

BREAKING THE CODE ! (part 1)



When you think of *spies and secret agents*, you might think of lots of things; nifty gadgets, foreign travel, dangerous missiles, fast cars and being shaken but not stirred. You probably wouldn't think of mathematics. But you should.

Cracking codes and unravelling the true meaning of secret messages involves loads of maths, from simple addition and subtraction, to data handling and logical thinking.

In fact, *some of the most famous code breakers in history have been mathematicians* who have been able to use quite simple maths to uncover plots, identify traitors and influence battles.

The Roman Geezer



Let me give you an example. Nearly 2000 years ago, Julius Caesar was busy taking over the world, invading countries to increase the size of the Roman Empire. He needed a way of communicating his battle plans and tactics to everyone on his side without the enemy finding out. So **Caesar would write messages to his generals in code.**

Instead of writing the letter 'A', he would write the letter that comes three places further on in the alphabet, the letter 'D'. Instead of a 'B', he would write an 'E', instead of a 'C', he would write an '.....' and so on. When he got to the end of the alphabet, however, he would have to go right back to the beginning, so instead of an 'X', he would write an 'A', instead of a 'Y', he'd write a '.....' and instead of 'Z', he'd write a '.....'.

Complete the table to find out how Caesar would encode the following message:

Caesar's message	A	T	T	A	C	K		A	T		D	A	W	N
	B	U												
	C	V												
Coded message	D													

When Caesar's generals came *to decipher the messages*, they knew that all they had to do was go back three places in the alphabet.

Have a go at trying to work out these messages which could have been sent by Caesar or his generals:

HQHPB DSSURDFKLQJ

WKLUBW GHGD

UHWUHDW WR IRUHVW

.....

.....

.....

Easy as 1, 2, 3

This all seems very clever, but so far it's all been letters and no numbers. So where's the maths? The maths comes if you think of the letters as numbers from 0 to 25 with A being 0, B being 1, C being 2 etc. Then encoding, shifting the alphabet forward three places, is the same as adding three to your starting number :

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

For example, encoding the letter 'A' is $0+3=3$, which is a 'D'.

Coding 'T' is : $..... + 3 = 11$, which is '.....'.

However, you do have to be careful when you get to the end of the alphabet, because there is no letter number 26, so you have to go back to number 0. In maths we call this 'MOD 26', instead of writing 26, we go back to 0.

Have a go at coding your name by adding 3 to every letter :

Then have a go at coding your name by shifting the alphabet forward by more places by adding greater numbers eg adding 5... then adding 10.

Then have a go at decoding. If your letters are numbers and encoding is addition, then decoding is subtraction, so if you've coded a message by adding 5, you will have to decode the message by subtracting 5.

HTSLWFYZQFYNTSX

The problem is when you don't know how the message was encoded. If you want to decipher it you have 25 possibilities!

Let's try another code

Let's use a more difficult operation to encode a message. For instance, multiply each number by 3 and then add 2.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2	5	8																							
C	F																								

Find the encoded message for : MATHS ARE EASY !



BREAKING THE CODE ! (part 2)

'Ancient Runes' *printed from <http://nrich.maths.org/>*



Let's study another way of coding messages thanks to drawings.
Here is a table containing all the letters of the alphabet :

Alphabet

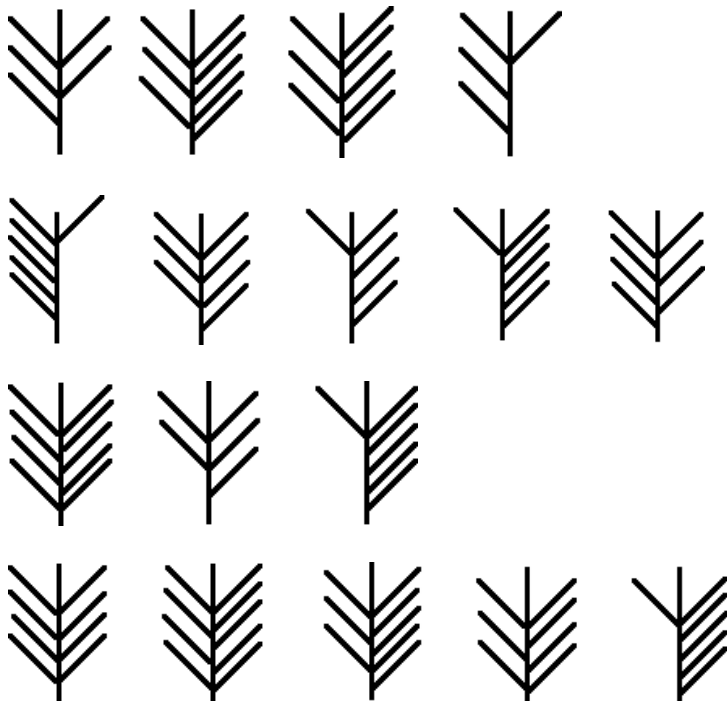
A	B	C	D	E
F	G	H	I	J
K	L	M	N	O
P	Q	R	S	T
U	V	W	X	Y
Z				

It has six rows (going from left to right) and five columns (going from top to bottom). The Vikings communicated in writing by making simple scratches on wood or stones called runes. Sometimes they were written in a secret or coded way. Here is 'was' written in coded runes:



Can you work out how the code works using the table of the alphabet?

Here is a message in secret runes:



Can you decipher it ?

Make up your own message :

BREAKING THE CODE ! (part 2)



Treason!

This type of code was used by Mary Queen of Scots when she was plotting against Elizabeth the First. Mary wanted to kill Elizabeth so that she herself could become Queen of England and was sending coded messages of this sort to her co-conspirator Anthony Babington.

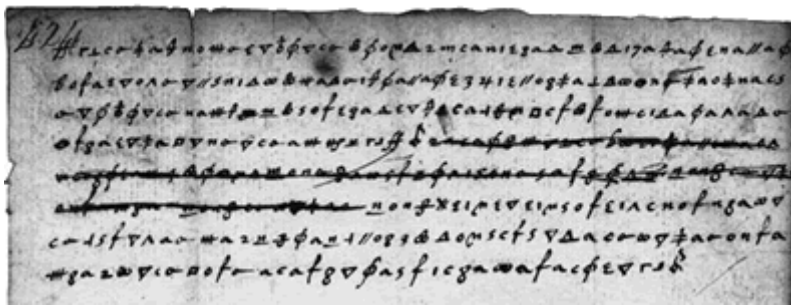


Elizabeth The First



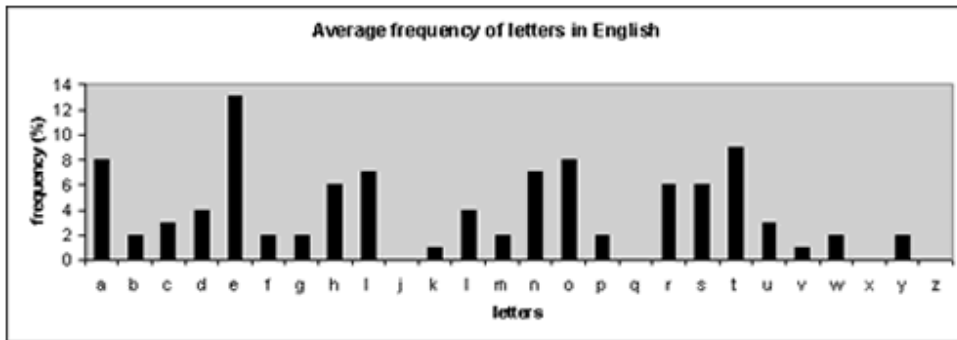
Mary Queen of Scots

Unfortunately for Mary, there is a very simple way of cracking this code that doesn't involve trial and error, but which does involve... surprise... surprise... **maths !**



Letter sent by Mary Queen of Scots to her co-conspirator Anthony Babington. Every symbol stands for a letter of the alphabet.

The graph below shows the average frequency of letters in English. To compile the information, people looked through thousands and thousands of books, magazines and newspapers, and counted the number of times each letter came up.



In English, which is the most commonly used letter ?

In any piece of writing, on average, how often do we use E ?

Which is the second most common letter ? and the third most commonly used letter ?

Let's complete the table below : *Average Frequency of letters in English*

Letters										J, Q, X, Z
Frequency (%)	13	9	8	7	6	4	3	2	1	0

This information that can help you to crack codes.

All Elizabeth the First's Spy-Master had to do to crack Mary's code, was to look through the coded message and count the number of times each symbol came up. The symbol that came up the most would probably stand for the letter 'E'.

When you crack codes like this, by looking for the most common letter, it's called '**frequency analysis**', and it was this clever method of cracking codes that resulted in Mary having her head cut off !

Test your talents



Cracking these coded messages doesn't just involve looking for the most common symbol, you can also look for symbols that are all out on their own in the message ie one letter words. There are only two one-letter words in English, 'A' and 'I', so a lone symbol would have to stand for an 'A' or 'I'. Another thing you can look out for are common words. The most common three letter words in English are 'the' and 'and', so if you see a group of three symbols that comes up quite a lot, they could stand for 'the' or 'and'.

If you would like to test out these code breaking tips and your new code breaking talents, have a look at [Simon Singh's Black Chamber](#). It has Caesar shift and frequency analysis puzzles for you to break, and other codes that you can try to unravel.

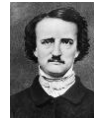
For more information about other secret codes that have been used throughout history, check out [Simon Singh's web site](#). It's packed full of information about all sorts of codes, including the famous story Enigma, the code machine used by the Germans during WWII. The Germans thought their code was invincible, but incredibly, British mathematicians managed to break the code and read all the messages sent by the Germans during the war. Historians think that having this inside information shortened the war by two whole years.

WARNING

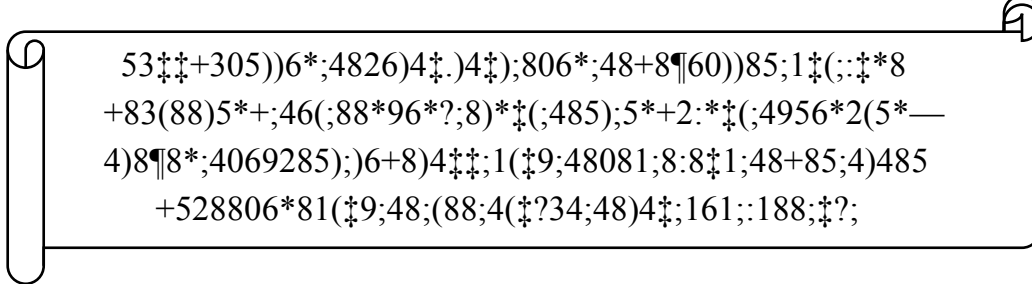
After reading this, you might fancy making up some codes of your own, and writing you own secret messages. BE WARNED. Other people have also read this article and they too will be top mathematical codebreakers. Spies are everywhere, so be careful - who's reading your messages?

BREAKING THE CODE ! (part 3)

Let us follow the story of *The Gold Bug* by Edgar Allan Poe.



Here is the message found on a parchment :



Cracking this code will allow the narrator to find a treasure ! Let's follow him to decipher the enigma...

1st step : Guessing the language in which the enigma is written → **English** for sure !

2nd step : Find all the characters used in the message. Count them all and find their frequency in it.

Character	8	;	4	‡	*	5	6	(	+	0	9	:	?	¶	—
				)					1		2	3			.
Times															

As the most frequent letter in English is, we shall guess that '8' represents

To verify this supposition, let's observe that the '8' is seen often in couples (for E is doubled with great frequency in English).

3rd step : The most frequent word in English is THE. Therefore find a repetition of three characters in the same order, the last of them being '8' :

Now you can guess which symbol represents T, and the one representing H. Write it in the table and replace all these symbols in the message.

4th step : Let's find a new word in the message. Look at this part of the message **THE T(EETH** . As we can't find any letter to complete the word *t.eeth*, we shall think that the last 'th' is the beginning of the following word. Can you find the missing letter in *t..ee* ? Try all the letters !

Now you can guess which letter stands for (.

5th step : By group try to decipher the whole message.

Complete the following table :

Characters	8	;	4	‡	)	*	5	6	(	+	1	0	9	2	:	3	?	¶	—	.
Letters																				

Now you can decipher the message :

