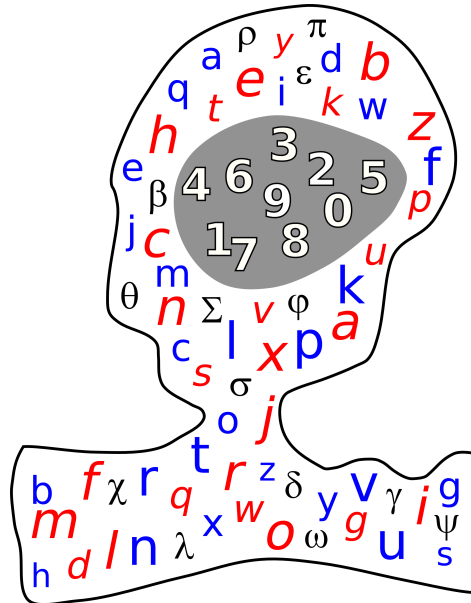


# Secret Codes & Number Games



*Cryptographic Projects & Number Games  
for Children Ages 5-16*

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## Secret Codes & Number Games

### 1 SECRET CODES

People have always kept secrets from each other. At home, children keep secrets from their parents, although they shouldn't. At school, and around their neighborhood, children keep secrets from other children. In the world at large, governments keep secrets from other governments, and companies keep secrets from other companies.

Keeping a secret is easy if you're the only one who knows it. It's harder if you want to tell someone else. If they're nearby, you whisper in their ear, hoping that no one else will hear you.

What if you want to tell someone a secret, but you're in your home, and the other person is in his home? Maybe you live in different cities. How do you tell someone a secret using email or postal mail so no one else will know the secret, even when they can peek and see the message?

Passing secret messages happens all the time on the Internet. When your parents use a credit card to order something online, their order is sent as a secret message. When a general needs to send a message to his troops, he might use a radio, but only his troops understand the message, since it's sent in a code.

This book will show you how secret messages are coded and decoded, and you'll learn a few ways to send secret messages, yourself.

The science of sending and receiving secret messages is called cryptography. The word, "cryptography," is the combination of two Greek words, "crypto," which means "hidden," and "graphos," which means writing.

Cryptography, as used today for things like purchasing things on the Internet, involves mathematics. Some math can be fun, so you'll learn a few number games, too.

## 5 CODING DEVICES - DECODING WHEEL

The following page shows how you can make a coding device called a decoding wheel. The decoding wheel is also called a cipher disk, an Alberti cipher disk, or a secret decoder ring.

The decoding wheel is a mechanical aid for doing a substitution cipher. A substitute alphabet (red in the figure) is written around the edge of a disk. This disk is attached inside another disk with the alphabet in regular order (blue).

You decide on how to make the substitution by rotating the disks to match one regular character to a substitute character. In cryptography, the regular characters are called the **plaintext**, and the substitute characters are called the **ciphertext**. This is the “key” that will unlock the coded message later.

You code your message by looking at each letter in your message (blue) and writing down the substitute letter (red). The person who gets this coded message will decode it by using the key to match the letters on his decoding wheel, reading the red letters and writing the blue letters.

For example, if we choose the key where the plaintext **2** is set equal to the ciphertext **5**, then the message,

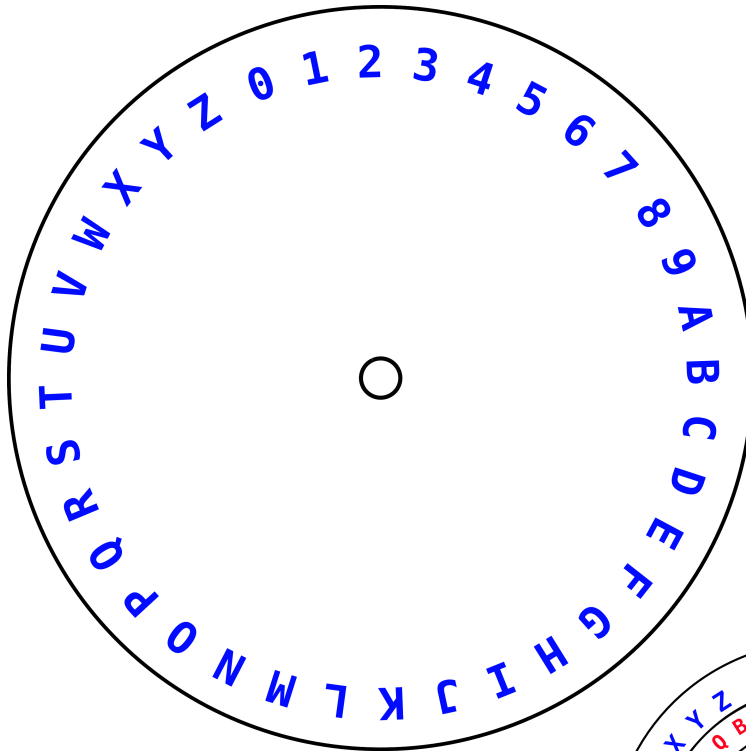
MARYHADALITTLELAMB

will be coded as

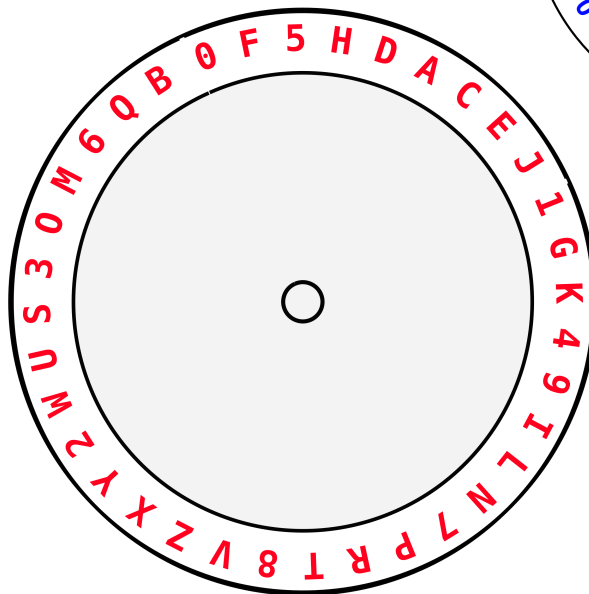
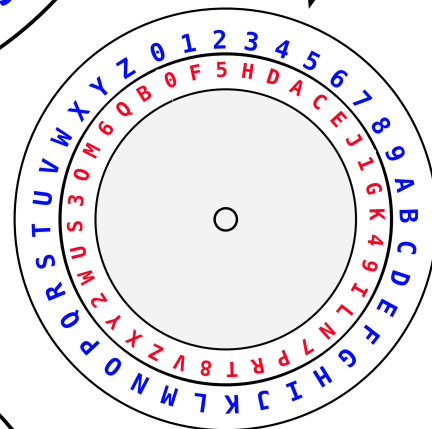
VGWQ7G9G8PSS8I8GVK

To make your own decoding wheel, have a copy of the next page made at a local copy center and paste it onto cardboard.

## Secret Codes & Number Games



**Directions:** Copy this page, cut out the circles and join them together with a paper fastener at the center. Rotate to select encoding character pair.



## 8 SYMBOL CIPHERS – FOREIGN ALPHABETS

A book written in a language you don't know is just like a code. People who understand the rules of the language are able to decipher the code.

Short of learning a new language, or inventing your own language, you can write messages that look like they're written in another language, but they aren't. In a process called transliteration, you substitute letters from the alphabet of another language for the letters in your message.

Transliteration is made easier by computer word processing programs that allow you to change the font of what you've written. You just highlight the text you want transliterated and select a foreign language font.

The charts that follow transliterate English characters into characters from four different languages; namely, Voynich, Greek, Hieroglyphic and Cyrillic fonts. Hieroglyphics are an ancient writing once used in Egypt, and Cyrillic is the font used in the Russian and Bulgarian languages.

The Voynich characters are unusual. They are found in the Voynich Manuscript, an ornately illustrated book in an unknown language. Cryptologists and linguists have studied the Voynich Manuscript for years, trying to decode it. They've found some properties that indicate that it's a real language, but they still don't have a translation. Here's what "Voynich Manuscript" looks like in the Voynich character set:

Ŧ 0 2 w v c ll      ww a w Ƨ 2 c Ŧcc v 8 2



# Secret Codes & Number Games

**Voynich**



























**Greek**

<b>A</b>	ᵃ	α
<b>B</b>	ᵇ	β
<b>C</b>	ᶜ	χ
<b>D</b>	ᵈ	δ
<b>E</b>	ᵉ	ε
<b>F</b>	ᶠ	φ
<b>G</b>	ᶢ	γ
<b>H</b>	ᶣ	η
<b>I</b>	ᶤ	ι
<b>J</b>	ᶦ	ς
<b>K</b>	ᶣ	κ
<b>L</b>	ᶣ	λ
<b>M</b>	ᵐ	μ

**Voynich**

**Greek**

<b>N</b>	ᵐ	ν
<b>O</b>	ᵒ	ο
<b>P</b>	ᵖ	π
<b>Q</b>	ᵖ	θ
<b>R</b>	ᶣ	ρ
<b>S</b>	ᶢ	σ
<b>T</b>	ᶢ	τ
<b>U</b>	ᶢ	υ
<b>V</b>	ᶣ	Δ
<b>W</b>	ᶢ	ω
<b>X</b>	ᶢ	ξ
<b>Y</b>	ᶢ	ψ
<b>Z</b>	ᶢ	ζ

	Hiero- glyphics	Cyrillic		Hiero- glyphics	Cyrillic
A		а	N		Н
B		б	O		О
C		ъ	P		П
D		д	Q		я
E		з	R		р
F		ф	S		с
G		г	T		т
H		ч	U		у
I		и	V		в
J		й	W		ш
K		к	X		х
L		л	Y		ю
M		м	Z		ц

## 11 SYMBOL CIPHERS - BRAILLE

Braille was an important communications medium for the blind before optical character recognition and text-to-speech systems became inexpensive and ubiquitous. The Braille code consists of small patches of raised dots. A skilled Braille reader can rapidly scan his fingers along lines of these patches to read text as easily as a sighted person reads a printed book..

When using Braille as a code, it isn't necessary to create the raised dots. Printed dots will work as well. The table on the next page shows the alphabet as Braille code.

“Mary had a little lamb” looks like this in Braille code.

●● ●○ ●○ ●●      ●○ ●○ ●●      ●○  
○○ ○○ ●● ○●      ●● ○○ ○●      ○○  
●○ ○○ ●○ ●●      ○○ ○○ ○○      ○○

●○ ○● ○● ○● ●○ ●○      ●○ ●○ ●● ●○  
●○ ●○ ●● ●● ●○ ○●      ●○ ○○ ○○ ●○  
●○ ○○ ●○ ●○ ●○ ○○      ●○ ○○ ●○ ○○

<b>a</b>	
<b>b</b>	
<b>c</b>	
<b>d</b>	
<b>e</b>	
<b>f</b>	
<b>g</b>	
<b>h</b>	
<b>i</b>	
<b>j</b>	
<b>k</b>	
<b>l</b>	
<b>m</b>	

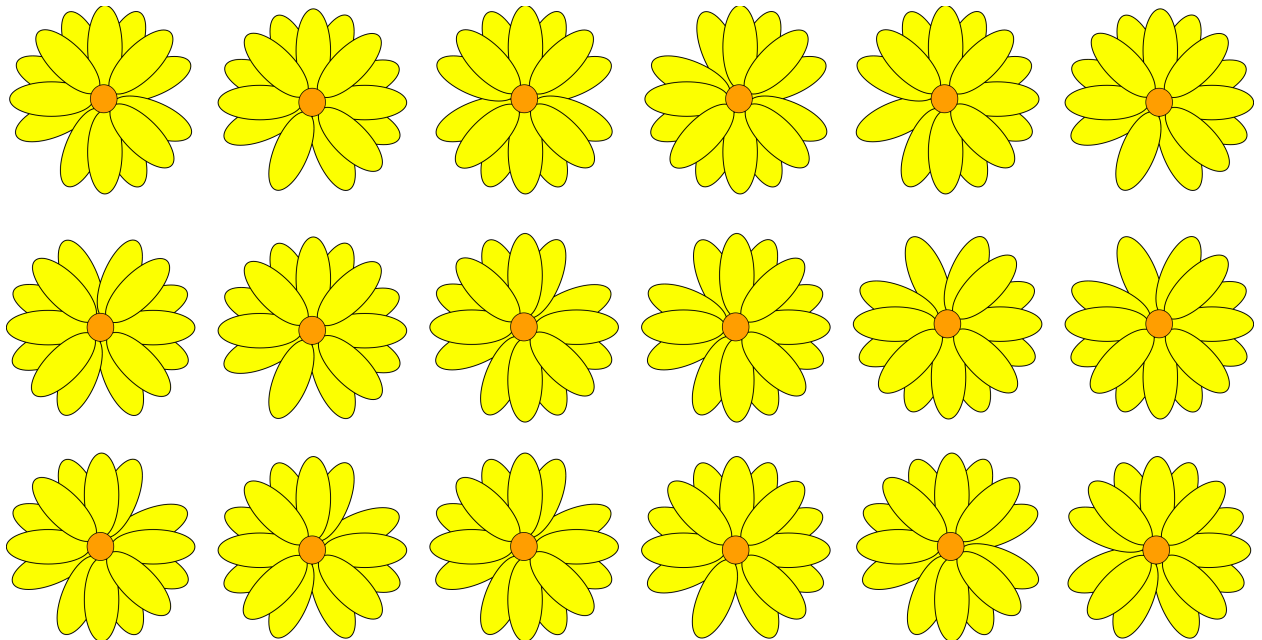
<b>n</b>	
<b>o</b>	
<b>p</b>	
<b>q</b>	
<b>r</b>	
<b>s</b>	
<b>t</b>	
<b>u</b>	
<b>v</b>	
<b>w</b>	
<b>x</b>	
<b>y</b>	
<b>z</b>	

### 14 SYMBOL CIPHERS – SAY IT WITH FLOWERS

What can be more innocent than a drawing of a flower? The petals on a flower can hide your secret message. The semaphore code in a previous chapter can be represented using a flower.

Since the semaphore code for a character just has two flags, this would translate to a flower with just two petals, which wouldn't look like a real flower. The best approach, as shown in the table on the next page, is to have the semaphore code done as the absence of a petal.

Such a code is still readily readable, as the following “Mary had a little lamb” example shows.



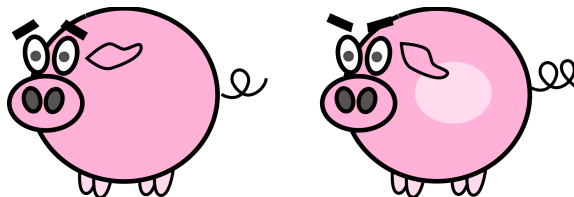
“Mary had a little lamb” in flower code.



### 17 SYMBOL CIPHERS – SAY IT WITH PIGGIES

Small changes to the shape, color or composition of an object might not be perceptible to a casual viewer. However, difference in an image can convey a code.

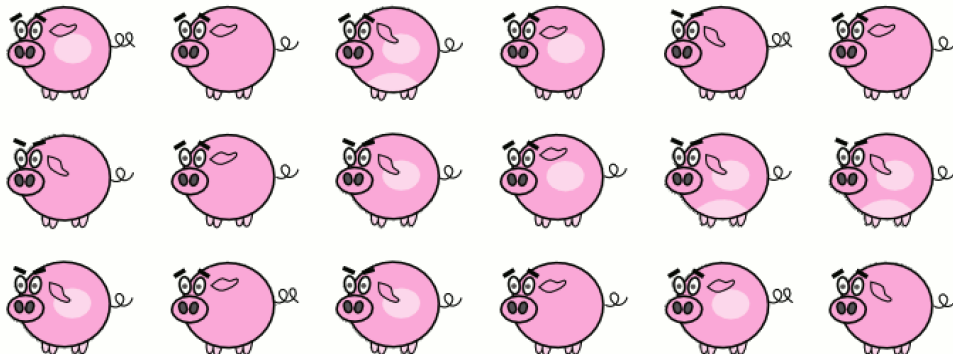
As an example of this, look at the following drawings of a cartoon pig.



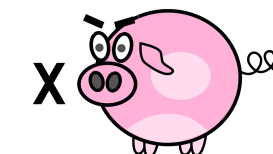
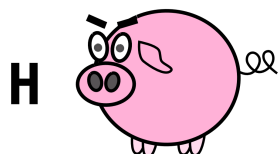
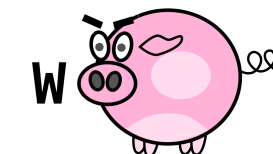
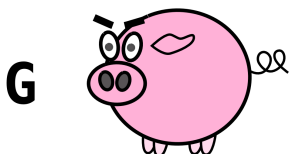
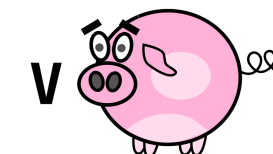
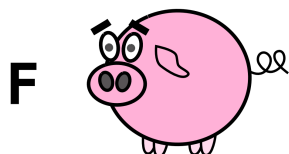
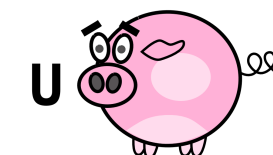
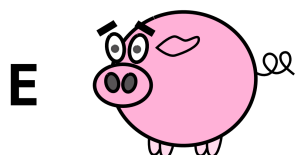
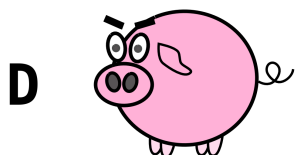
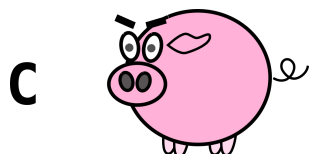
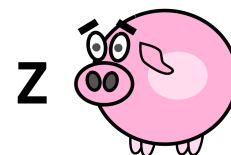
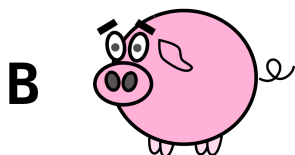
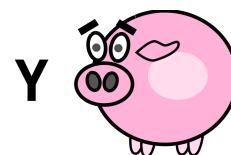
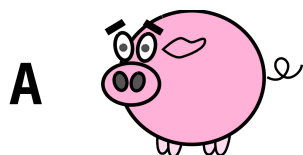
If you look closely, you'll see a lot of difference between the two pigs. The eyebrows are different, and one has a drooping ear, a spot, and an extra curl in his tail.

As the chart on the next page shows, you can use such changes to make twenty six different pigs to give you an alphabet for codes.

Here's what “Mary had a little lamb” looks like in piggie code.



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## 25 ADVANCED CIPHERS - KEYWORD CIPHER

Nearly everyone who's worked with computers knows about passwords. You need them to use most computers, to access some Internet web sites, and to make online purchases.

There's something similar to a password in cryptography. It's called a keyword, and it allows you to encode messages differently when using the same cipher.

As an example of how this is done, we'll choose "SUNNYDAY" as a keyword. The first step is to write down our keyword without repeating any letters. In this case, it means writing just the first "N" and the first "Y."

SUNYDA

The next step is to write down all the letters of the alphabet, in order, skipping any letters in the keyword. The first thing we realize is that we've already written down "A," so we write "B" and continue.

SUNYDABCEFGHIJKLMOPQRTVWXZ

We can then match these letters against the regular alphabet.

Plaintext:    ABCDEFGHIJKLMNOPQRSTUVWXYZ

↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑↑

Ciphertext:   SUNYDABCEFGHIJKLMOPQRTVWXZ

The letters labeled "plaintext" are the ones in your message, and the letters labeled "ciphertext" are the coded letters.

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

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

Coding and decoding is often easier if the letters are arranged vertically, as shown on the left. Use of the word, “KEYWORD” as a keyword is shown also on the left.

Our example phrase, “Mary had a little lamb,” would be coded as

HKNXAKWKGBQQGOGKHE

using “KEYWORD” as the keyword, and as

ISOXCYSYSHEQQHDHSIU

using SUNNYDAY as the keyword.

## 28 ADVANCED CIPHERS - POLYBIUS SQUARE

The Polybius square cipher is named after its inventor, the Greek scholar, Polybius, who lived in the second century BC. It's a simpler cipher than the four-square cipher of the previous chapter, so it's easier to code messages using it. That also means that it's easier to crack.

Like other ciphers, the alphabet characters are arranged in an array, as shown in the figure, with the rows and columns numbered. Since it's possible to fit numbers into such an array, they're included also.

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

To encode a message, you just write the row and column of each letter. The letter "A" will be encoded as the number 11, the letter "B" will be encoded as the number 12, and the number nine will be encoded as 66.

Our example phrase, "Mary had a little lamb," will be encoded as follows.

31 11 36 51 22 11 14 11 26 23 42 42 26 15 26 11 31 12