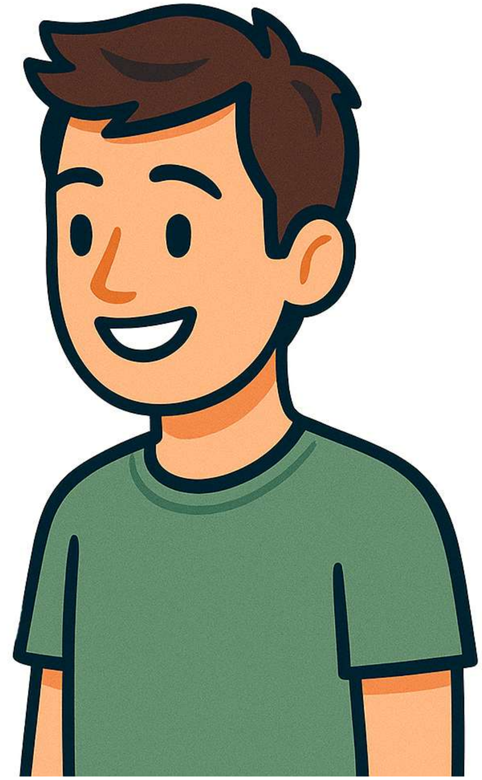
Numbering Systems

Language

**Hi Bob. I'm Alice.
I have a request for you.**

Hi Alice. What can I help you with?



Language Continued

Hola Bob. Soy Alicia.
Tengo una petición
para ti.

I’m sorry. I don’t
understand what
you are saying.

¿Qué?

Huh?

Why this matters

Language is important.

Computers speak a language we need to understand.

Important in a lot of areas, including:

- Cryptography
- Networking
- Forensics

We have an intro to networking class coming early 2026!

Numbers!


0101010110010100101010101
0101010101010101010110100
0101011010101011010100110
1100010101011101100101100
0100101100110011001010101

Computer Language - Binary

- Everything is ones and zeros to a computer
- Everything a computer does; every message, image, or click is just a pattern of 1s and 0s.
- Binary is the language of all digital life.
- Software consists of instructions to put context to the numbers

Binary

Binary is a number system different than human decimal numbers

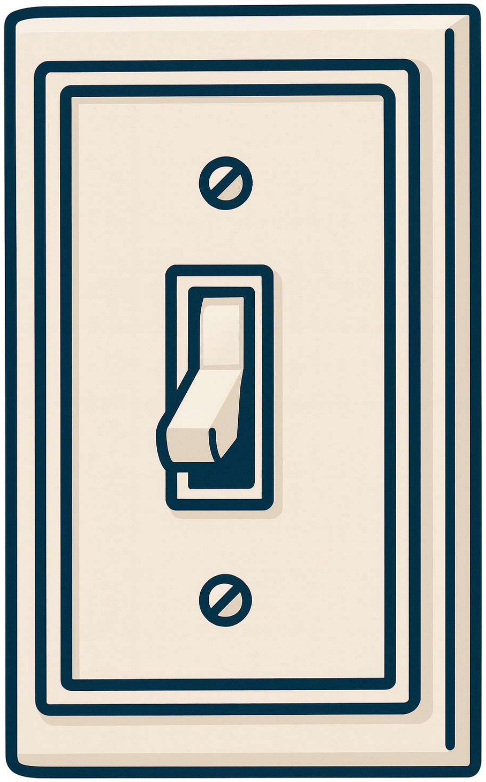
Imagine binary as a series of light switches.

Each switch is either on or off.

ON = 1

OFF = 0

Computers only understand these two states.



Bits and Bytes

Bit - a single 1 or 0

- 2 possible values
- 0 or 1

Byte - eight 1s and 0s

- 256 possible values
- 0 - 255

Nibble - four 1s and 0s

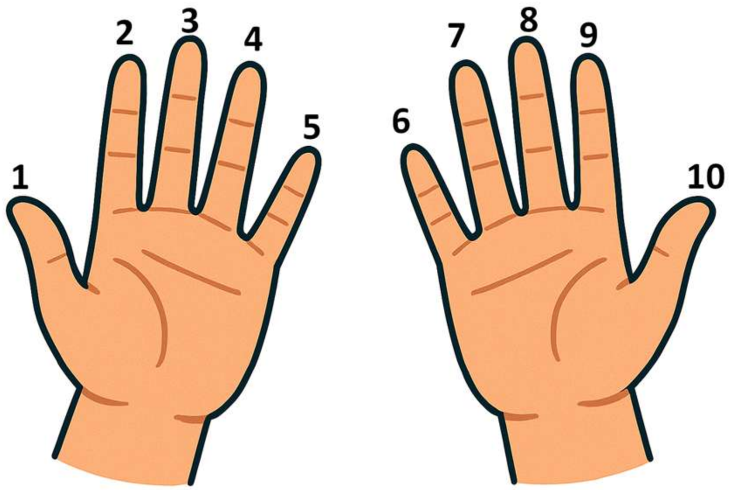
- 16 possible values
- 0 - 15

Note: Computers start counting at zero

The lowest binary value is 0

Base 10 - Decimal system

Humanity's numbering system



Numbering Systems - Decimal

Decimal

Base Ten

0-9

2	3	1
10^2	10^1	10^0
100	10	1

200 + 30 + 1 = 231

Numbering Systems - Binary

Binary

Base Two

0-1

1	1	1	0	0	1	1	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

128 + 64 + 32 + 0 + 0 + 4 + 2 + 1 = 231

Let's Practice!

Alice and Bob are ready to practice!
Are you?

Converting Bytes to Decimal

128	64	32	16	8	4	2	1		
0	1	0	1	1	0	1	1		
0	64	0	16	8	0	2	1	=	91

128	64	32	16	8	4	2	1		
1	0	0	0	1	1	0	0		
128	0	0	0	8	4	0	0	=	140

128	64	32	16	8	4	2	1		
0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	=	0

Converting Decimal to Bytes

	128	64	32	16	8	4	2	1
80 =	0	1	0	1	0	0	0	0
80 - 64 = 16	0	64	0	16	0	0	0	0

	128	64	32	16	8	4	2	1
173 =	1	0	1	0	1	1	0	1
173 - 128 = 45	128	0	32	0	8	4	0	1

	128	64	32	16	8	4	2	1
255 =	1	1	1	1	1	1	1	1
255 - 128 = 127	128	64	32	16	8	4	2	1

Converting Bytes to Decimal Again

128	64	32	16	8	4	2	1
0	1	0	1	0	0	0	0
0	64	0	16	0	0	= 0 80	0

128	64	32	16	8	4	2	1
1	0	1	0	1	1	0	1
128	0	32	0	8	4	= 0173	1

128	64	32	16	8	4	2	1
1	1	1	1	1	1	1	1
128	64	32	16	8	4	= 2 255	1

Nibbles

8	4	2	1	
1	0	1	1	
8	0	2	1	= 11

8	4	2	1	
0	0	0	0	
0	0	0	0	= 0

8	4	2	1	
1	1	1	1	
8	4	2	1	= 15

16 values – 0 through 15

Hexadecimal

Problem!

Decimal has only 10 characters and hexadecimal has 16!

Hexadecimal

Base 16

Decimal	Hex
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7

Decimal	Hex
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

Nibbles & Hexadecimal

8	4	2	1		
1	0	1	1		
8	0	2	1	=	B

8	4	2	1		
0	0	0	0		
0	0	0	0	=	0

8	4	2	1		
1	1	1	1		
8	4	2	1	=	F

Decimal	Hex
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7

Decimal	Hex
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

Converting Bytes to Hexadecimal

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128	64	32	16	8	4	2	1		
0	1	0	1	1	0	1	1		
0	64	0	16	8	0	2	1	=	91

8	4	2	1	
0	4	0	1	= 5

5

8	4	2	1	
8	0	2	1	= 11

B

Converting Bytes to Hexadecimal

128	64	32	16	8	4	2	1		
0	1	0	1	1	0	1	1		
0	64	0	16	8	0	2	1	=	91

8	4	2	1	
0	4	0	1	= 5

5

8	4	2	1	
8	0	2	1	= 11

B

Hexadecimal to Byte

5 B

8	4	2	1	
0	1	0	1	= 5
0	4	0	1	

8	4	2	1	
1	0	1	1	= 11
8	0	2	1	

Hexadecimal to Byte

FLATIRON INFOSEC

5

8	4	2	1	
0	1	0	1	= 5
0	4	0	1	

B

8	4	2	1	
1	0	1	1	= 11
8	0	2	1	

128	64	32	16	8	4	2	1
0	64	0	16	8	0	2	1

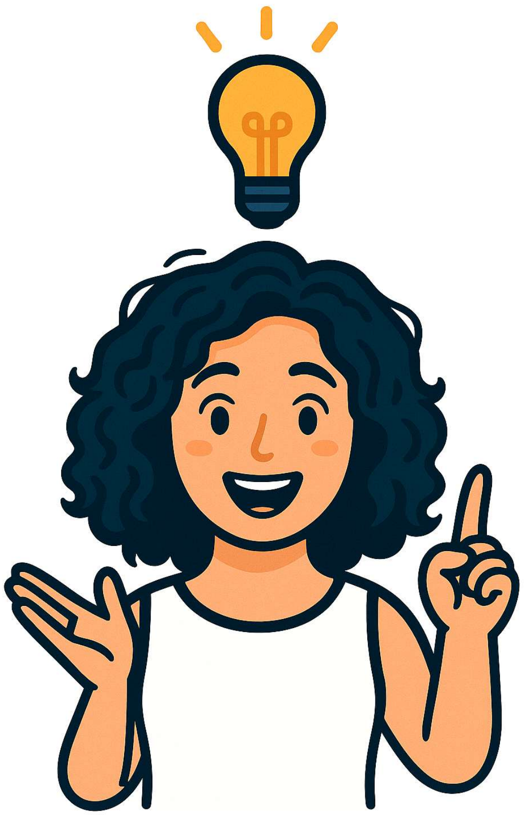
Numbering Systems!!!

Binary
- Base 2

Decimal
- Base 10

Hexadecimal
- Base 16

Byte
- Base 256



Larger Decimal Numbers

2 - byte values for numbers up to 65,535

128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
1	1	0	0	1	1	1	0	0	1	1	0	1	0	1	1
128	64	0	0	8	4	2	0	0	64	32	0	8	0	2	1

206 x 256 = 52,736 + 107 = 52,843

32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
1	1	0	0	1	1	1	0	0	1	1	0	1	0	1	1
32768	16384	0	0	2048	1024	512	0	0	64	32	0	8	0	2	1

32768 + 16384 + 2048 + 1024 + 512 + 64 + 32 + 8 + 2 + 1 = 52,843

Even Larger Decimal Numbers

4-byte values for numbers up to 4,294,967,295

The takeaway is that every bit added to the string doubles the size of the numbers we can represent!

16-byte numbers have 340 undecillion unique numbers!

ASCII

American Standard Code for Information Interchange

Turns numbers into “printable characters”

1, 2, 3, 4, etc.

a, b, c, d, etc.

A, B, C, D, etc.

!, @, #, $, etc.

Space bar, Esc key, Backspace, etc.

Thanks for Joining Us

Don't forget we have a Networking Class coming in 2026!