SMALL MATHS OUTREACH KIT

Information Booklet

National HE STEM Programme
maths careers endless opportunities
Institute of mathematics & its applications

**Watch the training DVD to see all Small Maths Outreach Kit items in action.
Also visit www.mathscareers.org.uk**

Small Maths Outreach Kit
Information Booklet

Welcome to the Small Maths outreach Kit!

If you are reading this booklet then hopefully your university department is the proud owner of a Small Maths Outreach Kit. Inside you will find a treasure trove of toys, games and puzzles, all of which have a mathematical basis or require the use of logic and spatial reasoning to solve a particular puzzle.

This Small Maths Outreach Kit was developed by the Institute of Mathematics and its Applications (IMA) as part of the National HE STEM Programme. It was created following feedback from the HEI maths community who voiced it was becoming more common for them to be asked to do something 'hands on' when doing outreach work with schools, particularly when they have a stall at an outreach event, careers fair, science fair or exhibition.

Two kits have been developed: this small briefcase sized kit which contains a number of small hands on activities, as well as a Maths Large Outreach Kit consisting of seven large hands on activities (see www.mathscareers.org.uk).

Features of the kit:

- A tutorial DVD showing the kit contents in action.
- Items are designed to be used on a stand where people might visit for five minutes or so, rather than as part of a longer outreach workshop - although feel free to use them in your maths outreach workshops.
- The majority have a mathematical basis, ranging from easy to extremely complicated. Inside this information guide you will find short information sheets explaining some of the maths in a simplified way, with the hope that similar ideas might help inform discussions with pupils.
- All the items are relatively inexpensive and a sheet at the end of this guide explains where replacements can be bought.

If you have any further questions about this kit, please contact the IMA via our website at www.ima.org.uk.

We are positive you will find some of these items useful. You might not like everything, but the hope is that there will be at least something which is of use to at least somebody in your department. So do please share it with others. We also think that it will spark new ideas for STEM outreach and potentially lead you to buy or develop other hands on activities.

Important Note:

Please read any individual manufacturers' instructions for each item, as age restrictions and health warnings may apply. Similarly it is probably best not to store the kit in a public area such as a staff common room - items may also not last very long if you leave it there!

Contents

Euler's Disk

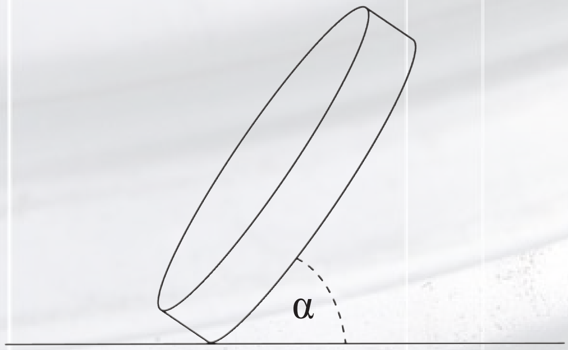
What is it?

Euler's disk is a heavy metal disk with a rounded edge. When you spin it, it will keep spinning much longer than you might expect with an average spin time of around a minute and a half. Just before it comes to a rest it will speed up and produce a high pitched noise.

Why does it work?

The way that Euler's disk moves is called *spolling*, or spinning and rolling at the same time. If it wasn't for friction and vibration, the disk would continue spolling forever.

The mathematician Professor Keith Moffat showed that $v^2 \sin\alpha$ is constant where v is the speed of the point of contact between the disk and the table and α is the angle between the disk and the table. Therefore as the angle α becomes smaller, this means that the speed of the point of contact becomes bigger. In fact as α tends to zero, the speed of contact between the disk and the table becomes very large. This continues until the disk loses contact with the table and comes to a noisy stop.



Euler's disk also relies on very low energy loss due to friction - in fact the power used for a 10 watt light bulb would keep 10,000 Euler's disks spinning continuously!

How can I find out more?

have a look at www.eulersdisk.com

FUNMATHS ROADSHOW

Sample Activities

What is the FunMaths Roadshow?

The FunMaths Roadshow is a collection of 350 mathematical activities suitable for use with school pupils, college students, and university undergraduates, between the ages of five and 20. The first 100 were developed to celebrate the centenary of the Liverpool Mathematical Society in 1999, and the further 250 have been developed subsequently.

Led by members of the Liverpool Mathematical Society, the development of the Roadshow is an ongoing attempt, in part, to provide a brief experience of some elements of what practicing mathematicians do in real-life. These include:

- **problem solving**
- **insight development**
- **ideas exploration**
- **solution achievement**
- **discussion with colleagues**
- **outcome interpretation**

How does it work?

The Funmaths Roadshow currently consists of fourteen ‘boxes’. Each box contains 25 mathematical activities displayed on coloured laminated A3 baseboards, with associated equipment in zip wallets. The boxes are roughly graded as follows:

Box -1	**Years 1 & 2**	**Box 6**	**Year 10**
Box 0	**Years 3 & 4**	**Box 7**	**Year 10/11**
Box 1	**Year 5**	**Box 8**	**Year 11/12**
Box 2	**Year 6**	**Box 9**	**Year 12**
Box 3	**Year 7**	**Box 10**	**Year 13**
Box 4	**Year 8**	**Box 11**	**Reality maths - Year 9 or above**
Box 5	**Year 9**	**Box 12**	**Reality maths - Year 9 or above**

For most groups of participants just two of the boxes are used. The activities are set out on tables in a hall or large space, and all that a participant needs is a pen or pencil.

Participants move around the room tackling the activities in any order they choose. Each participant has a customised response sheet to be stamped or initialled by a helper when each activity is successfully completed. Helpers in a school-setting could be staff or older pupils from the school or, in a primary school, perhaps even pupils from a secondary into which the primary school feeds. In a typical session of 50 - 75 minutes, with pupils working in pairs, most pupils will complete a dozen or so activities.

Certainly enjoyment and challenge are the most appropriate words to characterise the Roadshow as a whole. Most schools are keen to issue certificates to all participants, which may then be placed in pupils’ Progress File. Experience has shown that everyone succeeds, including children with special needs.

Included in the Small Maths outreach Kit are five sample activities from the Funmaths Roadshow.

• Activity no.31 Leap Frog • Activity no.38 Ordering the Milk • Activity no. 89 Court Sudoku
• Activity no. 94 P + S + V • Activity no. 101 Days of the Week

If you would like to order a CD containing the full set of activities please go to: www.maths.liv.ac.uk/lms/funmaths/
Here are the answers to the five sample activities:

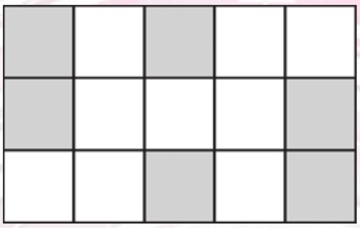
31. Leap Frog

Start with the only possible move by the red frog
then 2 moves by green frogs
then 3 moves by red frogs
then 3 moves by green frogs
then 3 moves by red frogs
then 2 moves by green frogs
then 1 move by red frog
It takes 15 moves in total

38. Ordering the Milk

When five bottles have been placed, the position of the sixth is unique. It must go in the column and row containing an odd number of bottles.

One possible solution:



The task cannot be completed with the word ‘even’ replaced by ‘odd’ for 6 cannot be the sum of three odd numbers.
Note: the number 0 is even, not odd.

89. Court Sudoku

The solution:
AS JH KC QD
QC KD JS AH
JD AC QH KS
KH QS AD JC
(A = Ace, K = King, Q = Queen, J = Jack,
C = Clubs, D = Diamonds, H = Hearts,
S = Spades)

94. P + S + V

The bottom layer is built up as follows:
W Z Z R R
W Z R R U
Z Z X R U

101. Days of the Week

This is John Conway’s Calendar Theorem.
He terms the last day of February Doomsday for the year, because it settles the fate of the whole year.
The days asked for here, in 2009, are Tue, Fri, Mon, Thu, Sun, Wed, Sat

Gyroscope

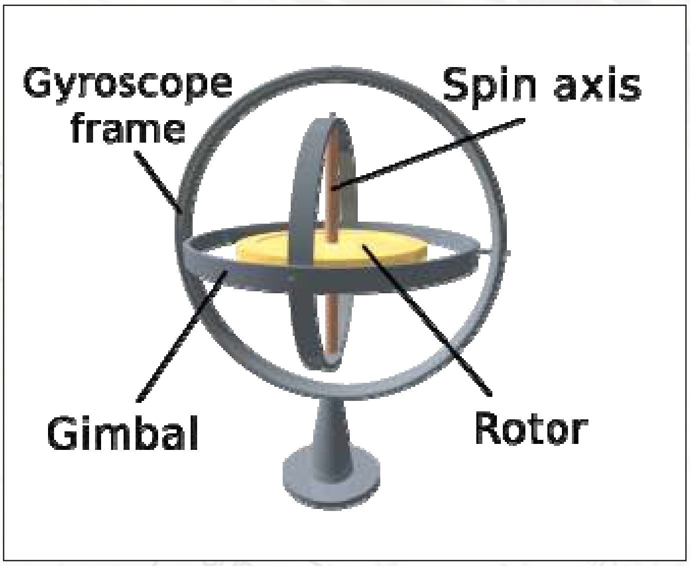
What is it?

Anything which is spinning around an axis can be considered to be a gyroscope – for example, a ball spinning on your finger or the earth spinning on its axis are both gyroscopes.

One of the simplest examples would be a disk spinning around a rod. Sometimes the spinning disk is held by gimbals which allow the axis to move freely in different directions.

What is special about gyroscopes is that they like to maintain the way that they are spinning. Try and balance a ball on your finger and it will fall off. Spin a ball on your finger (if you are well practised enough) and you will find that it will stay there without falling off.

Gyroscopes are really useful in aircraft because they stay spinning the same way up, even when the aircraft moves. A gyroscope can be set spinning in line with the North Pole and be used as a navigational device.



Why does it work?

Gyroscopes like to stay spinning about the same axis, due to the law of conservation of angular momentum. Momentum is what you get if you multiply the mass of an object by how quickly it is moving, so a flying arrow has a lot because it is moving very fast, and a double decker bus has a lot because it is very heavy. Angular momentum is momentum in a circle - an object spinning on the spot still has momentum, even though it isn't moving anywhere.

Conservation of angular momentum basically means that a force needs to be applied in order for the axis of spin to change. If nothing happens, the gyroscope will keep spinning the same way.

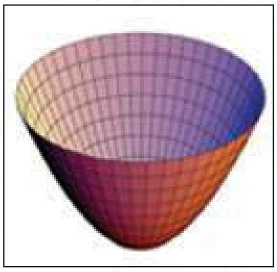
Lots of the weird behaviour of gyroscopes is down to what is called precession. Imagine you are looking from above at a gyroscope (in this case a simple disk which is spinning around a rod). Now gently push it in a northerly direction, the gyroscope will then move, not in a northerly direction as expected, but in an easterly direction. This is because when you apply a force to a gyroscope, it will move at 90° both to the axis of spin and the direction the force was applied in.

a more precise mathematical explanation can be found in many advanced mechanics textbooks.

Mirascope

What is it?

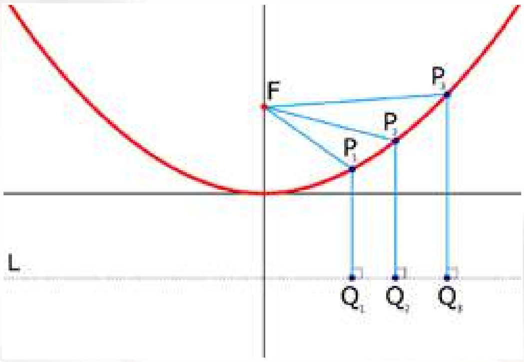
The mirascope is made of two parabolic mirrors stuck together with a hole in the top. When an object is put in the bottom of the mirascope, a floating 3D holographic image of the object appears in the hole. You will want to touch it, but your fingers will pass straight through it.



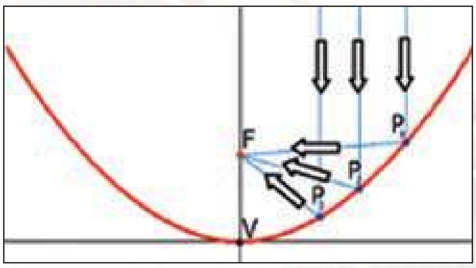
Why does it work?

A parabolic mirror is in the shape of a paraboloid of revolution: a surface obtained by revolving a parabola around its axis. A parabola is another name for the graph of a quadratic equation.

Parabolas have some special properties – for a parabola there is a point F (called the focus) and a line L (called the directrix) where every point on the parabola is equidistant from F and L.



There is also the property that light rays travelling downwards, parallel to the y axis will reflect from the parabola towards the focus F.



This is why parabolic mirrors or reflectors have lots of different uses, for instance they are used in satellites to increase the strength of a signal by focusing it towards one point. A parabolic mirror has even been used at the Olympics to focus sunlight and light the Olympic torch.

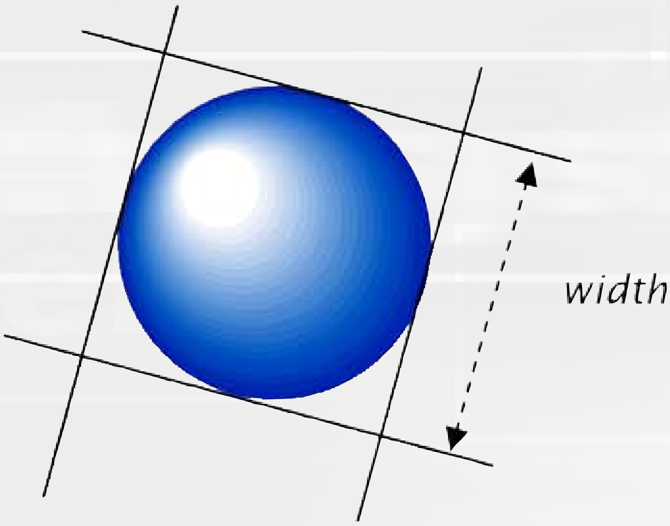
In a mirascope a similar effect is happening, light rays are bouncing off the object and being reflected in two parabolic mirrors, focusing on a different location from where the object is actually placed. This results in the reflected image of the object at the bottom of the mirascope appearing to be in the hole at the top.

Solids of Constant Width

What are they?

The width of a shape is the distance between parallel tangents which touch the shape. If a shape has constant width then this means that the distance between parallel tangents is the same all the way round.

A sphere is an obvious solid of constant width.



There are however many other solids of constant width which have surprising shapes. If you run a book over the top of these solids of constant width then it will roll smoothly, with the book staying a constant height above the table, as though there are spheres underneath.

Examples of 2D shapes of constant width are 20p and 50p pieces, where their constant width means that the coin's diameter can be consistently measured in vending machines and slot machines.

How can I find out more?

have a look at www.howround.com

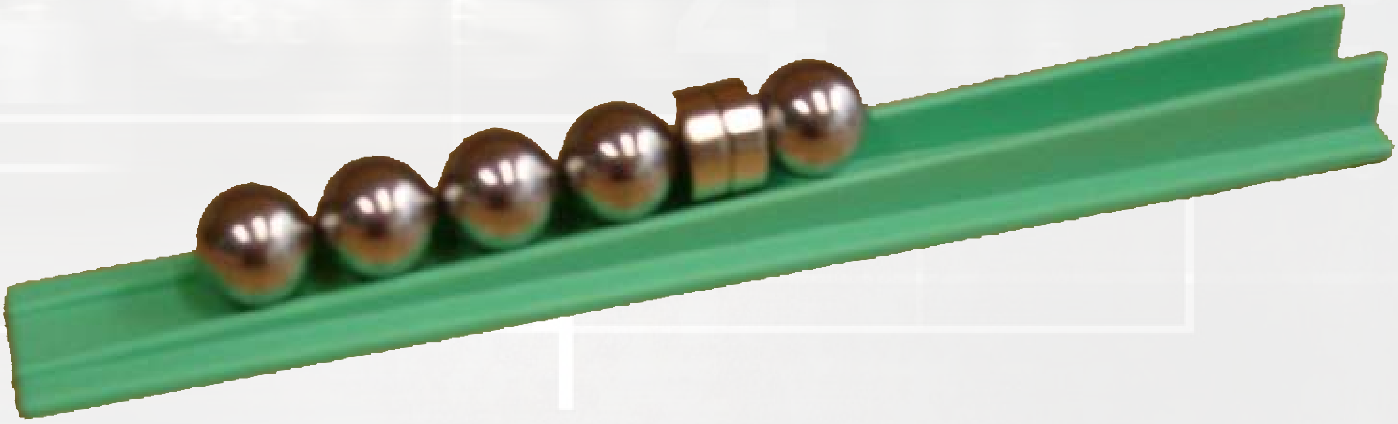
The book 'How round is your circle?' by John Bryant and Chris Sangwin is a good read for the more mature reader.

Gaussian Gun

What is it?

The Gaussian gun consists of five steel balls, a pair of neodymium magnets and a track for them to sit in.

Four of the steel balls are attached to the magnets and the fifth steel ball is allowed to gently roll towards the magnet. As the rolling ball gathers speed and hits the magnet, the ball furthest away shoots off at a surprisingly high speed.



Why does it work?

The neodymium magnets are very strong. Their attraction causes the steel ball to speed up, so that by the time that it hits the magnets, it is travelling quite fast.

The law of conservation of momentum states that:

If objects collide, the total momentum before the collision is the same as the total momentum after the collision (provided that no external forces, such as friction, act on the system).

As the ball hits the magnet and sticks, most of its momentum is transferred to the ball which is furthest away, leading to that ball firing off at a high speed.

How can I find out more?

There are lots of good videos on YouTube showing variations on the Gaussian gun.

Health warning!

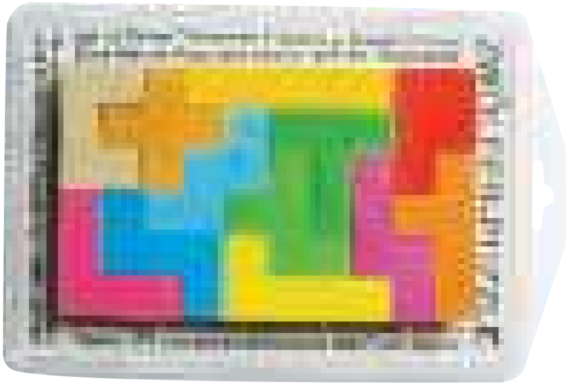
Strong magnets can be dangerous – read the product warning carefully if you purchase any.

Giant Playing Cards

These will be useful to use with the Manual of Mathematical Magic.
Even bigger cards (e.g. A4 sized) are available to purchase from the Internet and can be fun to use when demonstrating mathematical magic tricks.

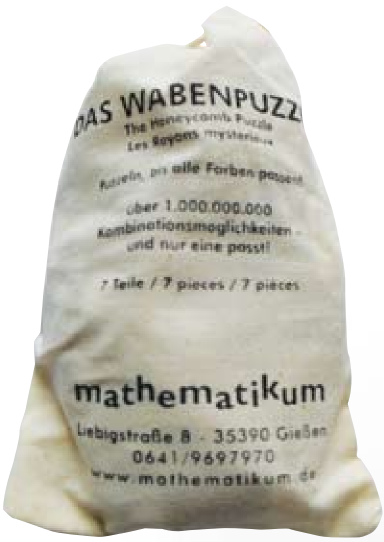
Five Puzzles

These are five puzzles which will test pupil's skills of logic and spatial reasoning.
Opposite are the answers which may be useful to give to any helpers who work with these puzzles.



Puzzle 1 - 3D Pentominos

Puzzle 2 - Addition



Puzzle 3 - Hexagon

Puzzle 4 - Pyramid

Puzzle 5 - Soma cube

Answers - Five Puzzles

Puzzle 1 - 3D Pentominos

Different solutions depending on date

Puzzle 2 - Addition puzzle

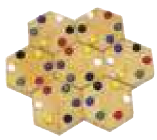
Here are three possible solutions, there may be more:

123-45-67+89 = 100

1+2+34-5+67-8+9=100

123-4-5-6-7+8-9=100

Puzzle 3 - Hexagon puzzle



Puzzle 4 - Pyramid Puzzle

Hint: The square side of a piece touches the square side of another piece.

Puzzle 5 - Soma Cube

Hard to give hints on solving this puzzle as there are 240 possible distinct solutions.

If you get fed up, then you could always look at the box.

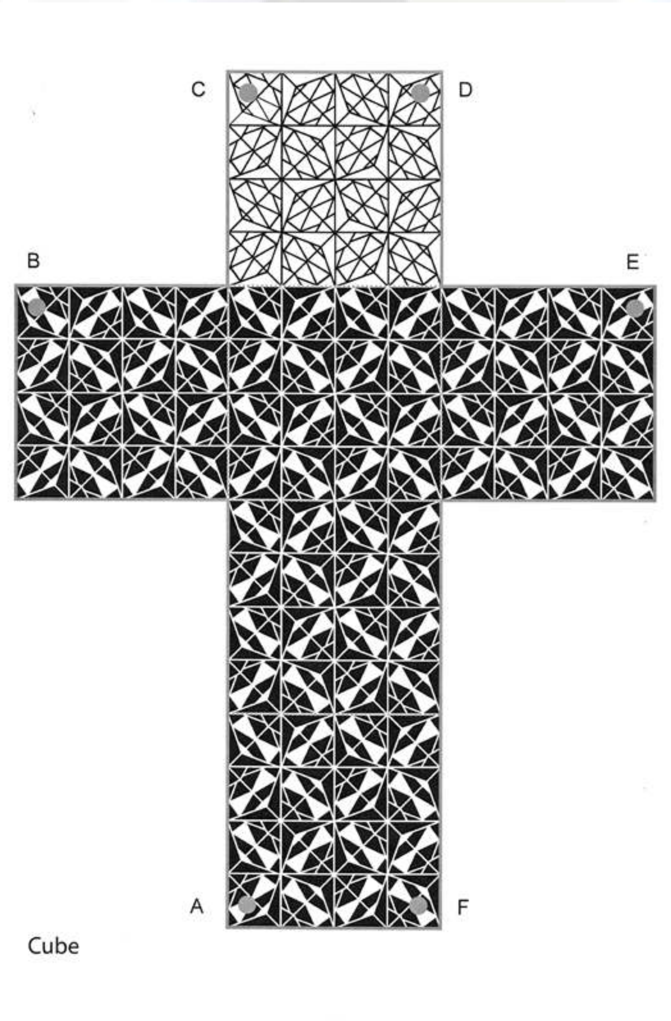
Pull Up Nets

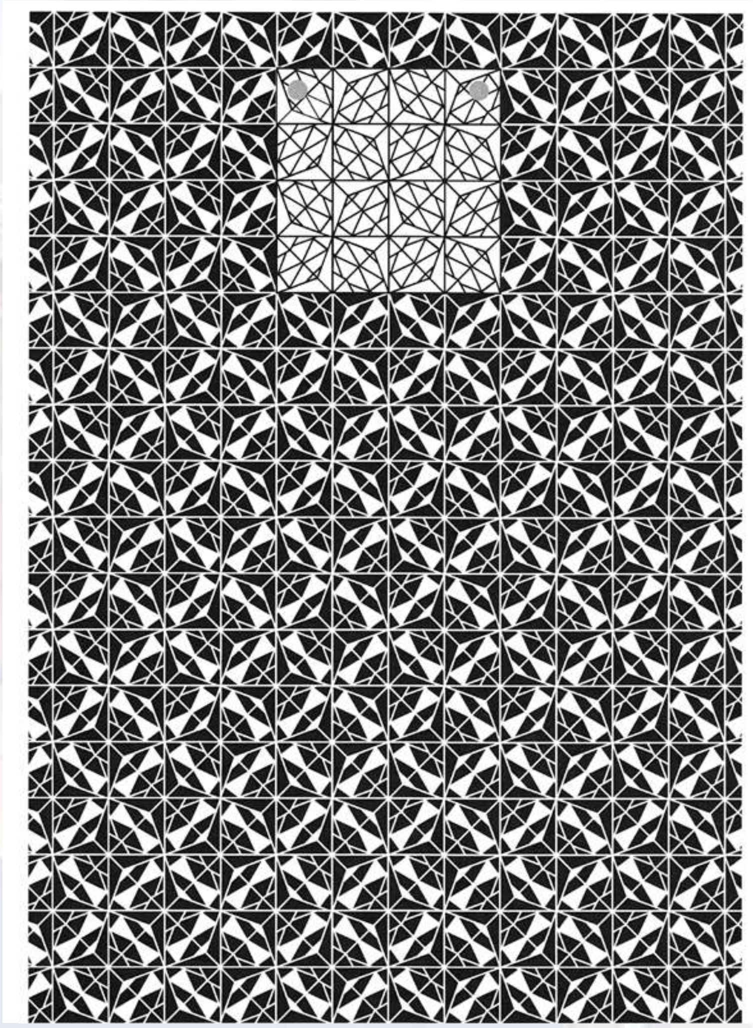
This activity allows pupils to create their own platonic solids which can be pulled up from flat nets with a tug of string.

They were first developed by Liz Meenan from the University of Leeds who then collaborated with Dr Briony Thomas who designed the attractive patterns which adorn the nets.

The Small Maths Outreach Kit contains one complete set of nets, ready photocopied onto coloured card.

To create more, photocopy the black and white master copies onto coloured card.





You will need single hole punches, scissors and string for this activity.

Basic instructions:

1. Cut out the net for your pull-up polyhedron.

2. Use a ruler and sharp point to score lightly along the faint grey dotted lines.

3. Make holes at the points A,B,C,D, etc.

4. Stick the light coloured polygon of the net onto the associated light coloured polygon on the A4 backing card with the same pattern.

5. Punch the two remaining holes in the backing card.

6. Thread and weave thin string through the holes A,B,C,D, etc, in that order to link the polygons together.

7. Gently pull up the net to make your polyhedron sit on the backing card.

- When you think you've got the hang of it, try creating your own nets for pull-up polyhedra.

- Are there other ways you could make a cube, or some of the other polyhedra?

The Teleporting Robot:

The one where the robot disappears before your eyes

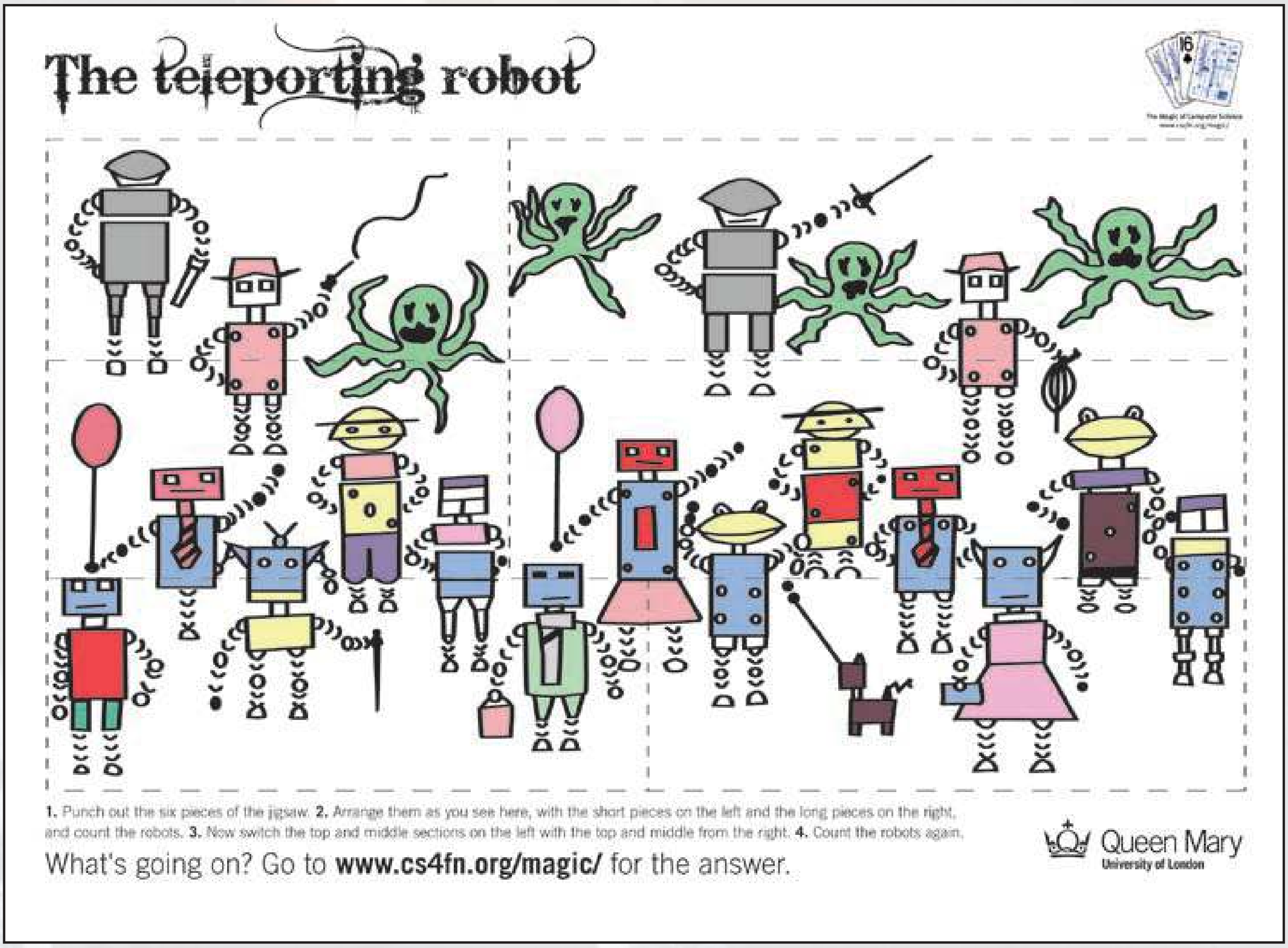
Description taken from www.cs4fn.org/magic/teleportingrobot.php

The magic effect

You introduce a simple jigsaw showing 17 robots (together with a few marauding Hexapi monsters). You collect the six pieces of the jigsaw in your cupped hands and concentrate. Your mind power will send one of the robots into another dimension, teleporting it to a distant unseen location. To prove your psychic blast has in fact done what you say, you reassemble the jigsaw. You and the spectators count the robots again. As you reach the higher numbers the amazement spreads through your audience. It's the same jigsaw as before but only 16 robots remain. Number 17 has vanished leaving no trace!

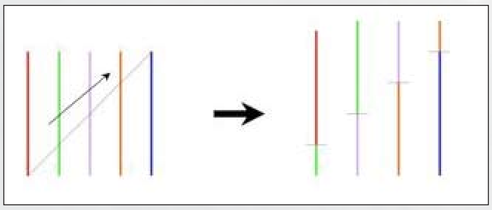
The mechanics

This amazing effect works through a combination of geometry and an error in the way people see. Look at the complete jigsaw. There are clearly 17 robots. Cut out the pieces. You are now going to rearrange them in a different order. The bottom two pieces go together as they did in the original, but you swap the position of the top two and middle two bits. What were originally the top left pieces are now top right and vice versa. Look at this new jigsaw. Count the robots. There are only 16 now. You've fooled yourself!



Prove it works!

Error!!! Can't Compute! Who needs more proof! It disappeared before your eyes! Where did number 17 go? How can just swapping the top two pieces make a whole robot vanish? The secret is called distributed concealment.



Look at the picture of coloured lines on the right. There are five vertical lines. Now imagine you cut those lines on a diagonal and slide the resulting top triangle along by one line space, the result is 4 lines. Where did the extra line go? It can't just have vanished can it? No, what's happened is that the remaining lines are all a little bit longer. We've made it really obvious here by only using a few lines. The more lines the harder it is to spot. Bits of the missing line have been added to each of the remaining lines. The 'vanish' is caused by spreading parts of the vanished object over lots of different locations. That's what distributed concealment is about. Why don't we spot it? Well, people aren't that good at accurately judging lengths by eye. The remaining lines look 'about the same' as before. About, yes, but the same, no! That's why we invented rulers!

Creating the vanishing robot jigsaw

The jigsaw is based on the above simple geometric vanish. The 16 robots left are all just that little bit longer and we make the mistake of not noticing this. Bits of each have been recycled into others to create a series of new, larger robots. Each loses a small bit (a part of a head say) and gains a bigger new version (a bigger head bit from someone else).

The jigsaw design is more cunning than the lines though. Rather than just having the robots in order, where a simple slide of the top section would make the remaining robots taller, the jigsaw design cleverly weaves the geometric vanish into different parts of the picture. We've used an extra layer of concealment, another way to throw the audience. The top two pieces throw in yet more confusion - those top four robots move around, but do not otherwise change.

All you have to do is correctly assemble the jigsaw in the first instance to show 13. Then, after you have collected the pieces, reassemble it in the order that shows only 12. Your spectators wont remember the exact order. Note to make it easier there are tiny dots on the top two pieces, join the dots together for the first 13 robot picture, and then keep them apart for the 12 robot finale. Like the changes in size the small dots wont be noticed!

The showmanship

Build a patter about how we are going to have to keep an eye on the robots. As with WALL-E they have a tendency to disappear on their own little excursions, once they start to develop minds of their own. Alternatively, you can worry about whether a Hexapus has eaten it...or did it teleport in time.

Play up the count - make your audience count the robots out loud, one by one with you. Do it both before and after reassembly! You could even write the resulting number 17 on a board where all can see and so no one can accuse you later of trickery.

You can then give your audience a bit of your magic to take away at the end as a reminder of your show, and of the Magic of Computer Science!

Tippe Top

What is it?

The tippe top is a kind of top which will flip over and spin on its stem when spun at a high speed. This seems to be against common sense, as we expect an object to want to keep its centre of gravity low.

Why does it work?

The tippe top has fascinated many mathematicians and its behaviour has even been the subject of a university thesis.

However, in simple terms, what causes the tippe top to turn upside down is a turning force or torque caused by sliding friction between the tippe top and the table. This friction decreases the kinetic energy of the top (slows it down), but the potential energy of the top is increased as the top raises its body, so the total energy does not actually increase.

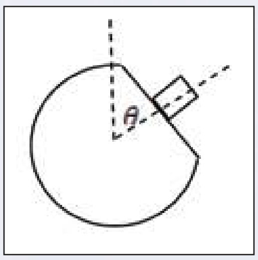
Mathematical explanation (Challenging!)

As with most physical models, we can simplify how we model the behaviour. (You will need to know A level maths to understand the following explanation.)

The technique which we will use is called dimensional analysis – this technique relies on the fact that in any equation, both sides must have the same dimensions (and units).

The dimension of a physical quantity is the combination of the basic physical dimensions (usually mass, length, time, electric charge, and temperature).

Look at the following diagram.



We want to know how θ changes with time, i.e. when does the tippe top tip up? We want to know $\frac{d\theta}{dt}$ which has dimension T^{-1} where T is time.

The table on the next page shows the relevant variables in the tippe top problem, it also shows their dimensions.

Relevant variables	**Representing the relevant variables**	**Dimension of the relevant variables (L = unit length M= unit mass T = unit time)**
Friction	μmg (Standard formula for maximum frictional force)	Friction is a force and Force = Mass × Acceleration. The dimension of Mass × Acceleration is $\boldsymbol{MLT^{-2}}$ (think about acceleration often being measured in metres per second squared)
Mass of tippe top	m	$\boldsymbol{M}$
Radius of tippe top	r	$\boldsymbol{L}$
Spin (angular velocity)	ω	$\boldsymbol{T^{-1}}$

We can find the equation which expresses $\frac{d\theta}{dt}$ in terms of the relevant variables above by comparing dimensions.

	Left Hand side of the equation	Right Hand Side of the equation
	$\frac{d\theta}{dt}$	Some combination of μmg , m , r , ω
Dimensions	$\boldsymbol{T^{-1}}$	Some combination of $\boldsymbol{MLT^{-2}, M, L, T^{-1}}$

It turns out that the easiest way for the right hand side of the equation to have dimension $\boldsymbol{T^{-1}}$ is to have the following relationship:

$\frac{d\theta}{dt} \approx \frac{\mu mg}{mr\omega}$ this would result in the dimensions of both sides of the equation being consistent: $\boldsymbol{T^{-1}} = \frac{\boldsymbol{MLT^{-2}}}{\boldsymbol{MLT^{-1}}}$

Remember that μ the coefficient of friction is dimensionless. However, dimensional analysis doesn't tell us if there is another constant present on the right hand side of the equation, but luckily in our case it is close to one. We want to know at what time the angle θ has changed by 180° or π radians, as this will let us know when the top has flipped over a full 180°.

Using our expression for $\frac{d\theta}{dt}$, the time at which this happens is given by $\frac{\pi r\omega}{\mu g}$.
We can make some estimates for our quantities
(these estimates are based on real life observations.): $r \approx 0.02m$, $g \approx 10m/sec^2$, $\mu \approx \frac{1}{2}$.

ω is the angular spin which is the number of turns per second times 2π, the angle swept out. We can make an estimate that the number of turns per second to be around 25.

Plugging these numbers into $\frac{\pi r\omega}{\mu g}$ we get $\frac{\pi \text{ x } 0.02 \text{ x } 25 \text{ x } 2\pi}{\frac{1}{2} \text{ x} 10} = \frac{\pi^2}{5} \approx$ 2 seconds

If you observe the tippe top you will find that it does indeed flip over after about two seconds.

This way of analysing the tippe top was seen in the LMS public lecture "Toy Models" by Tadashi Tokieda. You can purchase this on DVD from http://www.lms.ac.uk/content/popular-lectures-dvds

Rattleback

What is it?

A rattleback (sometimes known as a Celt) is an object which only likes to be spun in a preferred direction. When you spin it the opposite way it will rattle, stop and reverse direction.

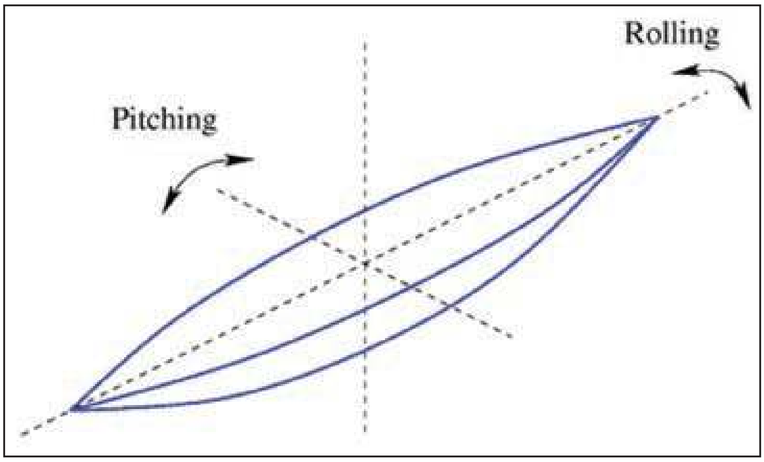
Rattlebacks have been discovered in Celtic and Egyptian burial sites and are now sold as toys.

Why does it work?

Mathematicians started to study the rattleback in the 19th century and have been writing papers about it ever since. When you first study the rattleback, it appears to go against the law of conservation of angular momentum, as it stops and reverses direction.

However if you look carefully at the rattleback you will see that it is asymmetric and it is this asymmetry which causes the interesting motion.

Mathematicians have discovered that the rattleback exhibits three main types of behaviour: spinning, pitching and rolling. Pitching is wobbling backwards and forwards, rolling is wobbling side to side. It has been discovered that when the rattleback moves, energy is shared periodically between the rolling, pitching and spinning motions.



If you start spinning the rattleback, say clockwise, it will start pitching and then this pitching motion will cause it to start spinning anti-clockwise. It will then start rolling; however, this is a weaker effect, so most rattlebacks will only reverse direction once. However, without friction the rattleback would keep reversing direction and there are some very precisely manufactured rattlebacks which can change direction more than once.

Manual of Mathematical Magic

Mathematics and magic may seem a strange combination, but many of the most powerful magical effects performed today have a mathematical basis.

The Manual of Mathematical Magic is a unique kit of magical miracles to impress and entertain your friends. The secrets behind street magic, close-up and stage tricks are explained clearly with instructions on how to perform them perfectly. Then you can also learn about the mathematical basis of the trick and how that same mathematics is instrumental in our modern world.

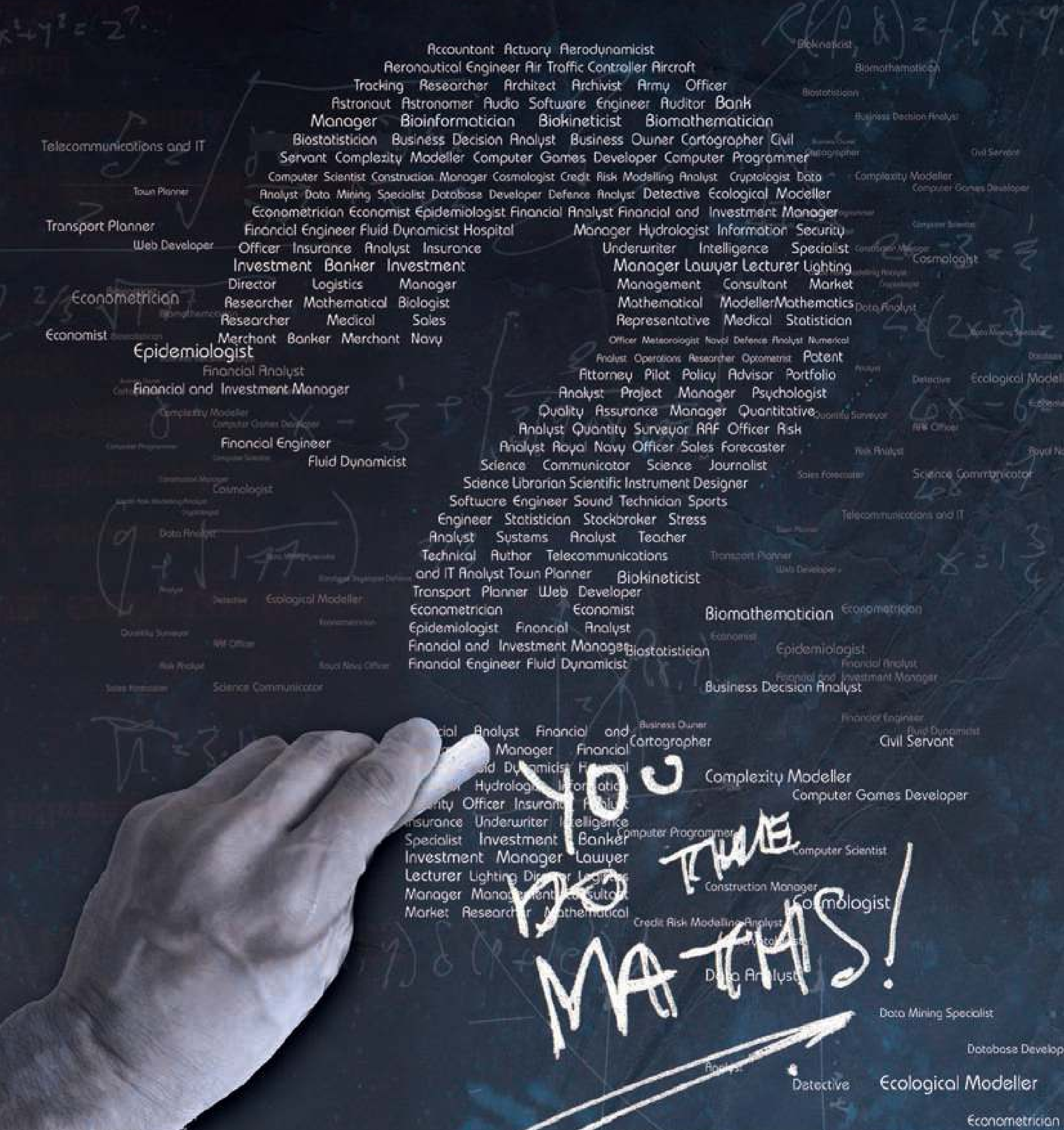
The Manual of Mathematical Magic is written by Professor Peter McOwan and Matt Parker from Queen Mary, University of London. For further information go to: www.mathematicalmagic.com

Where can I buy more of the items?

The best way to obtain most of the items is by doing an Internet search for the best price. However some of the more specialist items are more difficult to track down so we have written below where we purchased each item.

	Item	Where it was purchased or obtained for this kit
1.	Euler's Disk	www.grand-illusions.com
2.	FunMaths Roadshow Sample Activities	The CD can be purchased from www.maths.liv.ac.uk/lms/funmaths/
3.	Soma Cube	Plain wooden soma cubes are easy to find, however this coloured one came from www.friedrich-verlag.de/ in Germany.
4.	Pyramid Puzzle	www.happypuzzle.co.uk
5.	Gyroscope	www.gyroscope.com
6.	Giant Playing Cards	Various Internet sources
7.	Hexagon Puzzle	Can be found on ebay, but we bought ours from the Mathematikum museum shop in Germany. (They will ship abroad) www.mathematikum.de/
8.	Mirascope	www.grasshoppertoys.co.uk/ (trading on Amazon)
9.	Solids of Constant Width	These were kindly donated by Dr Chris Sangwin from the University of Birmingham. Some solids of constant width are available commercially, e.g. from www.grand-illusions.com
10.	Gaussian Gun	www.grand-illusions.com
11.	Pentominoes	Plain wooden pentominoes or 2D pentominoes are easy to find, however this coloured set came from the Mathematikum museum shop in Germany. (They will ship abroad) www.mathematikum.de/
12.	Five Puzzles	Feel free to photocopy the puzzles in this kit.
13.	Pull Up Nets	Feel free to photocopy the black and white master versions, for use in events with young people. (Please acknowledge Liz Meenan and Dr Briony Thomas where possible.)
14.	Teleporting Robots	It is possible to download more copies at: www.cs4fn.org/magic/teleportingrobot.php (The card versions were kindly donated by the Computer Science for Fun (cs4fn) project.
15.	Tippe Top	www.gyroscope.com
16.	Rattleback	Bought from American ebay, as English stockists didn't have any plastic ones available. This may of course change. A wooden one is available from www.grand-illusions.com
17.	Manual of Mathematical Magic	Free downloads of some of the material are available from: www.mathematicalmagic.com

Which subject at degree level gives you access to a thousand different careers?



Visit www.mathscareers.org.uk for more exciting information!

Welcome to the Small Maths Outreach Kit: Contents

1. Euler's Disk
2. FunMaths Roadshow Sample Activities
3. Soma Cube (to be used with item No. 12)
4. Pyramid Puzzle (to be used with item No. 12)
5. Gyroscope
6. Giant Playing Cards
7. Hexagon Puzzle (to be used with item No. 12)
8. Mirascope
9. Solids of Constant Width
10. Gaussian Gun
11. Pentominoes (to be used with items No. 12 & No. 2)
12. Five Puzzles
13. Pull Up Nets
14. The Teleporting Robot Puzzle
15. Tippe Top
16. Rattleback
17. Manual of Mathematical Magic
18. Small Maths Outreach Kit Information Booklet

Re-order: sales@highfieldconcepts.co.uk