UNITED STATES AIR FORCE ACADEMY

Binary and Hexadecimal Numbers for Computers

Binary Numbers

A base 2 (binary) number system that uses only **0** and **1**. "Regular" base 10 (decimal) numbers use 0-9.

Base 10	Base 2	Base 16
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
16	10000	10

Binary Numbers in Daily Life

- Computers
- Pictures
- Vehicles
- Videos
- Mobile phones
- Smart devices
- Text Messages
- Web pages

0's and 1's can represent numbers, letters, programs, pictures and more!

Base 10 and Base 16 Numbers

Base 10: $642_{10} = 6*10^2 + 4*10^1 + 2*10^0 = 6*100 + 4*10 * 2*1 = 600 + 40 + 2 = 642_{10}$

Base 16: $642_{16} = 6*16^2 + 4*16^1 + 2*16^0 = 6*256 + 4*16 + 2*1 = 1536 + 64 + 2 \ \ 1602_{10}$

Convert base 16 (hexadecimal) $1A3_{16}$ to Base 10 (decimal)

$1*16^{\_\_} + A = \_\_*16^{\_\_} + 3*16^{0}$

Hints:
$16^2=256$
$16^1=16$
$16^0=1$
A = 10

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Binary and Hexadecimal Numbers For Data

0's and 1's in a computer can represent whole numbers, decimal numbers, text, images, webpages, programs, and more!

1. Binary numbers as numbers

0's and 1's can represent whole numbers (like 5—see other side) or decimal (floating point) numbers such as 3.14.

2. Binary numbers as machine instructions

A computer needs instructions to "do" something. Multiple instructions together make up a program, such as a *game*. Program instructions are stored as 0's and 1's. The computer can fetch these instructions, decode them to figure out what it should do, and then execute ("do") the instructions. This is known as the **fetch-decode-execute cycle** that a computer does *millions of times per second (MHz)*!

1 mega (M)=1 million; 1 giga (G)=1 billion; hertz =cycles/second

3. Binary numbers as pictures

Images are stored 0's and 1's that get interpreted and displayed as a picture.

4. Binary Encoding / ASCII Chart

One way computers *encode* letters is the American Standard Code for Information Interchange (ASCII). Using the ASCII chart (right), decode binary and hexadecimal messages below.

1.

1000111 1001111 0100000 1000110 1000001 1001100
1000011 1001111 1001110 1010011 0100001

_ _ ( ) _ _ _ _ _ _ _ _ _

space=0100000

2.

43 4F 4C 4F 52 41 44 4F

_ _ _ _ _ _ _ _

ASCII character code chart

Decimal	Hex	Binary	Character
32	20	0100000	space
33	21	0100001	!
48	30	0110000	0
65	41	1000001	A
66	42	1000010	B
67	43	1000011	C
68	44	1000100	D
69	45	1000101	E
70	46	1000110	F
71	47	1000111	G
72	48	1001000	H
73	49	1001001	I
74	4A	1001010	J
75	4B	1001011	K
76	4C	1001100	L
77	4D	1001101	M
78	4E	1001110	N
79	4F	1001111	O
80	50	1010000	P
81	51	1010001	Q
82	52	1010010	R
83	53	1010011	S
84	54	1010100	T
85	55	1010101	U
86	56	1010110	V
87	57	1010111	W
88	58	1011000	X
89	59	1011001	Y
90	5A	1011010	Z

1. GO FALCONS! 2. COLORADO