

Decimal Numbers: Base 10

Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Example:

3271 =

$$(3 \times 10^3) + (2 \times 10^2) + (7 \times 10^1) + (1 \times 10^0)$$



Numbers: positional notation

• Number Base B \Rightarrow B symbols per digit:

- Base 10 (Decimal): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- Base 2 (Binary): 0, 1

• Number representation:

- $d_{31}d_{30} \dots d_1d_0$ is a 32 digit number
- value = $d_{31} \times B^{31} + d_{30} \times B^{30} + \dots + d_1 \times B^1 + d_0 \times B^0$

• Binary: 0,1 (In binary digits called “bits”)

• $0b11010 = 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$
 $= 16 + 8 + 2$
 #s often written = 6

0b... • Here 5 digit binary # turns into a 2 digit decimal #

• Can we find a base that converts to binary easily?



Hexadecimal Numbers: Base 16

• Hexadecimal:

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

- Normal digits + 6 more from the alphabet
- In C, written as 0x... (e.g., 0xFAB5)

• Conversion: Binary \Leftrightarrow Hex

- 1 hex digit represents 16 decimal values
- 4 binary digits represent 16 decimal values
- \Rightarrow 1 hex digit replaces 4 binary digits

• One hex digit is a “nibble”. Two is a “byte”

• Example:

- 1010 1100 0011 (binary) = 0x_____ ?



Decimal vs. Hexadecimal vs. Binary

Examples:

1010 1100 0011 (binary)
= 0xAC3

10111 (binary)
= 0001 0111 (binary)
= 0x17

0x3F9
= 11 1111 1001 (binary)

How do we convert between hex and Decimal?

00	0	0000
01	1	0001
02	2	0010
03	3	0011
04	4	0100
05	5	0101
06	6	0110
07	7	0111
08	8	1000
09	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111



Kilo, Mega, Giga, Tera, Peta, Exa, Zetta, Yotta

physics.nist.gov/cuu/Units/binary.html

• Common use prefixes (all SI, except K [= k in SI])

Name	Abbr	Factor	SI size
Kilo	K	$2^{10} = 1,024$	$10^3 = 1,000$
Mega	M	$2^{20} = 1,048,576$	$10^6 = 1,000,000$
Giga	G	$2^{30} = 1,073,741,824$	$10^9 = 1,000,000,000$
Tera	T	$2^{40} = 1,099,511,627,776$	$10^{12} = 1,000,000,000,000$
Peta	P	$2^{50} = 1,125,899,906,842,624$	$10^{15} = 1,000,000,000,000,000$
Exa	E	$2^{60} = 1,152,921,504,606,846,976$	$10^{18} = 1,000,000,000,000,000,000$
Zetta	Z	$2^{70} = 1,180,591,620,717,411,303,424$	$10^{21} = 1,000,000,000,000,000,000,000$
Yotta	Y	$2^{80} = 1,208,925,819,614,629,174,706,176$	$10^{24} = 1,000,000,000,000,000,000,000,000$

• Confusing! Common usage of “kilobyte” means 1024 bytes, but the “correct” SI value is 1000 bytes

• Hard Disk manufacturers & Telecommunications are the only computing groups that use SI factors, so what is advertised as a 30 GB drive will actually only hold about 28×2^{30} bytes, and a 1 Mbit/s connection transfers 10^6 bps.



kibi, mebi, gibi, tebi, pebi, exbi, zebe, yobi

en.wikipedia.org/wiki/Binary_prefix

• New IEC Standard Prefixes [only to exbi officially]

Name	Abbr	Factor
kibi	Ki	$2^{10} = 1,024$
mebi	Mi	$2^{20} = 1,048,576$
gibi	Gi	$2^{30} = 1,073,741,824$
tebi	Ti	$2^{40} = 1,099,511,627,776$
pebi	Pi	$2^{50} = 1,125,899,906,842,624$
exbi	Ei	$2^{60} = 1,152,921,504,606,846,976$
zebi	Zi	$2^{70} = 1,180,591,620,717,411,303,424$
yobi	Yi	$2^{80} = 1,208,925,819,614,629,174,706,176$

As of this writing, this proposal has yet to gain widespread use...

• International Electrotechnical Commission (IEC) in 1999 introduced these to specify binary quantities.

• Names come from shortened versions of the original SI prefixes (same pronunciation) and *bi* is short for “binary”, but pronounced “bee” :-)

• Now SI prefixes only have their base-10 meaning and never have a base-2 meaning.

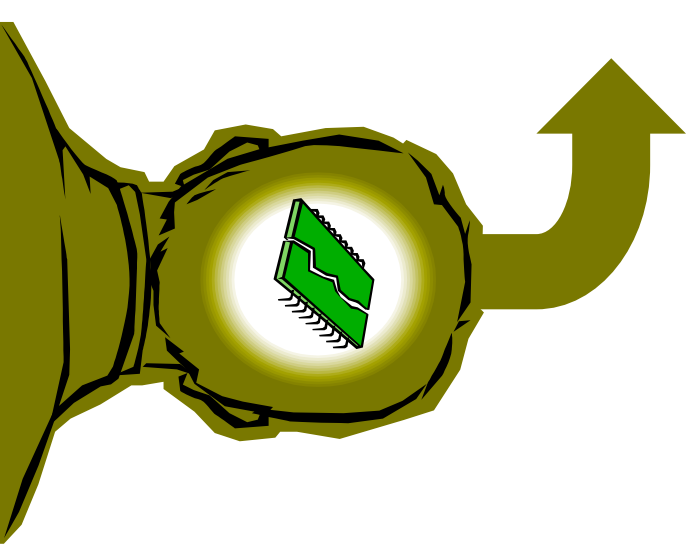


The way to remember #s

- What is 2^{34} ? How many bits addresses (I.e., what's $\text{ceil } \log_2 = \lg \text{ of } 2.5 \text{ TiB}$?)

- Answer! 2^{X^Y} means...

$X=0 \Rightarrow$	---	$Y=0 \Rightarrow$	1
$X=1 \Rightarrow$	kibi $\sim 10^3$	$Y=1 \Rightarrow$	2
$X=2 \Rightarrow$	mebi $\sim 10^6$	$Y=2 \Rightarrow$	4
$X=3 \Rightarrow$	gibi $\sim 10^9$	$Y=3 \Rightarrow$	8
$X=4 \Rightarrow$	tebi $\sim 10^{12}$	$Y=4 \Rightarrow$	16
$X=5 \Rightarrow$	pebi $\sim 10^{15}$	$Y=5 \Rightarrow$	32
$X=6 \Rightarrow$	exbi $\sim 10^{18}$	$Y=6 \Rightarrow$	64
$X=7 \Rightarrow$	zebi $\sim 10^{21}$	$Y=7 \Rightarrow$	128
$X=8 \Rightarrow$	yobi $\sim 10^{24}$	$Y=8 \Rightarrow$	256
		$Y=9 \Rightarrow$	512



MEMORIZE!

