

There are 3 things to watch for ...

Photo2: Magnet close to the yen.

1. When the magnet is held beside the coin it is the water that is first repelled creating a dip in the surface, which the yen floats into. This is because water is weakly diamagnetic which means it is repelled by a strong magnetic field.
2. But aluminium is weakly paramagnetic, which means the yen is weakly attracted by the strong magnetic field, hence moves slowly towards the magnet.
3. Induction: Moving the magnet beside the coin induces electric currents in the coins. These currents oppose the motion producing them, (Lenz's Law) Thus moving the magnet away attracts the coin, moving the magnet towards repels it.

Extensions

Here we have an aluminium yen coin "floating" on water ...or should I say held on the surface of the water by the surface tension forces. ...what will happen if you add a drop of soap?

6 MATHEMATICS

6.1 Heads or Tails

The Science:

Centre of mass and probability.

Description - What to do

Arrange the 50 (fairly new if possible) USA one cents balanced on their edge on a flat horizontal table (photo 1).


Photo 1: 50 (fairly new) US cent pieces.


Photo 2: Fallen coins after table is struck.

Give the table a sharp strike so that the coins all fall over (photo 2).
Now count the number of heads and the number of tails (photo 3)

Photo 3: Showing number of heads and tails.

Out of 50 coins in this experiment only three end up tails…a typical result.
(NOTE: Significantly different results are obtained if table is not level or old well-worn coins are used).

Explanation - Science in context

We all know that coins have two sides – heads and tails – and that the chance of a tossed coin landing one particular side up (heads, say) is 50%. But while this assumption is widely held, and relied upon in situations ranging from football match kick-offs to probability questions in maths, is it really true in practice?

The new US cents are minted with their centre of mass slightly nearer the tails side, so this side is more likely to land downwards.

See the section “Heads vs Tails” in Science in School, Summer 2019

https://www.scienceinschool.org/article/2019/fantastic-feats-magic-money/

Extensions

The theory can be verified using a "coin bank"...a simple child's money box, which is another way of getting fair results. A coin pressed through the hole in the lid and spins rapidly on the plinth inside the box and eventually stops and falls over onto one side. It is found that the majority of 1 euro cents land up with heads showing!!

Photo 4: Pushing the coin into the box so that it spins.

Again, this shows that the coins have a preference to land heads up, due to the mass distribution. Just tossing a coin in the air as at a football match gives a more random result as other factors are more important than this slight imbalance.

6.2 Coin Rolling Experiment

The Science

Geometry tells us that the circumference of a circle is directly related to its radius:

$$C = 2\pi r$$

When one circle rolls around another, we can explore this relationship in a surprising way.

What to do

How many times will a coin in contact with another coin rotate to go around the circumference of the first? Just something to think about when you have your coins out.

If two coins are the same size, intuition might suggest that the moving coin makes one full rotation as it travels once around the stationary coin.

Photo 1: Two similar coins.

Photos 2-4: Second coin moving round first.

1. Place one coin flat on the table.
2. Take another identical coin and position its edge against the first coin.
3. Slowly roll the second coin all the way around the stationary one, keeping their edges in contact.
4. Notice in the second photo that ¼ way round the rotating coin has made half a revolution. (Photos 1 and 2)
5. Count how many full rotations the moving coin makes before returning to the starting point.

Explanation: Science in context

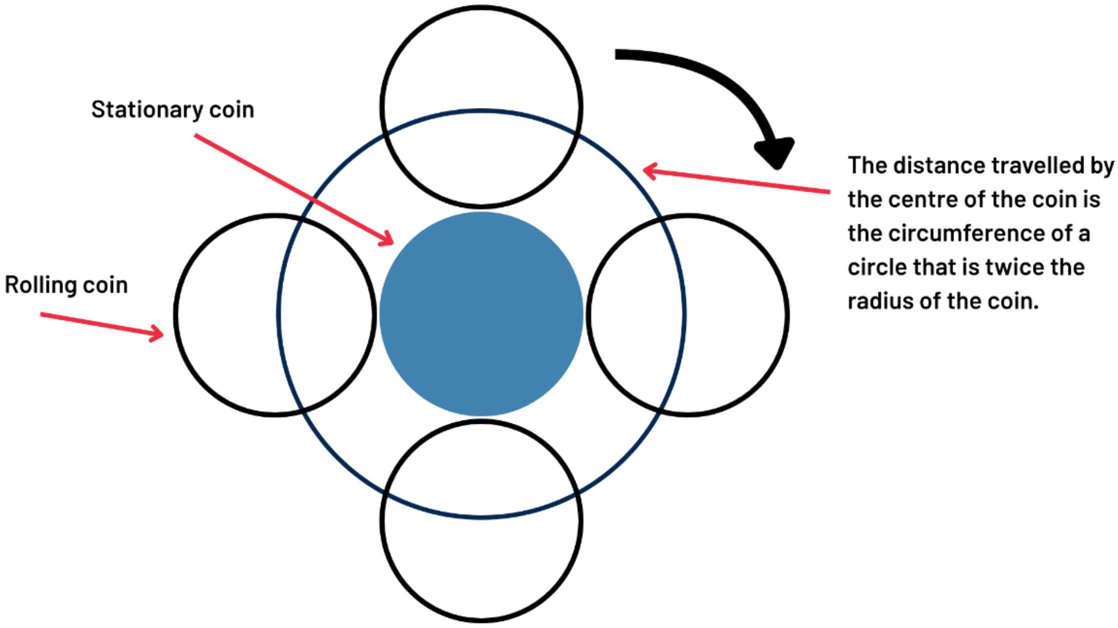
At first glance, you might think the moving coin will rotate only once, because the distance travelled around the other coin equals one circumference. However, there is an extra twist!

- As the rolling coin moves, it rotates once because of the distance travelled (equal to one circumference).
- But it also rotates a second time because it is curving around the stationary coin.

In total, the coin completes **two full rotations**.

But the circumference of the rolling coin itself is **2πr**.
So, if it were rolling in a straight line on a surface, to cover a distance of **4πr**, it would complete:

$$\text{Number of rotations} = \frac{\text{Distance travelled}}{\text{Circumference of the coin}} = \frac{4\pi r}{2\pi r} = 2 \text{ rotations.}$$



6.3 Mass and Volume – Finding Density

The Science

Graphs allow us to summarise results, predict future values (extrapolation) and understand complex mathematical relationships quickly and efficiently, making them essential tools in both theoretical and experimental work.

What to do

1. **Measuring Mass**: Use a digital scale to measure the mass of 10 coins.
2. **Measuring Volume – Method A (Geometry)**: Treat the coin as a cylinder and calculate the volume with

$$V = \pi r^2 h$$

   where *r* is the radius and *h* is the thickness.
3. **Measuring Volume – Method B (Water Displacement)**: Fill a graduated cylinder with water and record the volume. Drop the coins carefully into the water and measure the new volume. The difference gives the volume of the coins.
4. Plot the values of **mass (y-axis)** against **volume (x-axis)** for several coins.
5. Draw the best-fit line and determine its slope.

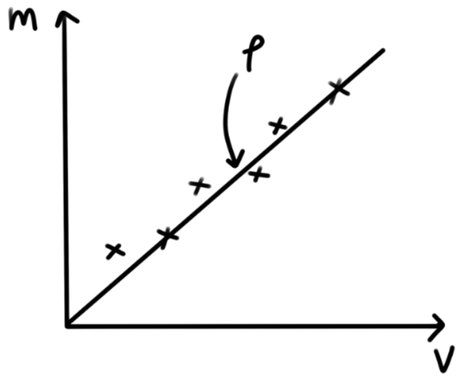
Explanation: Science in context

The mass of an object is directly proportional to its volume when it is made of a uniform material. The constant of proportionality is the **density (ρ)**:

$$\rho = \frac{m}{V}$$

If you plot **mass (m)** against **volume (V)**, the **slope of this line** corresponds to the density of the material. The straight line shows the proportionality between mass and volume. The slope of the line is equal to the **density**:

$$\text{slope} = \frac{\Delta m}{\Delta V} = \rho$$



By comparing the experimental density with known values (for example, copper ≈ 8.96 g/cm^3, aluminium ≈ 2.70 g/cm^3, steel ≈ 7.85 g/cm^3), you can estimate the materials or alloys that make up the coins.

7 GENERAL

In this chapter, we have several experiences that did not fit into the categories we presented earlier, but which could not be left out.

7.1 Balancing a Paper Note

The Science

Centre of mass.
(Note this is something we might categorise as “magic” or maybe deceit !!)

Description - What to do

Take a paper note that is easily folded, and fold it lengthwise into 3.
Unknown to the audience slip a coin into the note hidden at the end in your hand.
Balance this end on your finger, with the other end free (photos 1 to 4).

Photos 1 to 4: Step-by-step instructions.

Explanation - Science in context

The note appears to balance well away from its centre of mass as shown, however the hidden coin is not seen. The coin shifts the centre of mass to above the finger.

Extensions

Given a few coins, how can you use them to create objects that balance in unusual ways.

Use two coins on arms to lower the centre of mass below a pivot on a small puppet like model (photo 5). The model then can be balanced on a tower or elsewhere (photo 6).

Photo 5: Balance the butterfly.

Photo 6: Showing the coins which lower the centre of mass.

Photo 7: Instead of coins we can add paper clips.

Several desktop toys use the same principle where the centre of mass is made to be below the pivot.

Photo 8: Desktop toys.

7.2 Note and Paper Clips

The Science

Topology; Chemical reactions and Catalyst.

Description - What to do

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: https://youtu.be/3m8Je_jpfOY

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 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 the paper and are now linked showing the catalyst has worked!

1. Take a money note (which is often smooth and easier to use) and fold into an S shape (photo 1).
2. You want to join the front of the paper with the first 'fold' of the 's'-shape. 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 (photo 2).
3. 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.


Photo 1: Step 1

Photo 2: Step 2

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

7.3 Marble and Coin

The Science

Balance and turning.

Description - What to do

You need a light coin (0.10€ or a yen) with a radius just greater than the opening at the top of a bottle, a marble that will just fit into the bottle through the neck, and paper and transparent flexible plastic sheet to make two tubes that just fit over the bottle neck (photo 1). Place the coin horizontally on the opening (photo 2).


Photo 1: The apparatus needed


Photo 2: Coin on bottle opening

Place a paper tube over the opening of the bottle so that the coin is not seen. Ready to drop the marble photo 3 and 4.


Photo 3: Ready to drop marble.


Photo 4: After marble dropped coin still in position.

Next take the marble and drop it down the tube onto the coin on the bottle opening in the tube.

The marble mysteriously appears at the bottom of the bottle with the coin apparently undisturbed (photo 4). The experiment can be repeated using a transparent tube so that you can see what happens (photos 5 and 6).

Photo 5: With a transparent tube

Photo 6: "Watch carefully!"

If you look carefully, you can see that usually the coin itself "mysteriously?" turns over (photos 7 and 8).

Photo 7: At the start

Photo 8: At the end

See slow motion video: https://youtube.com/shorts/7MJ2n59fBP4

Explanation - Science in context

When the marble strikes the coin the coin "bounces" upwards in reaction, pivoting on the rim of the bottle neck turning as it rises sufficiently for the marble to pass into the bottle. Depending on the height of drop the coin will fall back on the bottle (constrained by the tube) having turned fully or just made a half turn (photos 7 and 8).

A full explanation is given here: https://www.youtube.com/shorts/kuBGgE-fHNw

Extension

Students can investigate the factors which affect the turn...mass of marble, height of drop, mass of coin.

7.4 The Coin and the Folded Toothpick

The Science

Capillary Action

Description - What to do

Place a coin on top of a wooden toothpick that has been bent in half and balanced over the mouth of a bottle. The coin rests right above the bottle's opening (photo 1).

Photo 1: Set up

The Challenge

Can you make the coin fall into the bottle without touching the toothpick or the coin?

Hint

A small drop can make a big difference.

Explanation - Science in context

Wood is porous and absorbs water. When you place a drop of water on the bent part of the toothpick, the fibres begin to swell.

As the wood absorbs the water, the bend slowly starts to open. Since the coin is resting on the folded toothpick, this movement causes the toothpick to straighten, making the coin lose balance and fall into the bottle.

Contribution: Nuria Molina (Science on Stage Spain)

7.5 Genie in the Bottle?

The Science

Expansion of gas - Pressure law.

Description - What to do

1. Place a coin in the neck of an empty bottle. (To make this easier, wet the coin first so that it sticks better to the glass).
2. Hold the bottle with your warm hands and rub it. After a while, the coin will start to bounce slightly.

Photos 1 to 3: Set up

Explanation - Science in context

The hands warm the bottle which warms the air inside. As air expands more than glass, for the same rise in temperature, air forces its way out of the bottle. The air trying to escape from the bottle causes the coin to jump.

Extensions

To verify how heating a gas demonstrates its expansion, it is possible to show this through the following experiment:

1. Place a balloon over the neck of a bottle.
2. Stand the base of the bottle in hot water for a few seconds – the balloon will start to inflate.
3. Remove the bottle and place it in cold water: the balloon deflates.

The balloon inflates when the air warms up and expands; it shrinks again when cooled. Heating makes the air molecules move faster and take up more space (greater volume).

Safety: Take care when handling hot water.

Photo 1: Bottle just out of the fridge.

Photo 2: Bottle after serious rubbing with hands.

The bigger the bottle the better the effect.

7.6 The Disappearing Coin?

The Science

Refraction of light.

Description - What to do

1. Place a coin on a table.
2. Place a transparent glass over the coin.
3. When looking from the side, you can see the coin.
4. Add water to the glass until it is almost full.
5. Now look at it again from the side — can you still see the coin? It seems to have disappeared!
6. Now look straight down through the water. Can you see the coin? Yes, she is there!

Photos 1 to 4: Set up

Explanation - Science in context

The science behind this trick is the refraction of light. The images we see are all rays of light that reach our eyes. When these rays of light travel through the same homogeneous medium, they do not undergo refraction. That is why it is initially still possible to see the coin through the side of the empty glass, as the light travels through only one medium, air.

When water is poured into the glass, the light undergoes refraction, i.e. it changes direction as it passes through two different media, water and air. After passing through the water and the side of the glass, none of the rays reach your eyes.

Therefore, when the rays of light are passing through the glass they are refracted and cannot reach your eyes.

7.7 Three Coin Challenge

Photo 1: Display

The Science

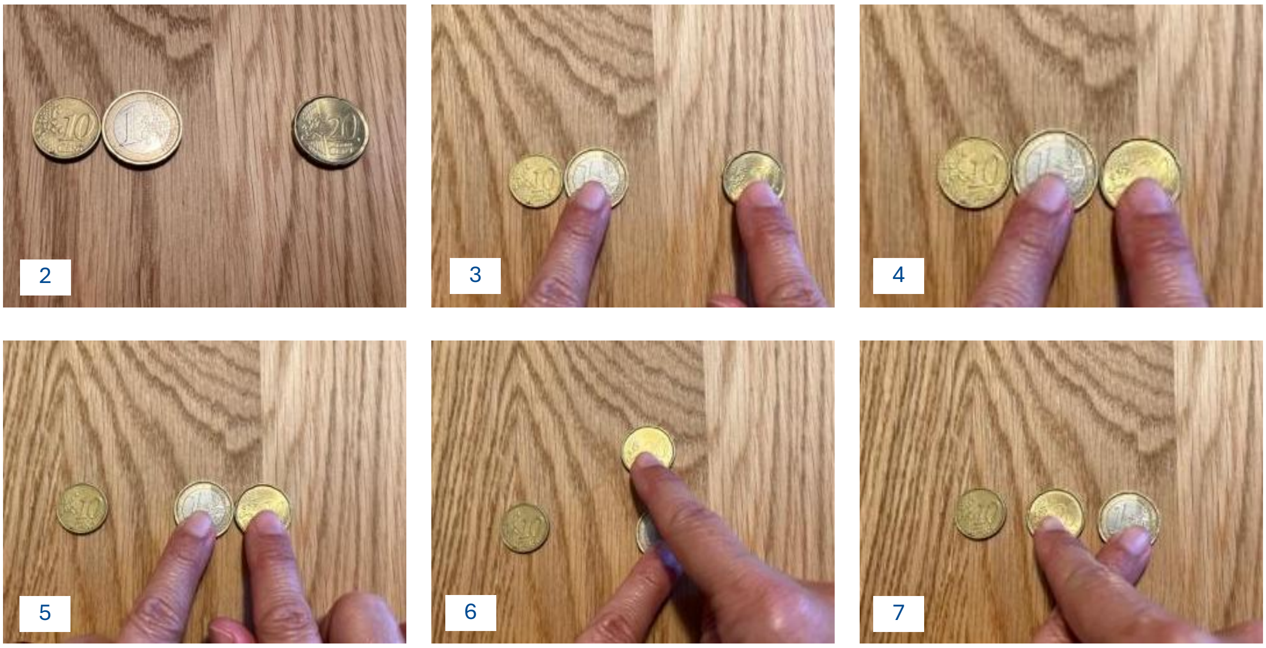
Collisions, inertia, Newton's cradle

Description - What to do

Three coins are placed on a table in a row as shown above.
The challenge is placing the 20-cent coin between the 10-cent and 1-euro coins without touching the 10-cent coin or moving the 1-euro coin. You can move the 20-cent coin. Hint: Think about Newton's Cradle

Explanation - Science in context

Solution: Place your left index finger on the 1-euro coin and use your right index finger to tap the 20-cent coin against the 1-euro coin.
What will happen is that the 10-cent coin will be removed from the 1-euro coin. Then, as we can change the 20-cent coin, we now have space to place it between the 10- and 20-cent coins.



Photos 2 to 7: Sequence of movements.

7.8 Properties of Coins, UK 10ps 5ps 2ps and 1ps, and notes, US 1 Dollar Paper Bill

The Science

Density, Mass and Volume

Description - What to do

Activity 1

Bring together a set of 10 or so coins (photo 1). Each pile is made up of the same coins.

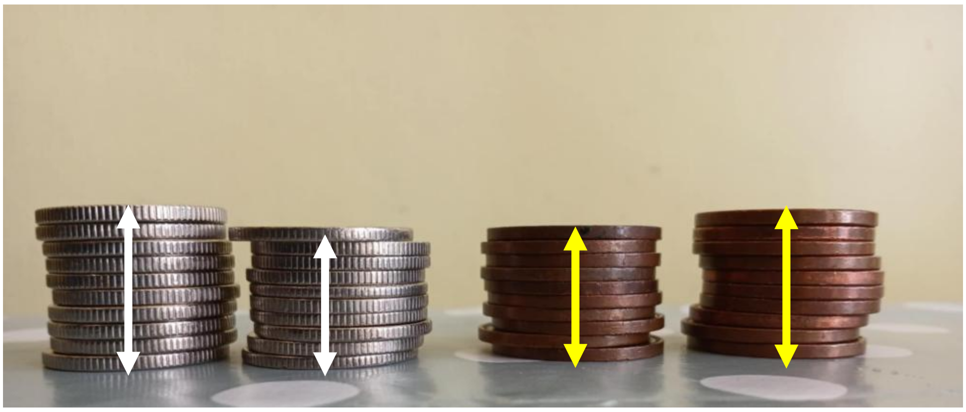


Photo 1: Each pile contains 10 coins, although the overall height of each pile seems to be different.

Activity 2

Can magnetism be detected in any of these coins, or notes?

Photo 2: A very strong magnet held beside a dollar bill will attract it.

Explanation - Science in context

Activity 1

The composition of UK coins 2p and 1p was changed in 1992 and of 5p and 10p in 2012.

Pre September 1992 1p and 2p were Bronze (97% copper, 2.5% zinc). After 1992 these coins were/are copper plated steel. In 2012 the 10p and 5p became nickel plated steel, having originally been minted from cupro-nickel CuNi (75% Cu 25% Ni). The change in density means that the newer coins are slightly thicker than the original which accounts for the piles of coins being of different heights. The switch to nickel-plated steel was made due to rising metal prices.

Activity 2

Some of the black ink used in the old one-dollar bills is magnetic. This was to avoid counterfeiting.

See https://youtu.be/juuN9VbvrPE

Extensions

Compare the magnetic properties of the coins above. The more recent coins have a basis of steel and therefore are attracted by a magnet.

Investigate which coins from all over the world are magnetic and which are not? What have some coins changed in recent years?

7.9 Detecting a Genuine Banknote with UV Light Challenge

The Science

Fluorescence. Fluorescence is an optical phenomenon in which certain substances absorb high-energy light, like UV and emit visible light, and is used in banknote security.

⚠ UV Light Safety Notice

When using ultraviolet (UV) light in classroom activities, only lamps specifically designed for safe educational use should be employed. Avoid direct eye or skin exposure and never use high-intensity UV sources. The UV lamp must always be handled by the teacher or a responsible adult, ensuring that pupils observe the effects safely without risk of harm.

Description - What to do

1. Take a genuine banknote and a suspected fake note (note from Monopoly or similar).
2. Turn off the lights or go to a dark room.
3. Shine a UV (ultraviolet) light on both notes.
4. Observe the areas of the banknotes that fluoresce or glow under the UV light.

What happens?

- The genuine banknote will show bright fluorescent security features, such as glowing stripes, fibres or symbols.
- The fake banknote will either show no fluorescence or very dull and inconsistent glowing patterns.

Explanation - Science in context

Genuine banknotes contain special UV-reactive inks and security threads that fluoresce under ultraviolet light. These inks are invisible in normal light but glow under UV light, making it easy to distinguish real money from counterfeit. Fake notes usually lack these inks or have poor-quality imitations that don't fluoresce properly.

Extensions

- Research how different countries design their UV security patterns on banknotes.
- Investigate other security features such as watermarks, microprinting, or holograms.

7.10 Turning a Note Upside Down

The Science

Symmetry and folding, topology.

Description - What to do

Materials needed

A (paper) note, preferably with a ruler's head on one side.

Experiment

1. Show the note to the audience.
2. Fold the note in half along its length.
3. Fold this long folded note in half at its centre.

Stage 1

Stage 2: Folding the note.

4. Repeat the centre fold in half with the quarter size note.
5. Repeat again (last two folds in third photo above).
6. Now unfold the note ...wow the face is upside down ... maybe?!

Stage 3: Unfolding the note.

Stage 4. WOW!!!

Explanation - Science in context

Folding can easily result in an upturned note, but how this time?

Track the position of the original corners of the note and see for yourself.

Where does the turnover actually happen? There are enough clues in the photo series demonstrating the folding.

7.11 Jumping Coin – The Power of Air

The Science

This experiment demonstrates Bernoulli's principle, part of the forces and fluids section of the science curriculum. It shows how air pressure changes with air speed, and how this effect can be used to move objects — similar to how airplanes gain lift.

See the section Jumping coin in:

https://www.scienceinschool.org/article/2019/fantastic-feats-magic-money/

Description - What to do

Materials Needed

- One small, light coin (aluminium coins like Japanese yen work well)
- Other small coins (optional)
- A small matchbox
- A cup or mug (preferably with sloping sides)
- A flat surface like a table

Steps

1. Set up the coin, match box and mug as shown in photo 1.
2. Position yourself as shown in photo 1, so that your breath will go straight over the coin.
3. Blow quickly and forcefully – the coin should 'jump' into the mug (photo 2).

Photo 1: The setup for the coin jump trick

Photo 2: The coin is lifted into the cup by the reduction in air pressure above it.

Explanation - Science in context

According to Bernoulli's principle, when the speed of a fluid (like air) increases, the pressure decreases.

When you blow quickly over the coin, the air pressure above it drops.

The higher pressure below the coin pushes it upwards, making it jump.

This is the same principle that explains how airplane wings generate lift: air moves faster over the curved top of the wing, creating lower pressure and lifting the plane.

Extensions

Try these extra activities:

- Compare Coins: Try the trick with different coins and measure how far or how high each one jumps.
- Bernoulli in Real Life: Research or demonstrate other applications of Bernoulli's principle, such as how a vacuum cleaner works or how perfume sprays.

7.12 Diffraction on a Canadian Banknote

The Science

Light behaves like a wave. When it passes through very fine, evenly spaced structures — such as the microstructures in the transparent security window of a Canadian banknote — the light is diffracted and spreads out. This creates an **interference pattern**.

A laser provides a single colour (monochromatic light), making the diffracted beams appear as a series of bright spots.

⚠ **Adult supervision!**

Note on Laser Use

The laser shown in the photo 1 and 2 was used for demonstration purposes only and operated by an adult under controlled conditions.

For this activity, always choose the safest laser. Avoid directing the beam towards the eyes or reflective surfaces and ensure that it is always handled responsibly.

The laser should only be operated by the teacher or a responsible adult with appropriate knowledge of the subject.

What to do

1. Find the transparent window on a Canadian banknote.
2. Set up a laser pointer and aim it carefully through the microstructured part of the note (photo 1).

Observe the pattern of **bright dots** that appear on the wall (photo 2).

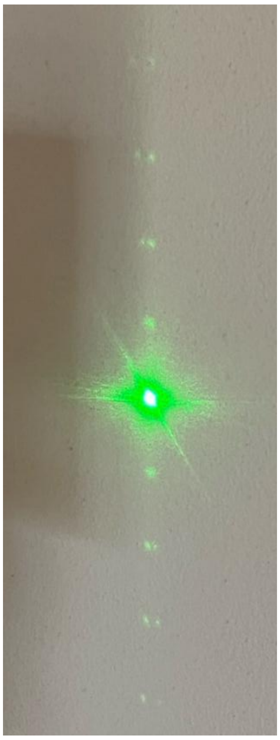


Photo 1: Set up

Photo 2: Diffraction

Explanation: Science in context

The microstructures on the note act like a **diffraction grating**.

- When the laser light passes through, the waves spread out and interfere with each other.
- At certain angles, the waves add together (constructive interference), producing bright spots.
- At other angles, they cancel out (destructive interference), leaving dark regions.

The result is a series of bright dots projected on the wall.

NOTES

SCIENCE ON STAGE EUROPE

THE EUROPEAN NETWORK FOR SCIENCE TEACHERS

MONEY MATTERS

SIMPLE SCIENCE EXPERIMENTS