Monthly Maths

MEI Innovators in Mathematics Education

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Emil Artin
1898 - 1962

Emil Artin was one of the leading mathematicians of the 20th century and a major contributor to linear algebra and abstract algebra. He made contributions to number theory, group theory, ring theory, field theory, Galois theory, geometric algebra, algebraic topology, and the theory of braids - a field he invented.

Artin served in the Austrian army during WW1, before receiving a Ph.D from the University of Leipzig in 1921. He was a professor at the University of Hamburg until 1937, before emigrating to America until 1958. Artin received the American Mathematical Society's Cole Prize in number theory.

Artin also solved one of the 23 famous problems posed by the eminent mathematician David Hilbert in in 1900. Besides mathematics, Artin had a deep interest in chemistry, astronomy, biology, and music. He died of a heart attack at the age of 64, in 1962.

May Day

Traditionally, the Maypole Dance is a dance performed in celebration of May Day, the first day of May.

The maypole has an even number of ribbons, the same number as there are dancers. The height of the pole depends to a certain extent on the height of the dancers and the number of dancers.

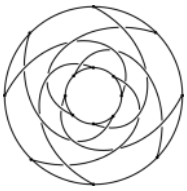
The dancers are divided into two groups, e.g. A and B, with A's moving clockwise and B's counterclockwise. The dancers move alternately right and left of the dancers going in the opposite direction.

One of the main patterns that the dancers move to is: over, under, over, under, over, under etc. On the count of "over", the dancer raises his ribbon slightly so the dancer coming in the opposite direction can duck under his ribbon. On the count of "under" the dancer ducks under the ribbon of the dancer coming in the opposite direction.

YouTube View videos **here** and **here**.

As this is happening the ribbons wind around the pole, making a decorative braided pattern.

Braid theory



Looked at from above, the dancers form a pattern with their ribbons, represented here on an annulus, which is topologically the same as a cylinder. You can read more about how braid theory relates to maypole dancing in the **Division by Zero** blog **here**.

Braids can be found in many places in everyday life, e.g. jewellery and hairdressing. Braids are studied also as mathematical objects, because their mathematical structure is very rich and deep.

In topology, braid theory is an abstract geometric theory studying the everyday braid concept, and some generalisations. Braids can be organised into groups, in which the group operation is 'do the first braid on a set of strings, and then follow it with a second on the twisted strings'. Such groups may be described by explicit presentations, as shown by Emil Artin (left).

MEI Maths Item of the Month

Braid Theory

Joan Birman

1927 -

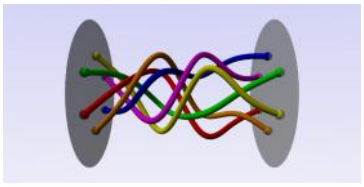
Joan Birman is an American mathematician, specialising in braid theory and knot theory.

She received a BA in 1948 in mathematics from Barnard College and an MA in 1950 from Columbia University. After receiving her Ph.D. in 1968 from New York University, she took up a position at the Stevens Institute of Technology.

In 1973, she joined Barnard College, Columbia University, where she is currently Research Professor Emerita. Birman has also been a Sloan Foundation Fellow and a Guggenheim Foundation Fellow.

In topology, braid theory is an abstract geometric theory studying the everyday braid concept, and some generalisations. Braids can be organised into groups, in which the group operation is 'do the first braid on a set of strings, and then follow it with a second on the twisted strings'. Such groups may be described by explicit presentations, as shown by Artin in 1925.

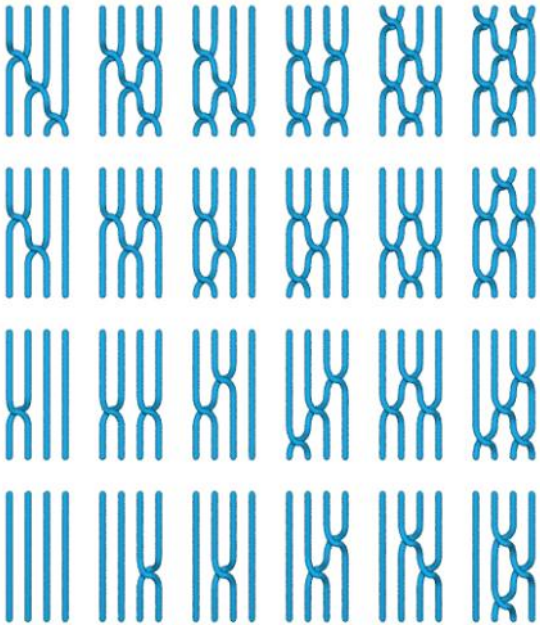
'A first definition of a braid is a collection of strands between two parallel discs. Braids are considered the same if they can be deformed into each other without cutting the strands and keeping the endpoints fixed (braid isotopy).' (Dalvit)



'Braids. A movie' shows a journey through the mathematical theory of braids. This film has been produced by Ester Dalvit as part of her PhD thesis at the University of Trento and is being distributed under a Creative Commons license.

The film is divided into four chapters, each of about 15 minutes. The first contains the basic concepts: the formalization of braids and the group structure on the set of braids. The second chapter deals with the word problem: when do two words represent the same braid? In the third chapter knots are presented and put in relation with braids. The last chapter describes braids as dances, that is motion of points in the disc.

You can download the film and a trailer **here.** Unfortunately, the trailer has no audio, but does illustrate clearly how braid theory relates to the Maypole dance.



This image is a file from the **Wikimedia Commons**. It shows the 24 elements of a permutation group on 4 elements as braids. Note that all crossings shown are of the left -over-right sort and other choices are possible. Indeed, the braid group on two or more strands is infinite.

Wolfram MathWorld has a good introduction to braid groups **here**, and Wikipedia has some good diagrams and descriptions of braids **here** and information about braid theory **here**. PlanetMath has a page about braid groups **here**. A MegaMath class activity is available **here**.

Birman has many professional memberships, including the American Academy of Arts and Sciences, European Academy of Sciences, American Mathematical Society, Mathematical Association of America, and American Women in Mathematics. She is also a member of the Human Rights Committee, New York Academy of Sciences.

Birman's research Interests are knots, braids, 3-manifolds, mapping class groups of surfaces; related topics in geometric group theory, algorithms, contact geometry, and dynamical systems. Her book *Braids, Links, and Mapping Class Groups* has become a standard introduction, with many of today's researchers having learned the subject through it. Her publications can be downloaded **here**.

Mayday!

Many people believe SOS stands for 'Save Our Ship,' 'Save Our Souls,' 'Stop Other Signals.' Actually, the letters have no significance whatever. The first distress call used by the early Marconi Company was CQD, CQ being the general call to alert other ships that a message is coming and D standing for 'danger' or 'distress.'

For various technical reasons this proved unsatisfactory and in 1908, by international agreement, a signal made up of three ‘dits’, three ‘dahs’ and three ‘dits’ was adopted as the one most easily transmitted and understood. The easy-to-remember dashes and dots coincidentally spell out ‘SOS’.

Mayday distress signals

Mayday is an emergency procedure word used internationally as a distress signal in voice procedure radio communications. It is used to signal a life-threatening emergency primarily by mariners and aviators but in some countries local organisations such as police forces, fire-fighters, and transportation organisations may also use the term. The call is always given three times in a row ("Mayday Mayday Mayday") to prevent mistaking it for some similar-sounding phrase under noisy conditions.

The Mayday call sign was originated in 1923 by Frederick Stanley Mockford, a senior radio officer at Croydon Airport in London. Mockford was asked to think of a word that would indicate distress and would easily be understood by all pilots and ground staff in an emergency. Since much of the traffic at the time was between Croydon and Le Bourget Airport in Paris, he proposed the word "Mayday" from the French *m’aider*. "Venez m'aider" means "come help me."

Pan-pan

In radiotelephone communications, a call of three repetitions of **pan-pan** is used to signify that there is an urgency on board a boat, ship, aircraft or other vehicle but that, for the time being at least, there is no immediate danger to anyone's life or to the vessel itself. This is referred to as a state of urgency.

This is distinct from a Mayday call, which means that there is imminent danger to life or to the continued viability of the vessel itself. Thus "pan-pan" informs potential rescuers (including emergency services and other craft in the area) that a safety problem exists whereas "Mayday" will call upon them to drop all other activities and immediately initiate a rescue attempt.

In addition to distress signals like **Mayday** and **pan-pan**, most vessels, especially passenger ships, use some emergency signals to internally alert the crew on board, and in some cases also the passengers. These can be in form of blasts on alarm bells, sounding the ship's whistle or code names paged over the PA system.

Here are some other emergency signals:

- **Mr. Skylight** paged over the PA system is an alert for the crew on board and means there is a minor emergency somewhere.
- **Mr. Mob** means man overboard. Man overboard can also be signaled with three prolonged blasts on the ship's whistle and general alarm bell (Morse code "Oscar").
- **Code Blue** usually means a medical emergency.
- **Assemble at Muster Stations** or **Abandon Ship**, seven or more short blasts on the ship's whistle and general alarm, followed by one long blast.
- **Fire and emergency**, continuous ringing of the general alarm bell for ten seconds and a continuous sounding of the ship's whistle for ten seconds.
- **Bravo, Bravo, Bravo**, used by many cruise lines to alert crew to a fire or other serious incident on board without alarming passengers.

Morse Code

View a video about the invention of the Morse Code **here**.

Listen to the Morse code song **here** (strangely catchy!)

Learn 0 to 9 in Morse code **here**.

Learn Morse code in one minute (or so it claims!) **here**.

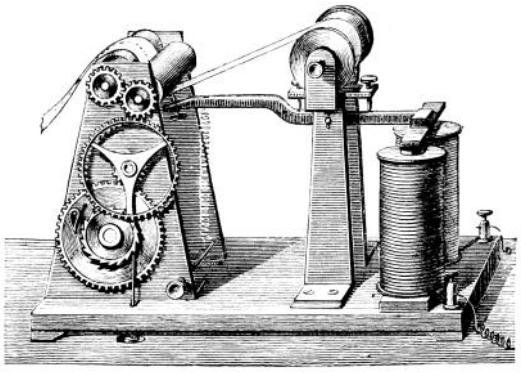
Science Notebook helps you learn both Morse code and tap code (used by American prisoners of war during the Viet Nam War to communicate with one another inside POW camps when talking was not allowed). Read more **here**.

A Morse code encoder is available **here**.

Morse code

The use of the SOS signal was first introduced in Germany in 1905 as part of a set of national radio regulations, which introduced three new Morse code sequences, including the SOS distress signal. Morse code is a method of transmitting textual information as a series of on-off tones, lights, or clicks that can be directly understood by a skilled listener or observer without special equipment.

It took American inventor Samuel Morse three years to develop the telegraph. His first device, built in 1835, was an electromagnetic pendulum that carried a pencil in constant contact with a moving strip of paper. Morse's partner Alfred Vail, came up with the idea of a lever at the transmitting end, while operating a armature at the other. They then had to take these two inventions and find a way to convert the opening and closing of the lever into numbers and letters.



They used pulses of current to deflect an electromagnet, which moved a marker to produce written codes on a strip of paper - the invention of Morse Code. The following year, the device was modified to emboss the paper with dots and dashes.

The International Morse Code encodes the basic Latin alphabet, some extra Latin letters, the Arabic numerals and a small set of punctuation and procedural signals as standardised sequences of short and long signals called "dots" and "dashes" respectively, or "dits" and "dahs". Morse's original code was not quite the same as the one in use today as it included pauses as well as dahs and dits.

A	● ▬	U	● ● ▬
B	▬ ● ● ●	V	● ● ● ▬
C	▬ ● ▬ ●	W	● ▬ ▬
D	▬ ● ●	X	▬ ● ● ▬
E	●	Y	▬ ● ▬ ▬
F	● ● ▬ ●	Z	▬ ▬ ● ●
G	▬ ▬ ●		
H	● ● ● ●		
I	● ●		
J	● ▬ ▬ ▬		
K	▬ ● ▬	1	● ▬ ▬ ▬ ▬
L	● ▬ ● ●	2	● ● ▬ ▬ ▬
M	▬ ▬	3	● ● ● ▬ ▬
N	▬ ●	4	● ● ● ● ▬
O	▬ ▬ ▬	5	● ● ● ● ●
P	● ▬ ▬ ●	6	▬ ● ● ● ●
Q	▬ ▬ ● ▬	7	▬ ▬ ● ● ●
R	● ▬ ●	8	▬ ▬ ▬ ● ●
S	● ● ●	9	▬ ▬ ▬ ▬ ●
T	▬	0	▬ ▬ ▬ ▬ ▬

A dit takes - 1 unit of time
A dah takes - 3 units of time
The pause between letters - 3 units of time
The pause between words - 7 units of time

Because many non-English natural languages use more than the 26 Roman letters, extensions to the Morse alphabet exist for those languages. Read more **here**. Since December 2003, Morse Code has included the @ symbol: it is a combination of a and c: • - - •-• and is the first change to the system since before World War II.

KS2-5 information about Morse code is available from nrich **here**. You can download a Morse code font for Windows **here**. There are KS3 activities **here**.

The Plymouth University based Centre for Innovation in Mathematics (CIMT) provides teachers' resources **here** and **here**.

Codes and cryptograms

The Institution of Engineering and Technology (IET) takes a look at the history of code-breaking and how this became so important during World War II. Read more **here**.

There is also an article about Morse's visions of submarine telegraphy **here**.

The US National Security Agency has an interactive website called CryptoKids, for 'future codemakers and codebreakers'. The site has several examples of different sorts of codes. Read more **here**.

Codes & Ciphers Maths Resources for Teachers have been developed by **CIMT** (Centre for Innovation in Mathematics Teaching), in collaboration with **Bletchley Park National Codes Centre.** View **here**.

Code breaking Y9 class activities

A PowerPoint introduction, with worksheets and solutions, uses logic and frequency analysis to read and write in code. These activities have been developed by two Maths practitioners (Danny Hoskin and Darren Farman) at Lynn Grove High School in Gorleston, Norfolk. The tasks are open ended and can be adapted to give each pupil a feeling of achievement no matter what their level of Mathematics is. Read more **here**

There are other resources on the Functionalmathematics.co.uk website, including an Excel file that randomly creates a selection of numeracy starters: download **here**.

If you use these resources, please take some time to send Danny and Darren your feedback to help them to improve the unit: contact them **here**

Cryptography Supersleuth KS3 activities

A whole-lesson activity which consists of a series of cryptographic challenges including Caesar Ciphers, simple substitution ciphers, Morse code and combinations of them. The clues will require adaptation to your individual department, but the structure can be maintained. Students work in teams to learn how cryptography works and to solve some cryptograms as quickly as possible.

Read more **here**.
(You need to be registered with TES Resources to download the resources).

The Enigma Project

Part of the family of activities in the **Millennium Mathematics Project, this** was originally set up in 2002 by the science writer and broadcaster, Simon Singh (author of the best-selling 'Fermat's Last Theorem', 'The Code Book' and 'The Big Bang').

'The Enigma Project aims to get as many young people interested in maths, science and history as possible through the delivery of hands-on code breaking workshops in schools, museums and other educational establishments throughout the UK. Code making and breaking promotes problem solving skills and logical reasoning.'
Read more **here**.

On Simon Singh's **website** there is an extensive section on cryptography: **here**.

This includes cryptograms divided into three categories, which increase in difficulty: read more **here**.

The interactive CD-ROM version of Simon's 'The Code Book' is available to download free **here**.

'The CD-ROM is ideal for teenagers, parents who want to encourage an interest in science and mathematics in their children, grown-ups interested in the history of cryptography, amateur codebreakers and anybody who wants to know about encryption in the Information Age.

'The aim of the project was to create an interactive version of The Code Book, so that readers could encrypt, break codes and see how the Enigma machine really works. However, it soon became clear that the CD-ROM had a huge potential for getting young people interested in mathematics.'