A BEGINNERS GUIDE TO...

BINARY & HEXADECIMAL

0110 0101 0111 0110 1011 1010 0110 1001 0111 1110 1011 1001 1110
0110 0111 0110 0110 1111 1011 0110 1001 1101 1110 1010 1001 1010
1110 0100 0111 0110 1101 1010 0100 1101 1001 1110 1100 1111 1010
1100 0100 0001 0110 1011 1010 0111 1001 0011 1110 0100 1011 1010

* A zine for anyone interested in CS! No knowledge of programming or computers required! Everyone is welcome!

By : Arielle Tycko

What's binary, and what's it got to do with computers?

We normally use decimal numbers, which are numbers in a base ten system. A base ten system utilizes ten digits, 0-9.

Binary numbers are a base TWO system, using two digits, 0 and 1.

Computers rely on binary because of its simplicity. For example, this is important in computer processors, which are little devices in computers that translate inputs into outputs. Processors consist of transistors, which act like switches turned on and off by electronic signals. **A binary system enables this by providing two distinct 'on' and 'off' or 'high' and 'low' states, represented by either 0 (off) or 1 (on).**

Computers use bits (BInary digiTS) to represent data. Eight bits make up a **Byte**. A byte can have values ranging from 0-255. Bytes represent many different values like...

★ Color: On a screen, images are composed of many many tiny points of color, called pixels. Pixels are given a red, green, and blue (RGB) value. The 'amount' of each RGB color is represented by a Byte. Different amounts of red, green, and blue give rise to different colors.

★ ASCII Code: ASCII stands for the American Standard Code for Information Interchange. It's a standard for character encoding, designating each character to a byte (more on this later!)

How do you convert between binary and decimal?

To understand binary, we should first know to convert between binary and decimal numbers.

Binary numbers work like this: Just like decimal numbers have "places" (i.e. a "one's" place," a "ten's place," etc), binary numbers have "places." The places are the "one's place," the "two's place," the "four's place," the "eight's place," and so forth. Note the pattern.... each "place" is a subsequent power of 2. So how do places work?

Let's first look at a decimal system example:

3 | 1 | 5 over 100 | 10 | 1

$5 \times 1 = 5$
$1 \times 10 = 10$
$3 \times 100 = 300$
$= 315$

We can apply this same logic to a binary system example:

$\frac{1}{4}\ \frac{1}{2}\ \frac{1}{1} = (1\times1) + (1\times2) + (1\times4) = 7$ ...so 7 in binary is 111

"4's place" "2's place" "1's place"

$\frac{1}{16}\ \frac{0}{8}\ \frac{0}{4}\ \frac{1}{2}\ \frac{0}{1} = (0\times1) + (1\times2) + (0\times4) + (0\times8) + (1\times16) = 18$ ... so 18 in binary is 10010

($16 = 2^4$, $8 = 2^3$, $4 = 2^2$, $2 = 2^1$, $1 = 2^0$)

Onto some practice...

Examples | Practice!

1. What is 1101 in decimal?

$\frac{1}{8}\ \frac{1}{4}\ \frac{0}{2}\ \frac{1}{1} = (1\times8)+(1\times4)+(0\times2)+(1\times1) = 13$

2. What is 86 in binary?

$\frac{1}{64}\ \frac{0}{32}\ \frac{1}{16}\ \frac{0}{8}\ \frac{1}{4}\ \frac{1}{2}\ \frac{0}{1} = 64+16+4+2 = 86$ → 1010110

NOTE: Start adding 1's (then 0's) left to right until they add to 86

3. What is 100110 in decimal?

$\frac{1}{32}\ \frac{0}{16}\ \frac{0}{8}\ \frac{1}{4}\ \frac{1}{2}\ \frac{0}{1} = (1\times32)+(0\times16)+(0\times8)+(1\times4)+(1\times2)+(0\times1)$
$= 38$

4. Using the ASCII key, write your name!

ASCII Alphabet

A	1000001	N	1001110
B	1000010	O	1001111
C	1000011	P	1010000
D	1000100	Q	1010001
E	1000101	R	1010010
F	1000110	S	1010011
G	1000111	T	1010100
H	1001000	U	1010101
I	1001001	V	1010110
J	1001010	W	1010111
K	1001011	X	1011000
L	1001100	Y	1011001
M	1001101	Z	1011010

Example : My name is ARIELLE.

A: 1000001 ↳ 65
R: 1010010 ↳ 82
I: 1001010 ↳ 73
E: 1000101 ↳ 69
L: 1001100 ↳ 76
L: 1001100 ↳ 76
E: 1000101 ↳ 69

What's hexadecimal, and what's it got to do with computers?

Hexadecimal is a **base sixteen** system, (using sixteen digits), the conventional 0-9 digits as well as the letters A-F, which correspond to the decimal values 10-15.

You might have realized that a byte (8 bits) is not very easy to read and interpret. That's why we have hexadecimal. While computers rely on binary, we often represent binary numbers as hexadecimal numbers to make it easier for us as computer scientists to read. Two hexadecimal digits, (rather than eight binary digits), can represent a byte. Hexadecimal can **represent larger numbers in many fewer digits** than binary, making it easier to read and compressing information (hooray for concision!).

So why do we not just use decimal instead to represent larger numbers? Decimal is a base ten system, which does not match up nicely with a base so system (i.e. four binary digits could be one OR two decimal digits). Since sixteen is a power of two, **it always matches up nicely** with binary— one hexadecimal digit is added every time the number of binary digits increases by four. This easy compression of binary makes hexadecimal a good number system for computer scientists to use.

0 1 2 3 4 5 6 7 8 9 A HEX B C D E F

How do you convert between binary and hexadecimal?

We can apply the same techniques we learned from converting between binary and decimal to converting between hexadecimal and decimal. Keep in mind the conversions of the digits:

★ The standard 0-9 digits are the same.

★ A = 10, B = 11, C = 12, D = 13, E = 14, F = 15

Hexadecimal, being a base sixteen system has a "1's place," a "16's place," a "256's place," and so forth. Notice again the pattern... each new place is a subsequent power of sixteen.

Let's look at some hexadecimal examples:

$\frac{A}{16}\ \frac{C}{1} = (12\times1) + (10\times16) = 172$

"16's place" "1's place"

$\frac{1}{256}\ \frac{8}{16}\ \frac{3}{1} = (3\times1) + (8\times16) + (1\times256) = 387$

($256 = 16^2$, $16 = 16^1$, $1 = 16^0$)

Hexadecimal can be tricky! 183 can also be a decimal number, so be careful about specifications in future practice problems!

Speaking of practice...

Examples | Practice!

What is decimal 87 in hexadecimal?

$\frac{5}{16}\ \frac{7}{1} = 7 + 80 = 87$ → 57

What is E5 in decimal? What is it in binary?

$\frac{E}{16}\ \frac{5}{1} = (5\times1)+(14\times16) = 229$

$\frac{1}{128}\ \frac{1}{64}\ \frac{1}{32}\ \frac{0}{16}\ \frac{0}{8}\ \frac{1}{4}\ \frac{0}{2}\ \frac{1}{1} = 128+64+32+4+1 = 229$ → 11100101

Using the ASCII key and practice on page 4, write your name in hexadecimal!

Same example : My name is ARIELLE.

A: 41 ↳ dec. 65
R: 52 ↳ dec. 82
I: 49 ↳ dec. 73
E: 45 ↳ dec. 69
L: 4C ↳ dec. 76
L: 4C ↳ dec. 76
E: 45 ↳ dec. 69

ASCII Alphabet

A	1000001	N	1001110
B	1000010	O	1001111
C	1000011	P	1010000
D	1000100	Q	1010001
E	1000101	R	1010010
F	1000110	S	1010011
G	1000111	T	1010100
H	1001000	U	1010101
I	1001001	V	1010110
J	1001010	W	1010111
K	1001011	X	1011000
L	1001100	Y	1011001
M	1001101	Z	1011010

Summary / Conclusions

- Binary is a BASE TWO system, using digits 0 and 1
- Computers store and read information represented as binary digits (bits), often as bytes (8 bits). This info can include color (RGB values) and ASCII code
- Hexadecimal is a BASE SIXTEEN system, using digits 0-9 and A-F
- Hexadecimal makes binary easier to read and work with because a byte can be represented as 2 hex digits rather than 8 binary digits
- Keep practicing, and great job learning!!!