The math behind bits and bytes

By Gale, Cengage Learning, adapted by Newsela staff on 11.20.17
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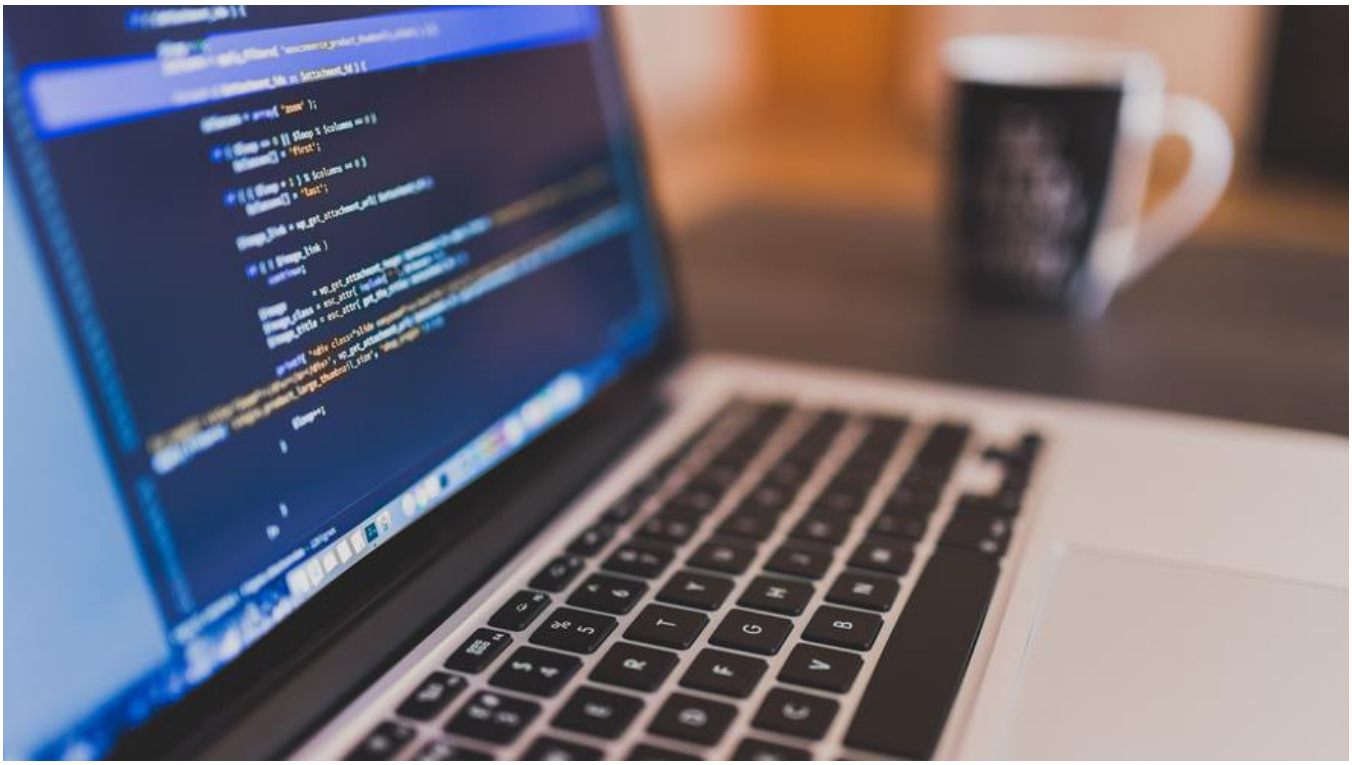
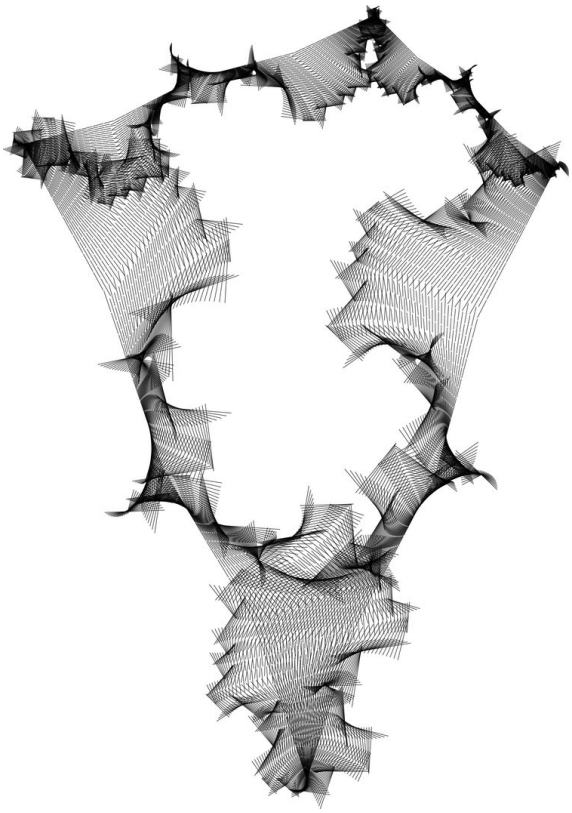


Computers have their very own language, made of just two symbols: 0 and 1. Photo from Pexels

Computers are used for education, business and entertainment. Today, computers sit on desks, fit into wristwatches and run everything from cars to calculators. All these computers rely on mathematics.

The word "computer" comes from computing, such as calculating the answer to a math problem. Computers use math to work with data or information. Math is what guides how computers process, store, display and share information.

Algorithms



An algorithm is a list of steps, like those used to solve addition and multiplication problems. An algorithm could also be the instructions for building a house, such as building first the floor, then the walls and then the roof.

Computers follow specific steps to accomplish tasks. For example, "booting" or turning on a computer causes it to follow an algorithm to load its operating system. Software programs consist of numerous algorithms.

Bits And Bytes

A computer is made up of a huge number of tiny switches which can be either off or on. The computer uses its own language to indicate the state of a switch. The value of on or off is called a bit, and it is a computer's smallest unit of information. Off is represented by 0, and on is represented by 1. A bit is also called a binary number, since there are only two possible values.

All data in computers is stored in bits, but 8t bits are grouped together into a byte. Computers store data and process instructions in bytes. The byte 01011010 stands for the letter "z," for example.

It takes many bits and bytes to store a great deal of information. To handle large quantities of information bytes are grouped into kilobytes, megabytes and gigabytes. These are respectively 1,024 bytes, 1,048,576 bytes and 1,073,741,824 bytes.

Coding For Numbers

In our number system, we normally use the decimal system, which has 10 symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. However, computers have to store numbers using only the symbols 0 and 1, which is a binary system.

In the decimal system, each place value increases by a factor of 10. As an example, the number 111 means 100 + 10 + 1 = 111. It represents a 1 in the hundreds place, 1 in the tens place and a 1 in the ones place.

In the binary system, the number 111 represents something very different. Each place value increases by a factor of 2. In binary, 111 means a 1 in the fours place, a 1 in the twos place and a 1 in the ones place. So the binary number 111 means a value of 4 + 2 + 1 = 7.

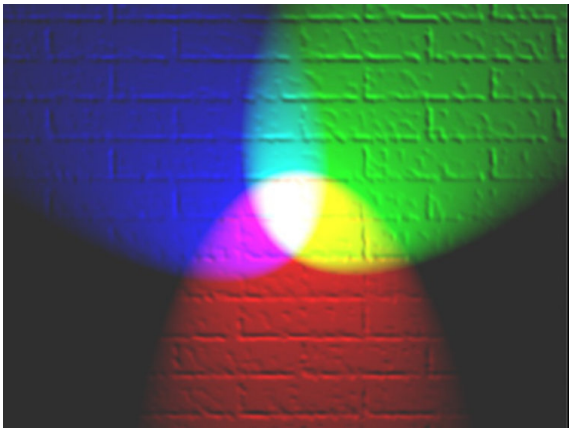
Coding For Text

Decimal		Binary
0	=	0
1	=	1
2	=	10
3	=	11
4	=	100
5	=	101
6	=	110
7	=	111
8	=	1000
9	=	1001
10	=	1010

Computers must also store words in binary. To help everyone use the same binary code for the same letters, standard rules called ASCII were developed. ASCII stands for American Standard Code for Information Interchange. The ASCII system assigns a different code to uppercase and lowercase letters, as well as to other characters such as commas.

For example, the ASCII code for "A" is 65, which is 1000001 in binary. A small "a" is 97, which is 1100001 in binary. Since every character is stored as 1 byte, the word "happy" uses 5 bytes.

Coding For Color

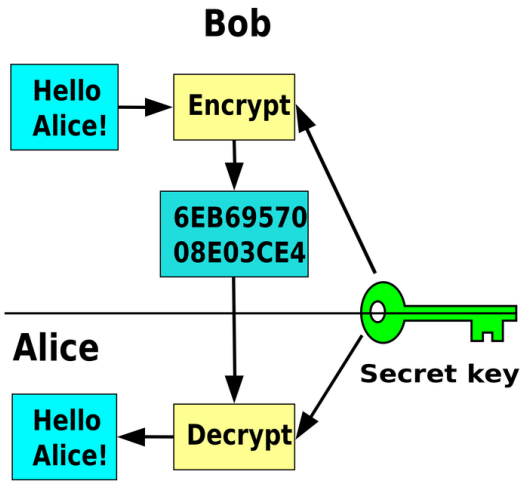


The binary system is used to represent more than just text. It is also used for images, which are made up of numerous tiny square pixels. The word pixel comes from the words picture and element. For example, a computer monitor can show an image that is 800 pixels wide and 600 pixels high. This means it can display an image that has 800 x 600 = 480,000 total pixels.

The color of each pixel depends on the amount of red, green and blue light it contains. This scheme is called RGB, and modern computers use one byte for each of these RGB values. Each byte indicates how much light of a certain color should be in a certain pixel. This means that for 480,000 pixels, the computer needs to store 3 x 480,000 = 1,440,000 bytes.

Coding For Security

Displaying images and text is not all that computers can do. People have used math to code secret messages since ancient times. Now, computers encrypt data, or convert messages using codes. Encrypted messages cannot be decoded without the key.



One simple way to encrypt a message is to replace each symbol with another one, such as replacing letters with numbers and vice versa. The message "abc456" can be encrypted as "123def." In this case, guessing the key is quite simple, but computers use more complex algorithms to keep data safe.

Quiz

1 Read the following sentence from the section "Coding For Text."

> *To help everyone use the same binary code for the same letters, standard rules called ASCII were developed.*

Which of the following words, if it replaced the word "standard" in the sentence above, would CHANGE the meaning of the sentence?

(A) common

(B) definitive

(C) unique

(D) official

2 Read the following selection from the section "Coding For Security."

> *The message "abc456" can be encrypted as "123def." In this case, guessing the key is quite simple, but computers use more complex algorithms to keep data safe.*

Why does the author compare encryption with a key?

(A) To explain the role encryption plays in keeping information safe.

(B) To contrast old ways of keeping information safe with the more advanced methods used by computers.

(C) To show where in the computer most encryption occurs.

(D) To describe the process used by computers to encrypt messages.

3 Which selection from the article is BEST illustrated by the graphic in the section "Coding For Color"?

(A) The binary system is used to represent more than just text. It is also used for images, which are made up of numerous tiny square pixels.

(B) The word pixel comes from the words picture and element. For example, a computer monitor can show an image that is 800 pixels wide and 600 pixels high.

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4 How do the image and paragraphs in the section "Coding For Numbers" develop a coherent understanding of the binary system?

(A) Both demonstrate how the decimal and binary systems are similar.

(B) Both emphasize the differences between the decimal and binary systems.

(C) Both demonstrate the importance of binary conversions to the operation of computers.

(D) Both emphasize the history of both the decimal and binary systems.

Answer Key

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