MOTIVATION

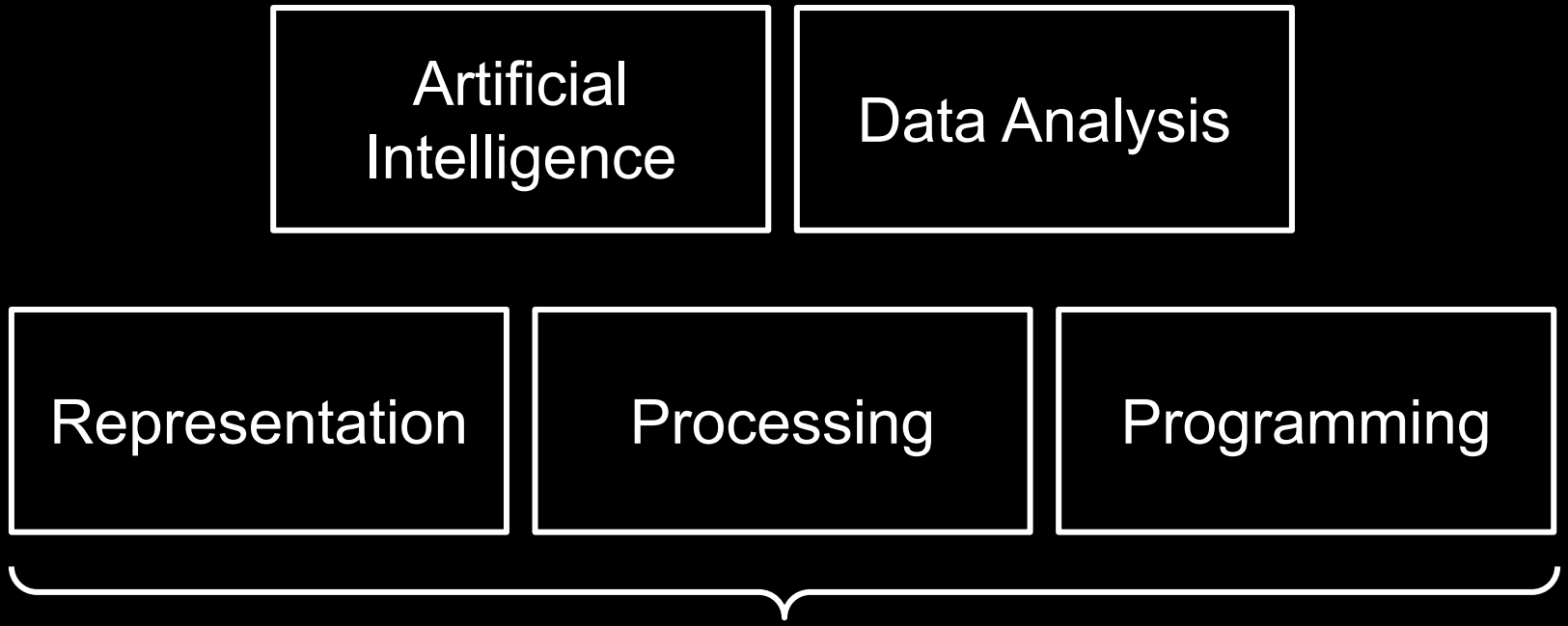
Artificial Intelligence

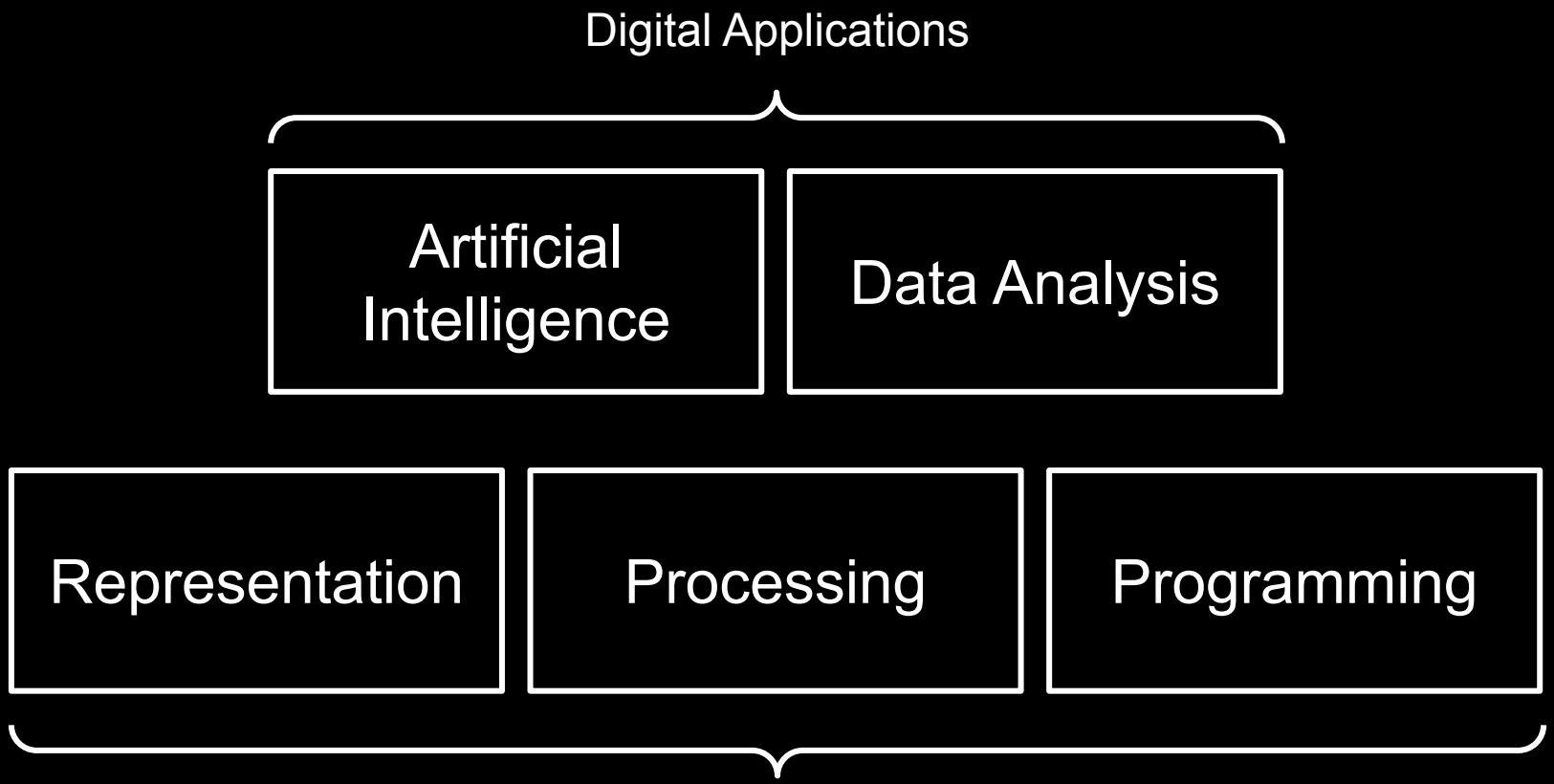
Data Analysis

Representation

Processing

Programming

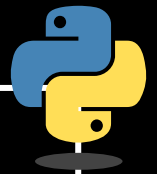

Artificial Intelligence
Data Analysis
Representation
Processing
Programming
Digital Fundamentals


Digital Applications
Artificial Intelligence
Data Analysis
Representation
Processing
Programming
Digital Fundamentals

Digital Applications

Artificial Intelligence

Data Analysis



Representation

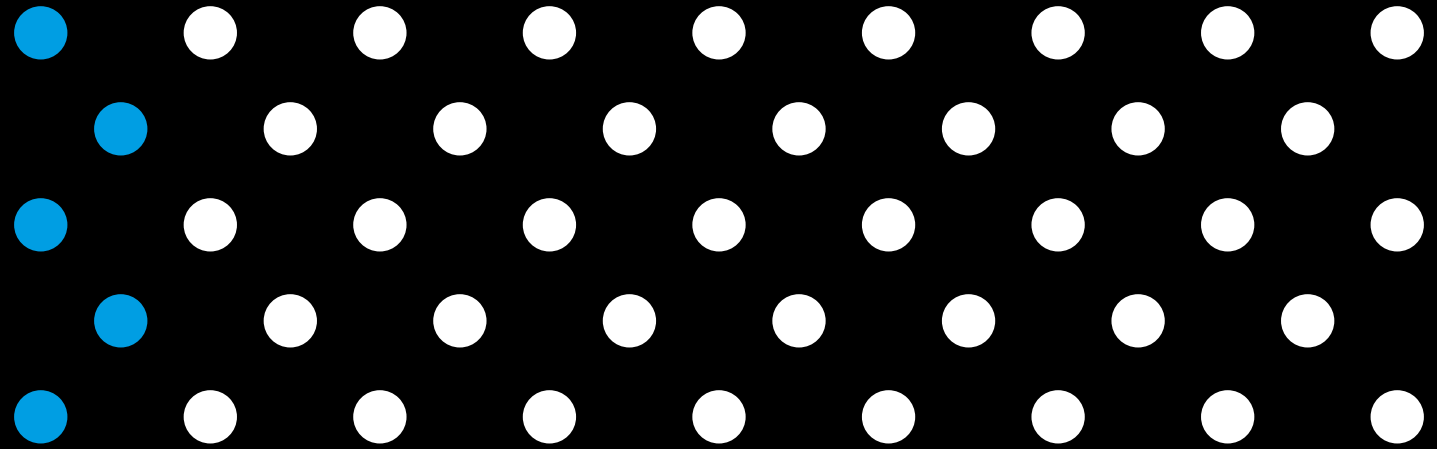
Processing

Programming

Digital Fundamentals

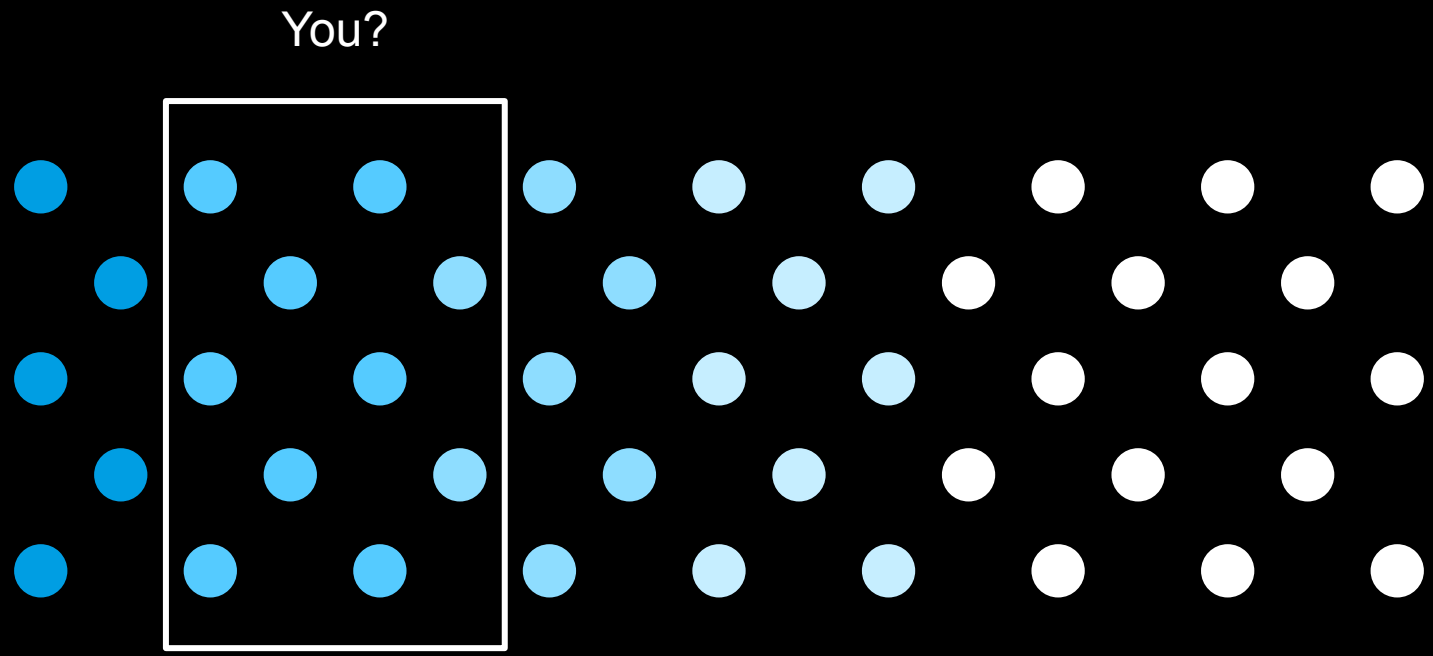
A few experts

Digitally uneducated society



Digitally illiterate society with a few experts

Collective Understanding

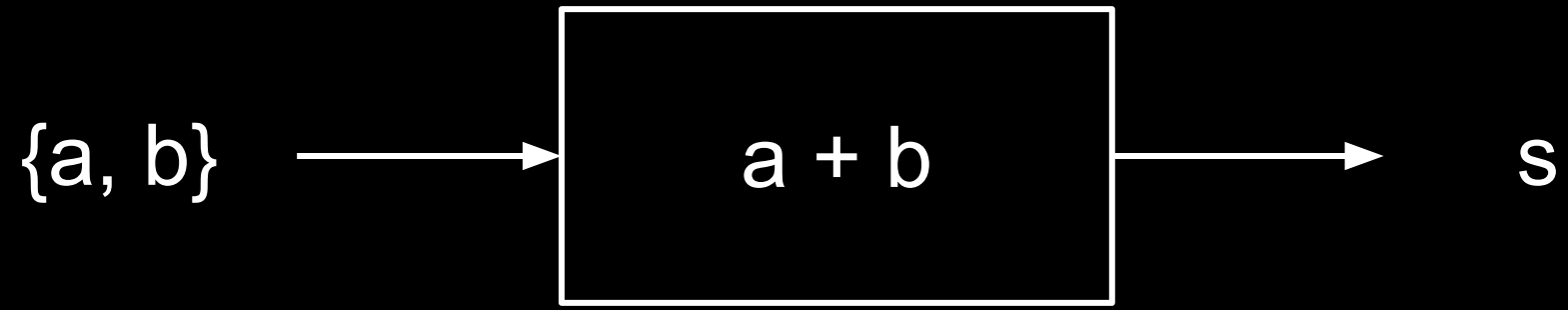


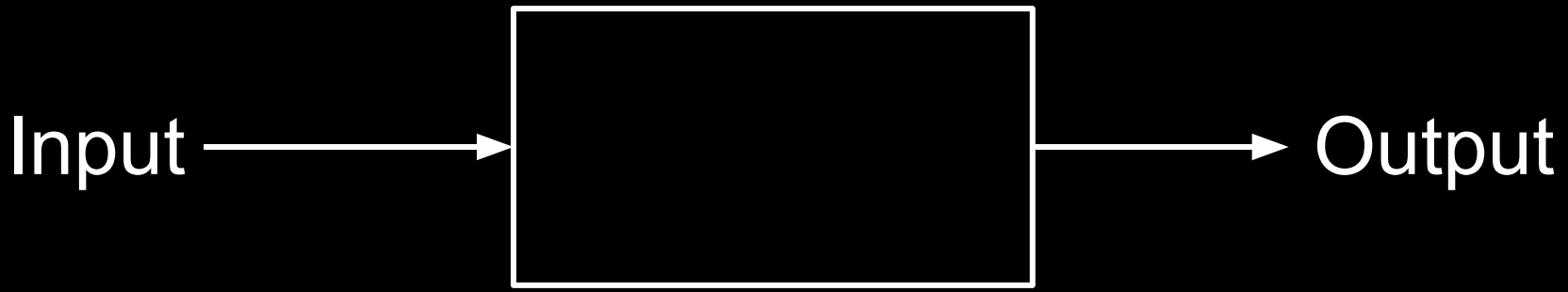
Society with a distributed and high degree of digital education

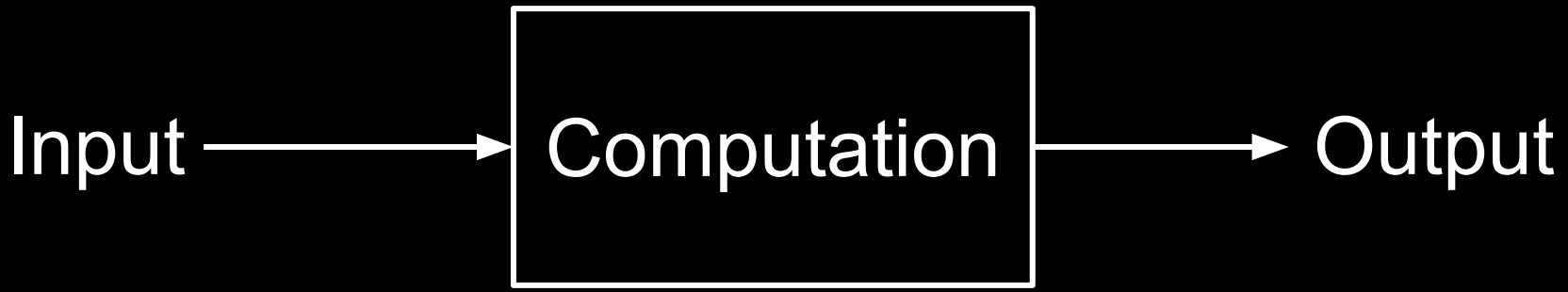
PROBLEM SOLVING

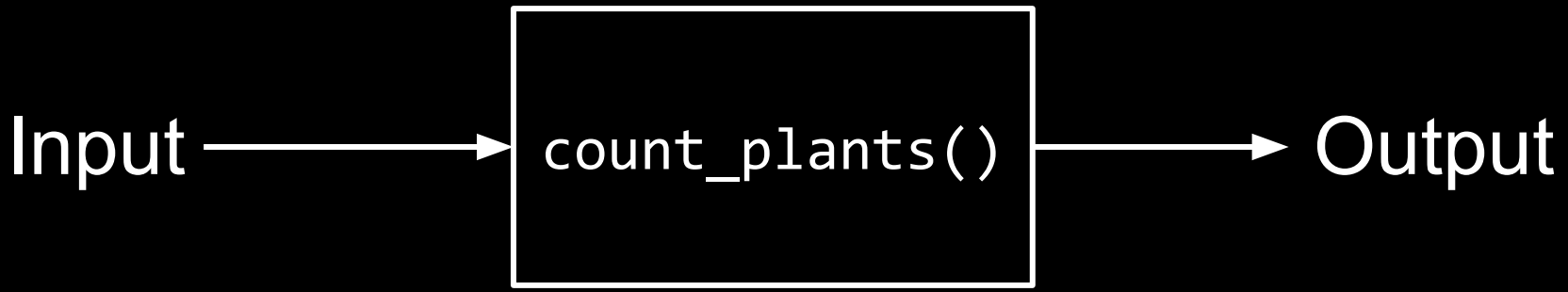
A Model for Solving Problems

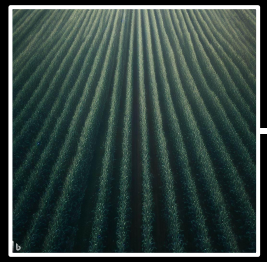
A Model for Solving Problems

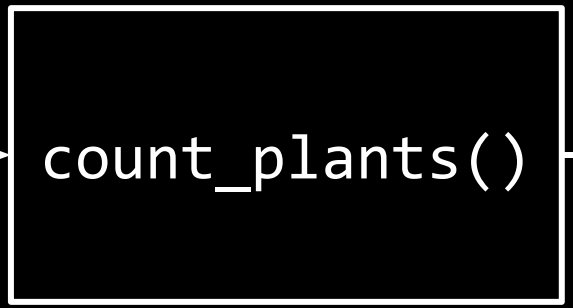



Input
Output


Input
Computation
Output

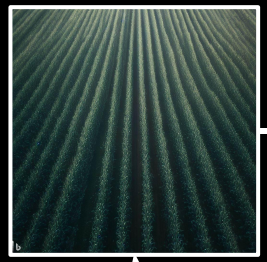

Input
count_plants()
Output





42

Processing of information

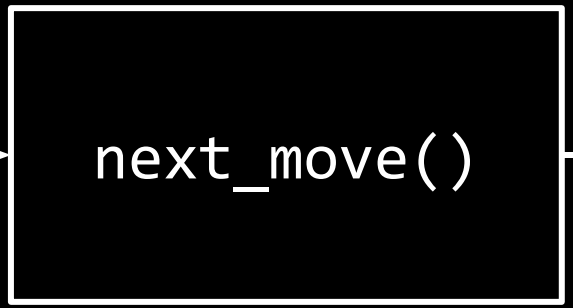


```
count_plants()
```

42

Representation of information

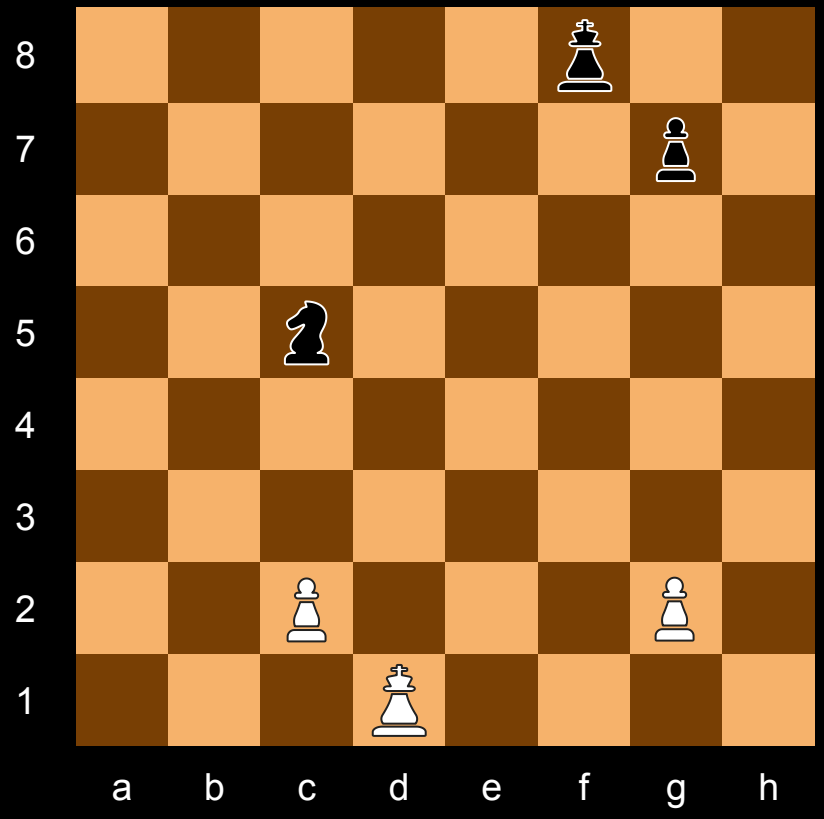

Input
ChatGPT
Output

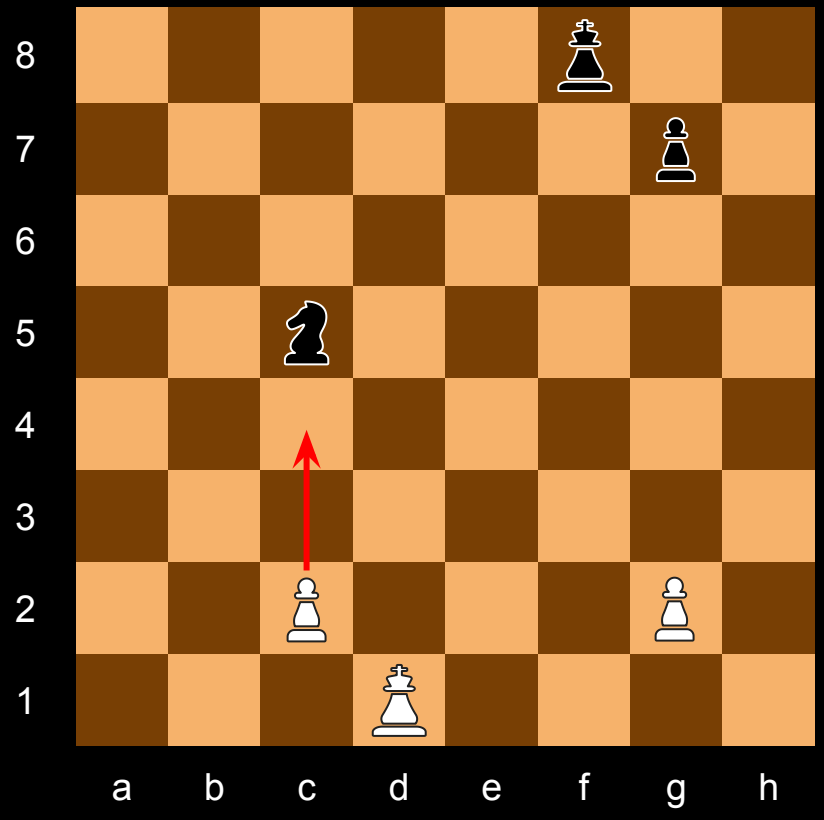


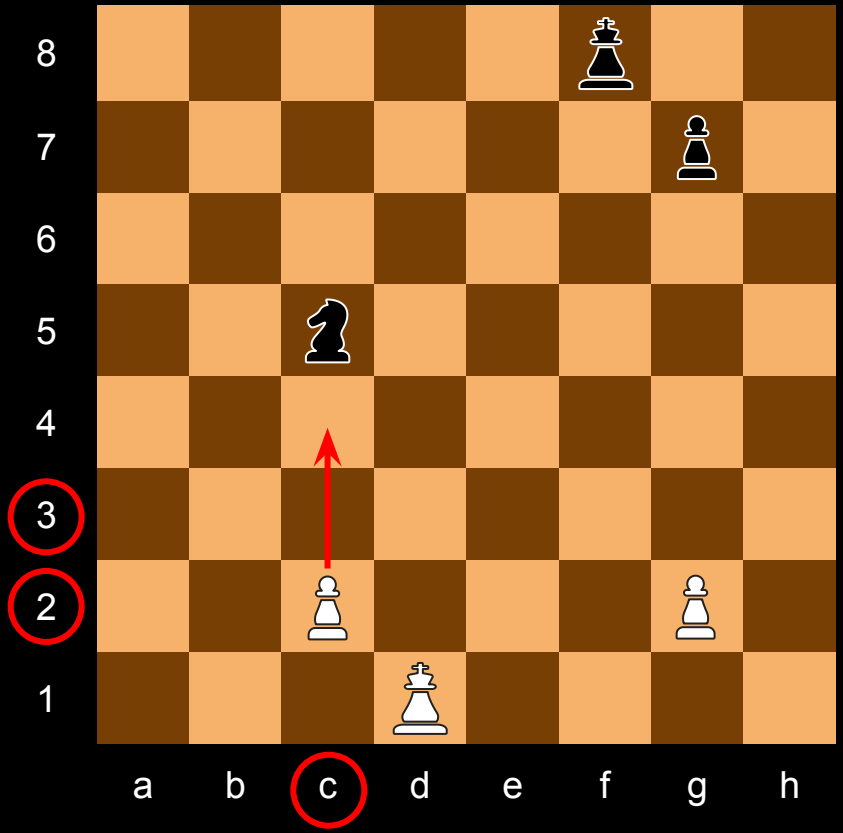
E2 → E4

INFORMATION

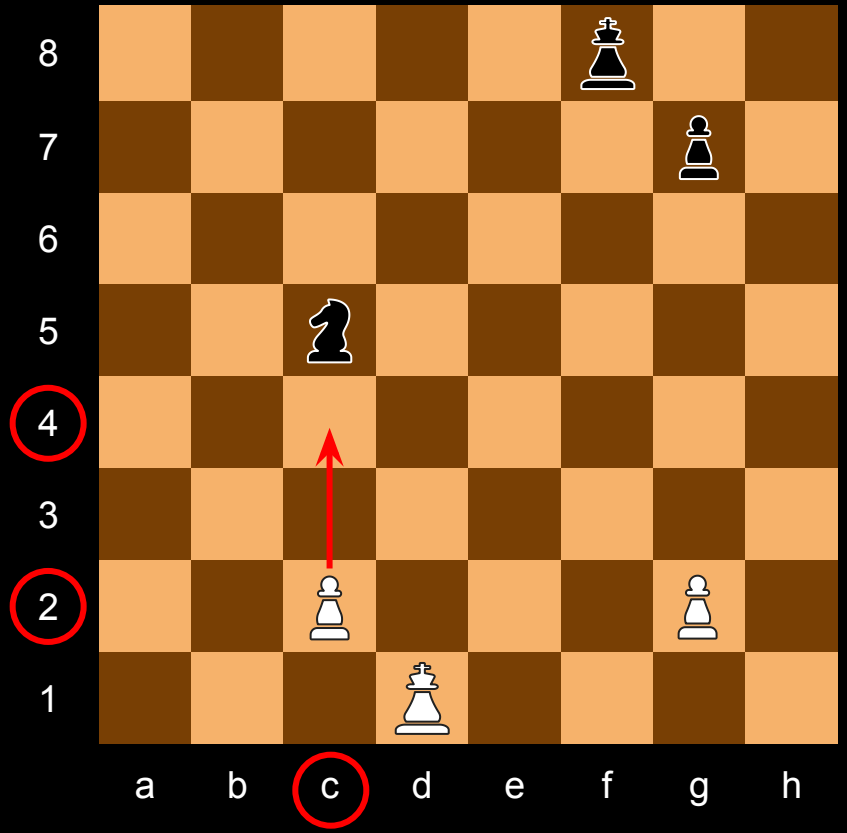
Image created with DALLE-3


8
7
6
5
4
3
2
1
a b c d e f g h

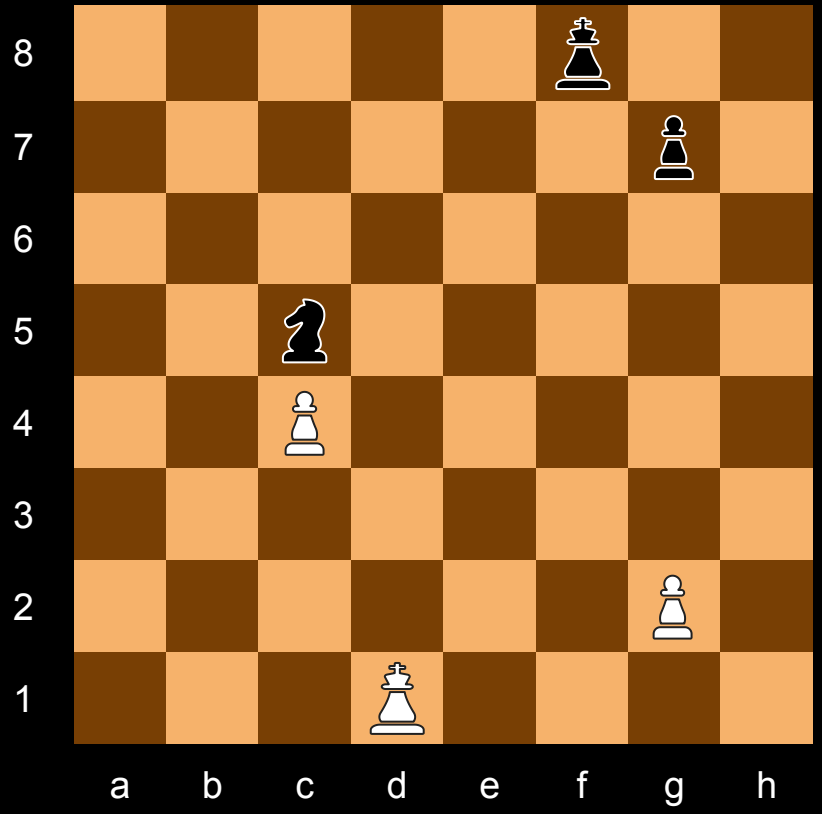

8
7
6
5
4
3
2
1
a b c d e f g h


8
7
6
5
4
3
2
1
a
b
c
d
e
f
g
h

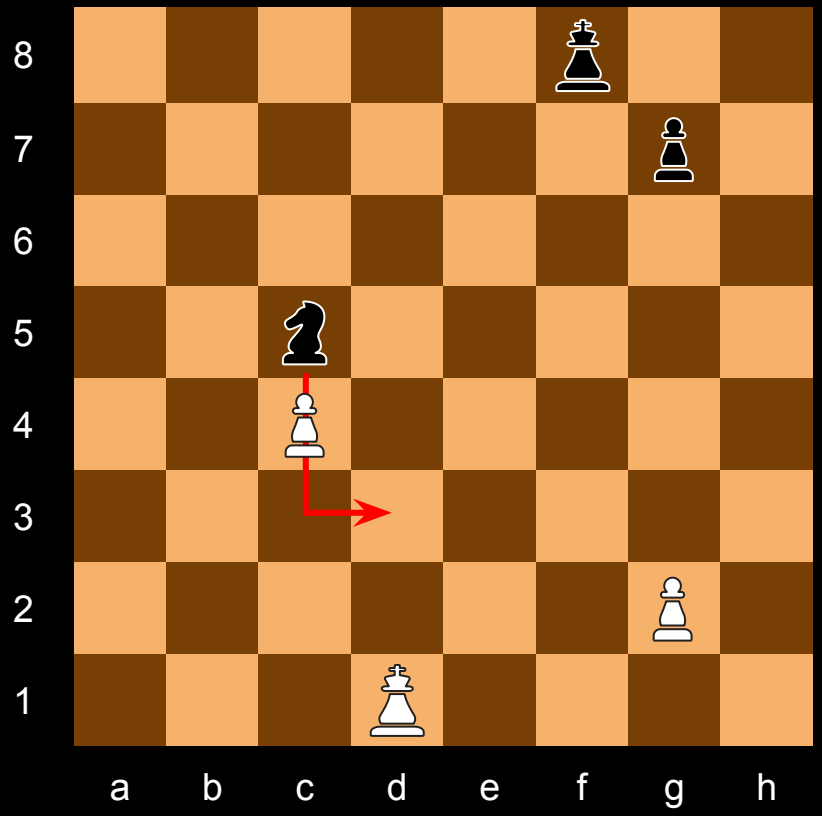
c2 → c4



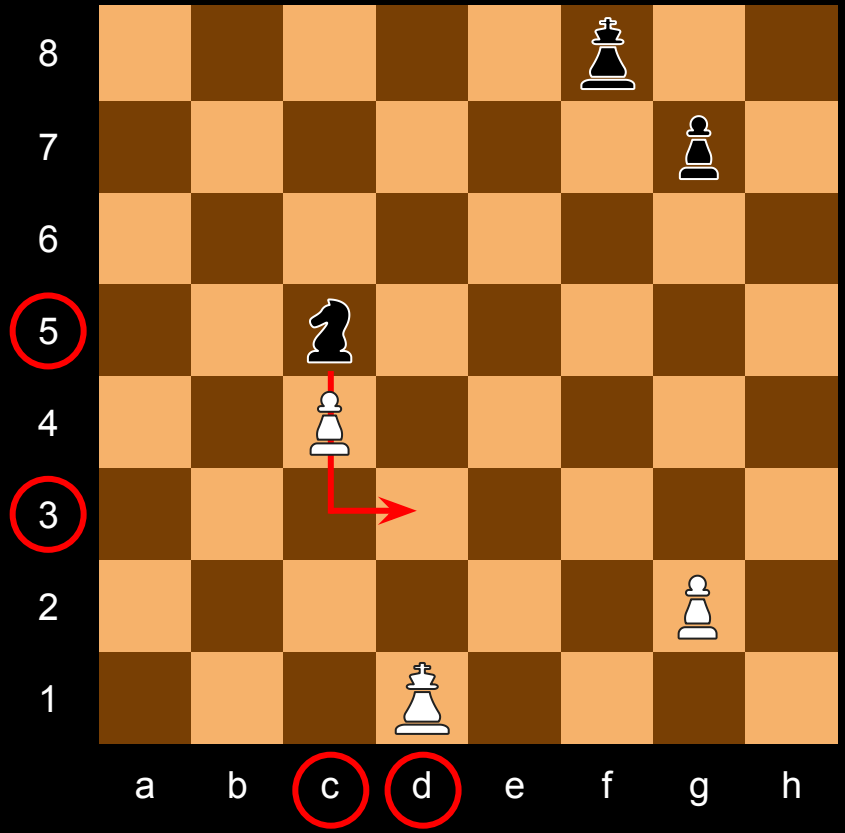
c2 → c4



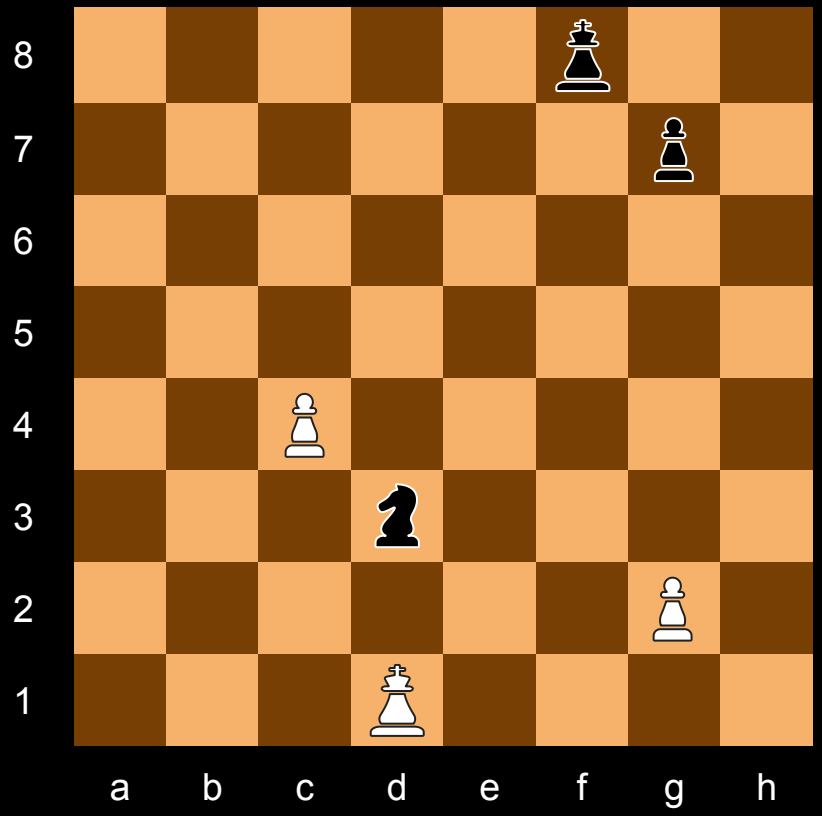
c2 → c4

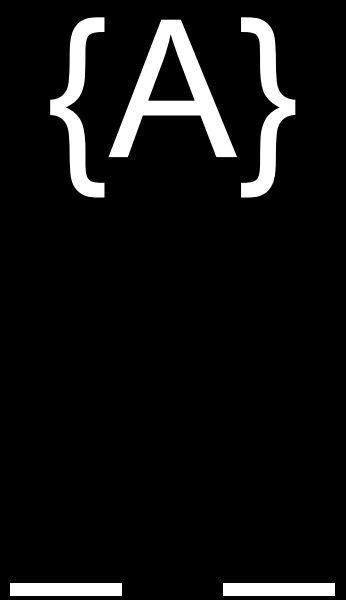


c2 → c4
c5 → d3



c2 → c4
c5 → d3
…




{A}

{A}

A A

{A, B}

_ _

{A, B}

A A

{A, B}

A B

{A, B}

B A

{A, B}

B B

{A, B, C}

_ _ _

{A, B, C}

_ _

{A, B, C}

AA, AB, BA, BB,
AC, BC, CA, CB, CC

{A, B, C, D}

_ _

{A, B, C, D}

AA, AB, BA, BB, AC, BC, CA, CB,
CC, AD, DA, BD, DB, CD, DC, DD

{A, B, C, D, E}

_ _

{A, B, C, D, E}

AA, AB, BA, BB, AC, BC, CA, CB, CC,
AD, DA, BD, DB, CD, DC, DD, AE, EA,
BE, EB, CE, EC, DE, ED, EE

with length n = 2

# symbols	# messages
1	1
2	4
3	9
4	16
5	25

with length n = 2

# symbols		# messages
1		1
2	f(x)	4
3	→	9
4		16
5		25

COUNTING

1 2 3

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

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

$= 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$

$= 1 \times 100 + 2 \times 10 + 3 \times 1$

$= 123$

4	1	2	3
?	10^2	10^1	10^0

4	1	2	3
?	10^2	10^1	10^0

$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

4	1	2	3
?	10^2	10^1	10^0

$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$

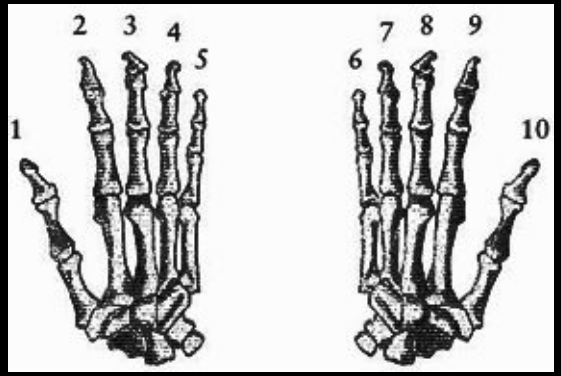
$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$

4	1	2	3
?	10^2	10^1	10^0

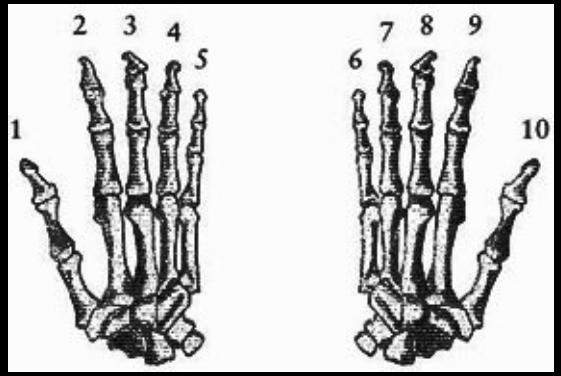
$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$

$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$

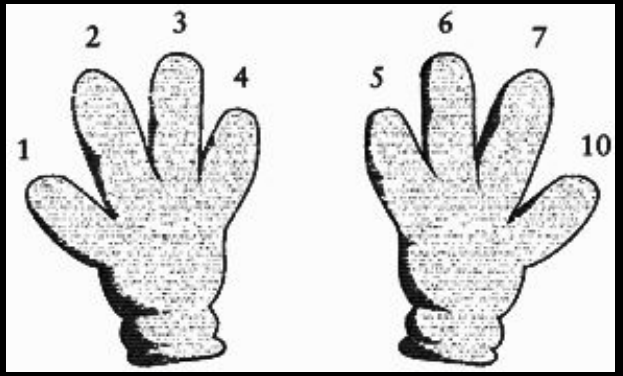
$= 4123$



Human Hand



Human Hand



Cartoon Character’s Hand

1 2 3 (octal)

1	2	3	(octal)
8^2	8^1	8^0	

1	2	3
8^2	8^1	8^0

(octal)

$$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$$

1	2	3
8^2	8^1	8^0

(octal)

$$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$$

$$= 1 \times 64 + 2 \times 8 + 3 \times 1$$

1	2	3
8^2	8^1	8^0

(octal)

$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$

$= 1 \times 64 + 2 \times 8 + 3 \times 1$

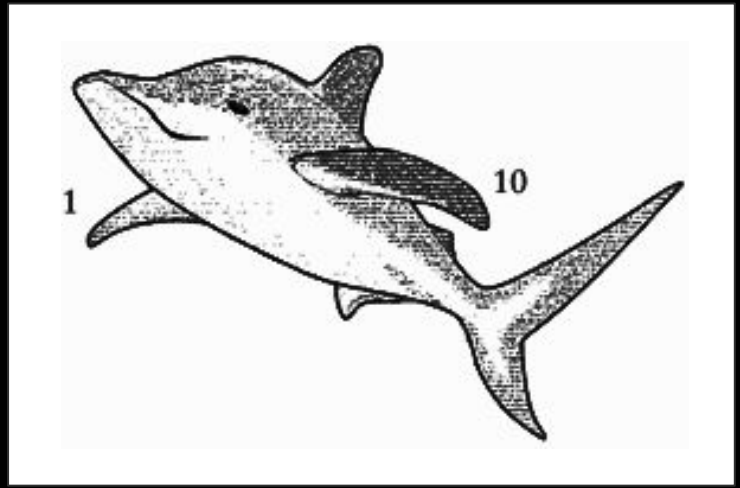
$= 83$ (decimal)


decimal
octal
8
?


decimal
octal
?
7


decimal
octal
16
?


decimal
octal
?
100



What now?

0, 1, …

0, 1, 10, …

0, 1, 10, 11, …

0, 1, 10, 11, 100, …

0, 1, 10, 11, 100, 101, …

0, 1, 10, 11, 100, 101, 110

1 1 0 (binary)

1	1	0	(binary)
2^2	2^1	2^0	

1	1	0
2^2	2^1	2^0

(binary)

$$= 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$

1 1 0 (binary)

2^2 2^1 2^0

$= 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$

$= 1 \times 4 + 1 \times 2 + 0 \times 1$

1	1	0	(binary)
2^2	2^1	2^0	

$= 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$

$= 1 \times 4 + 1 \times 2 + 0 \times 1$

$= 6$ (decimal)

2 3 4 5 6

0, 1, 10, 11, 100, 101, 110

Place Value Systems

$$N = d_n * R^{n-1} + \ldots + d_1 * R^1 + d_0 * R^0$$

$d \in \{ 0, 1, \ldots R-1 \}$

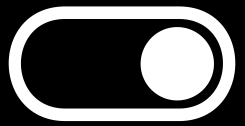
n = Number of digits

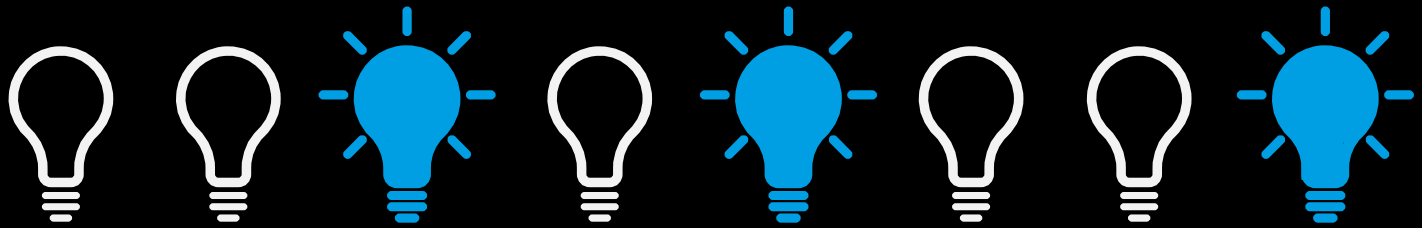
Place Value Systems

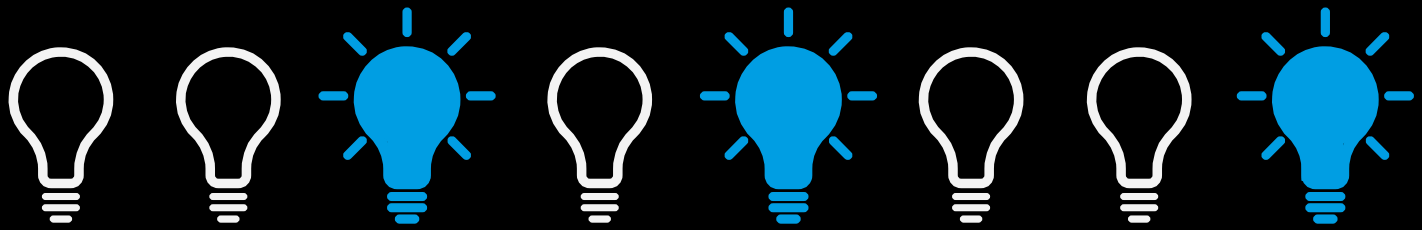
$$R \geq 2$$

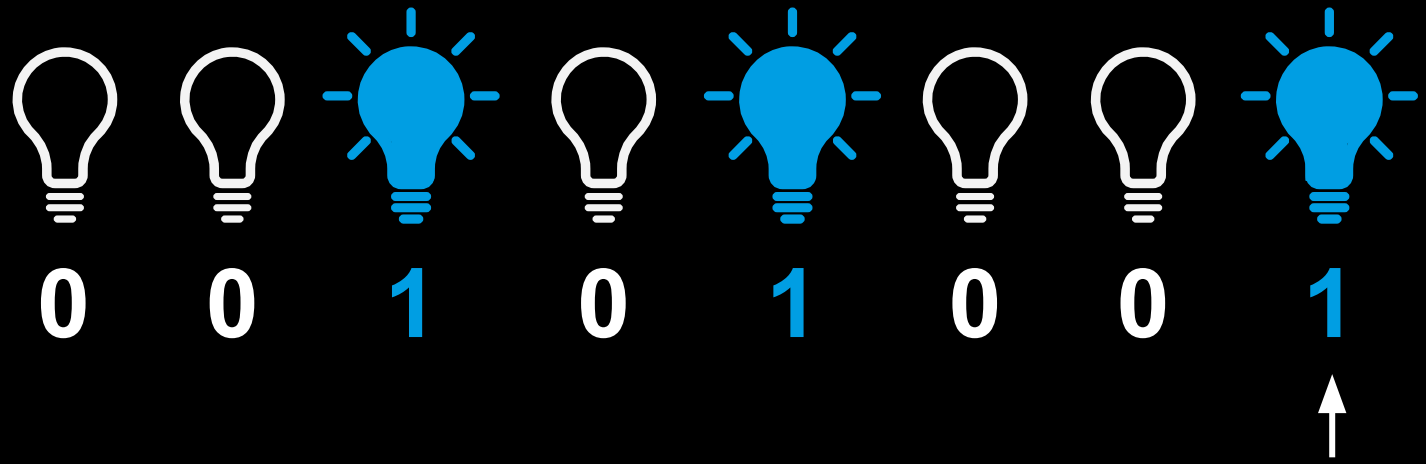
BITS

Why do computers think binary?

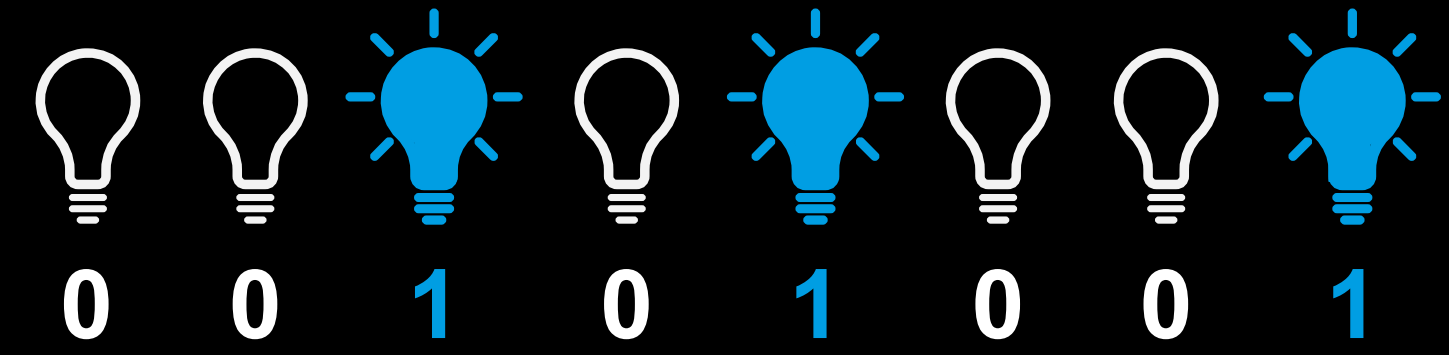





0 0 1 0 1 0 0 1

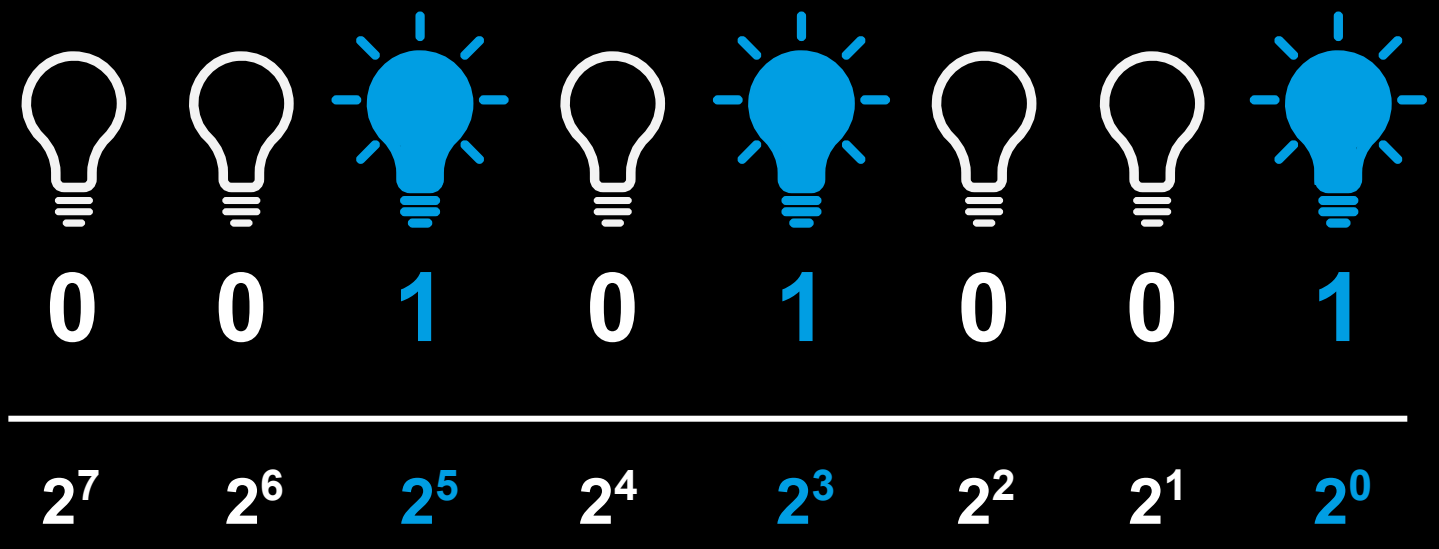


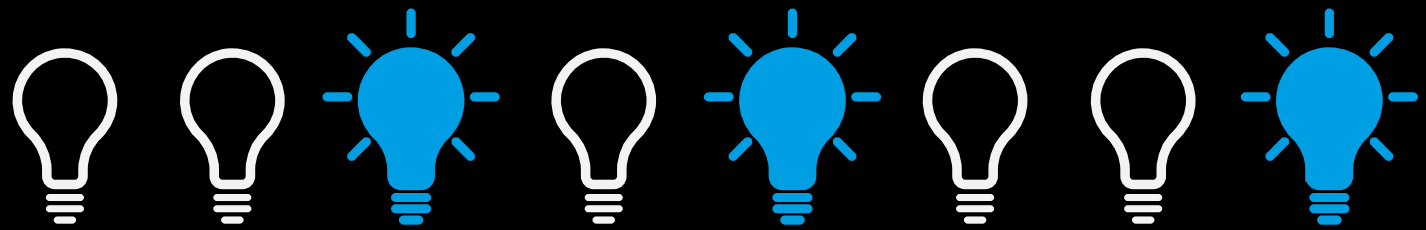
A **Bit** (binary digit)



A **Bit** (binary digit)

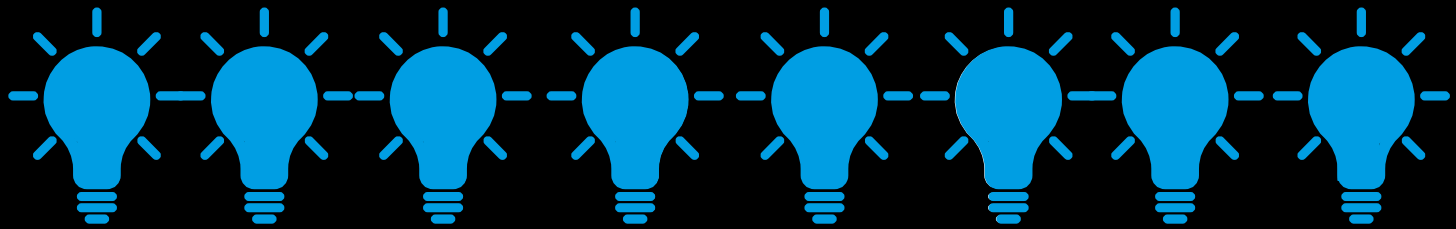
A **byte** (8 bits)


0 0 1 0 1 0 0 1
2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0



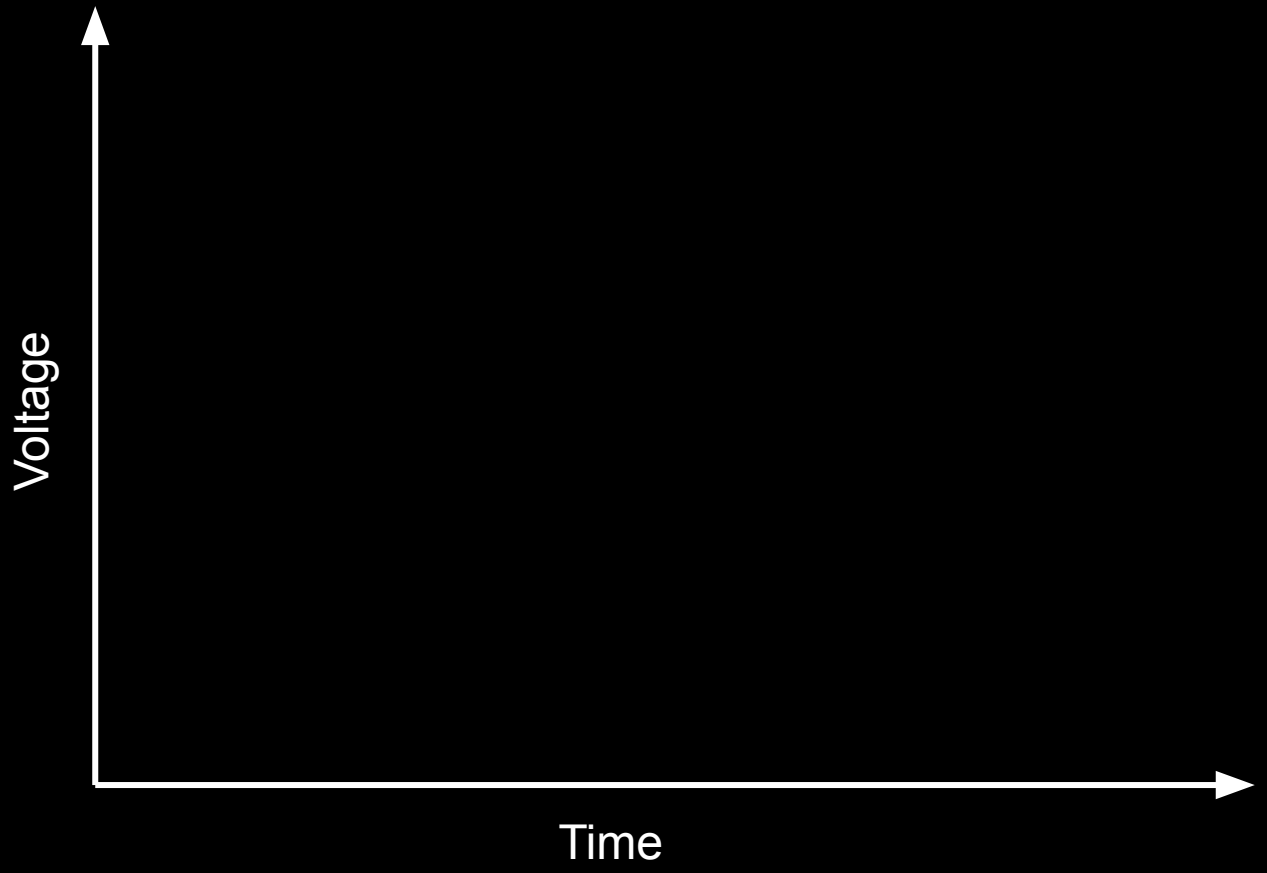
0	0	1	0	1	0	0	1

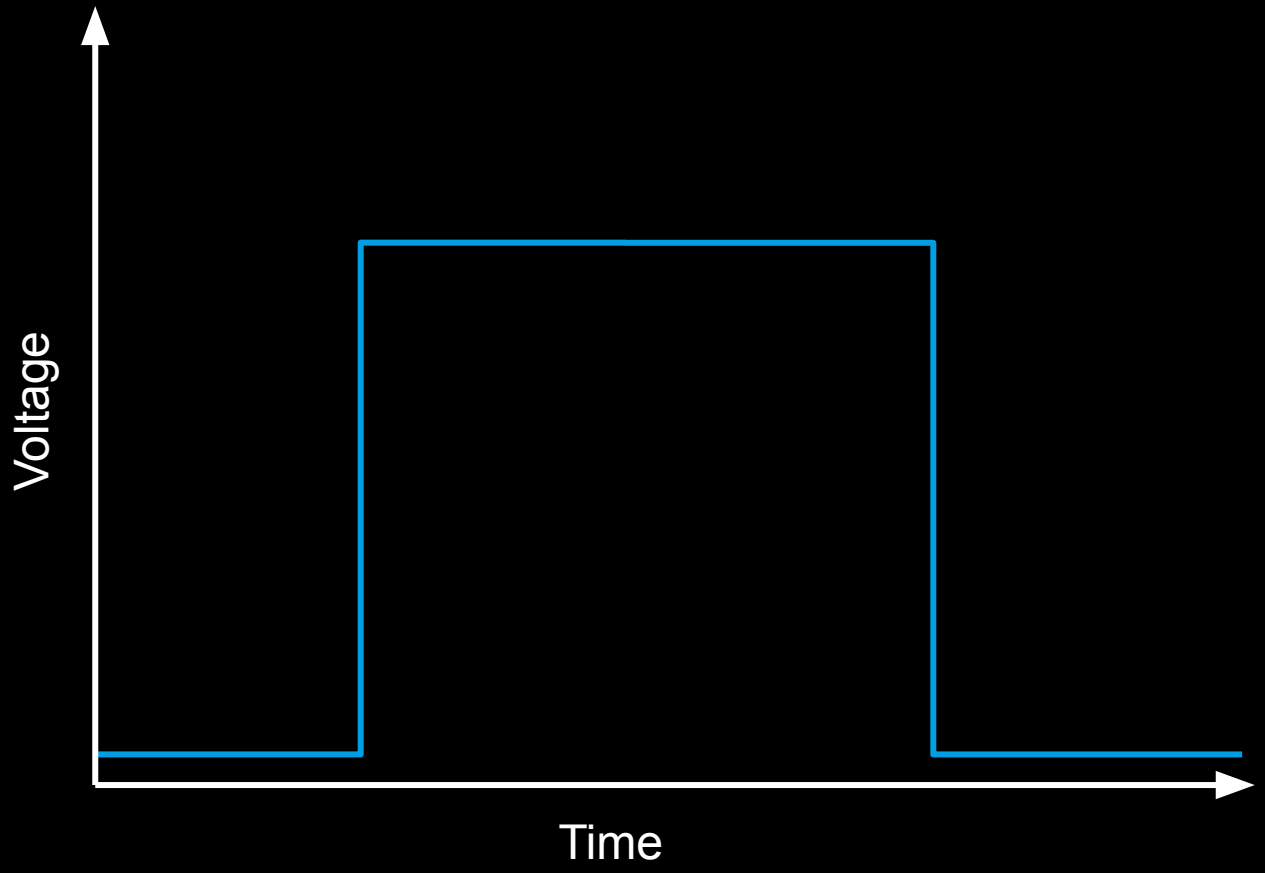
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

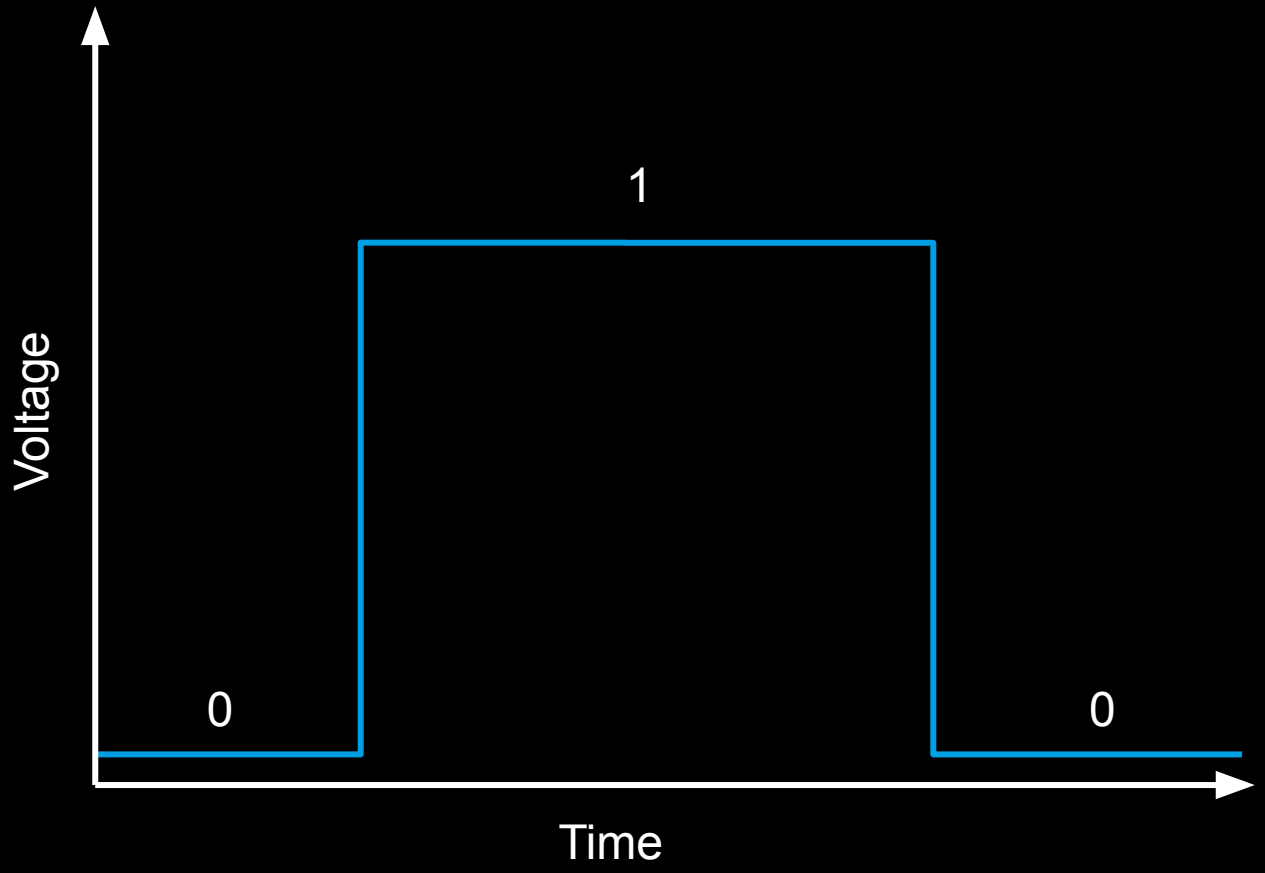


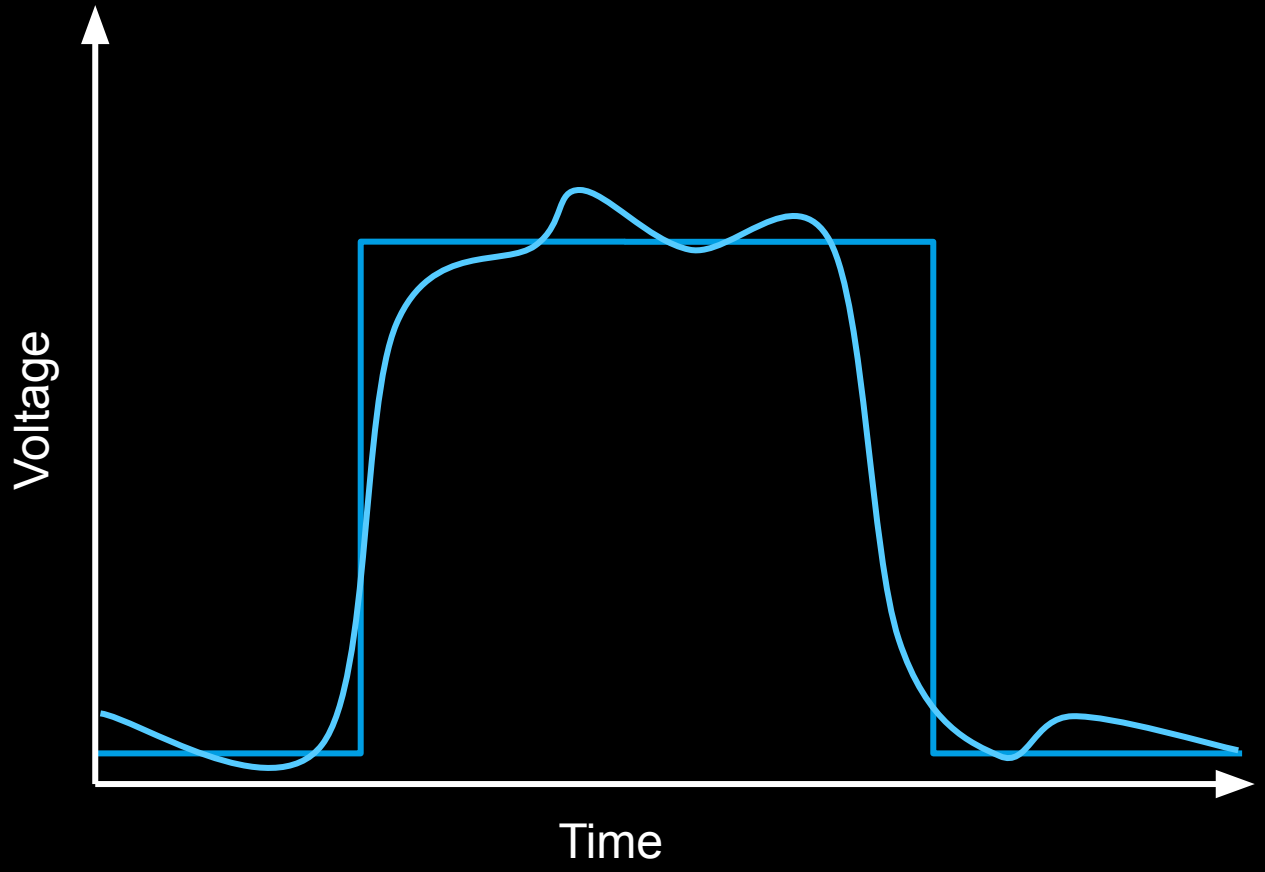
What can we store in one byte?

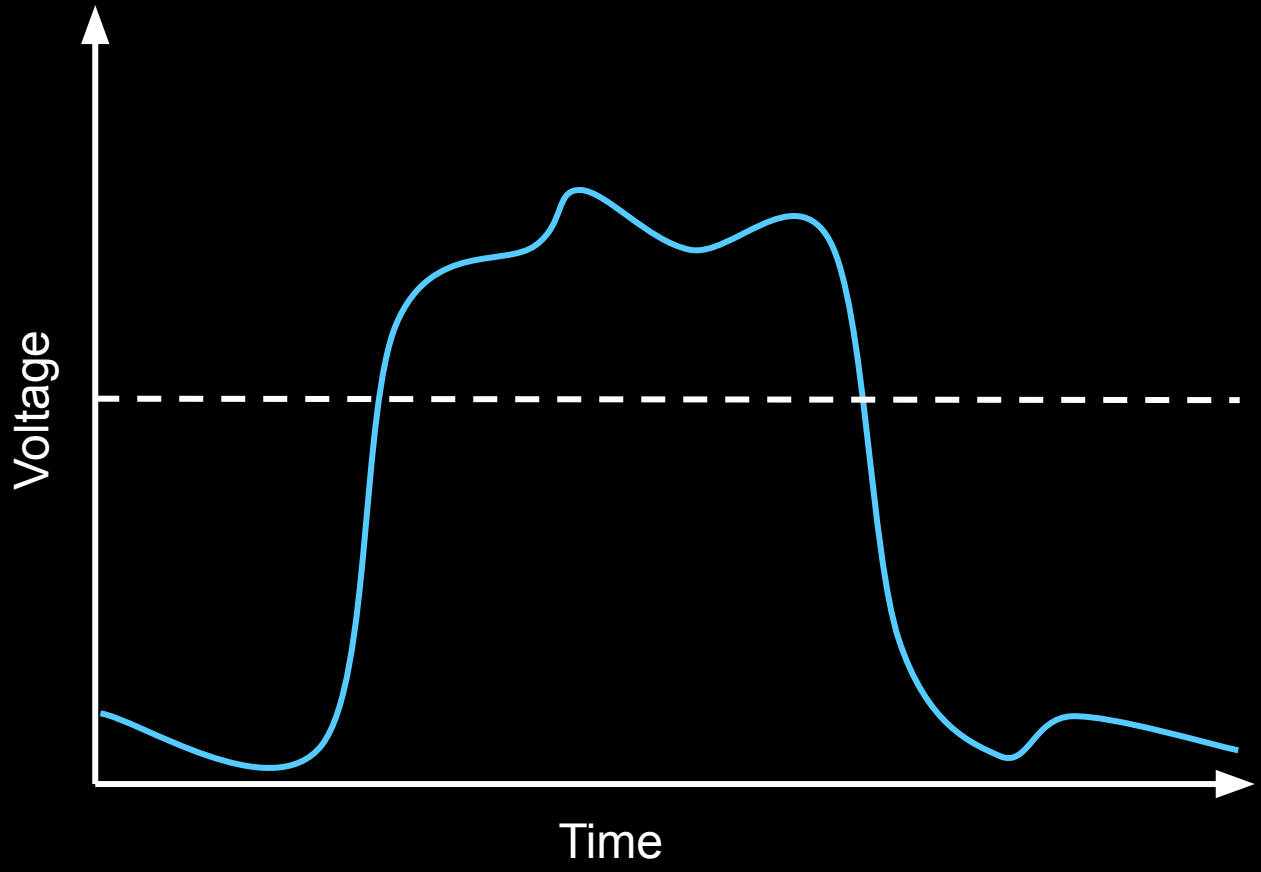
Are we stuck with binary?

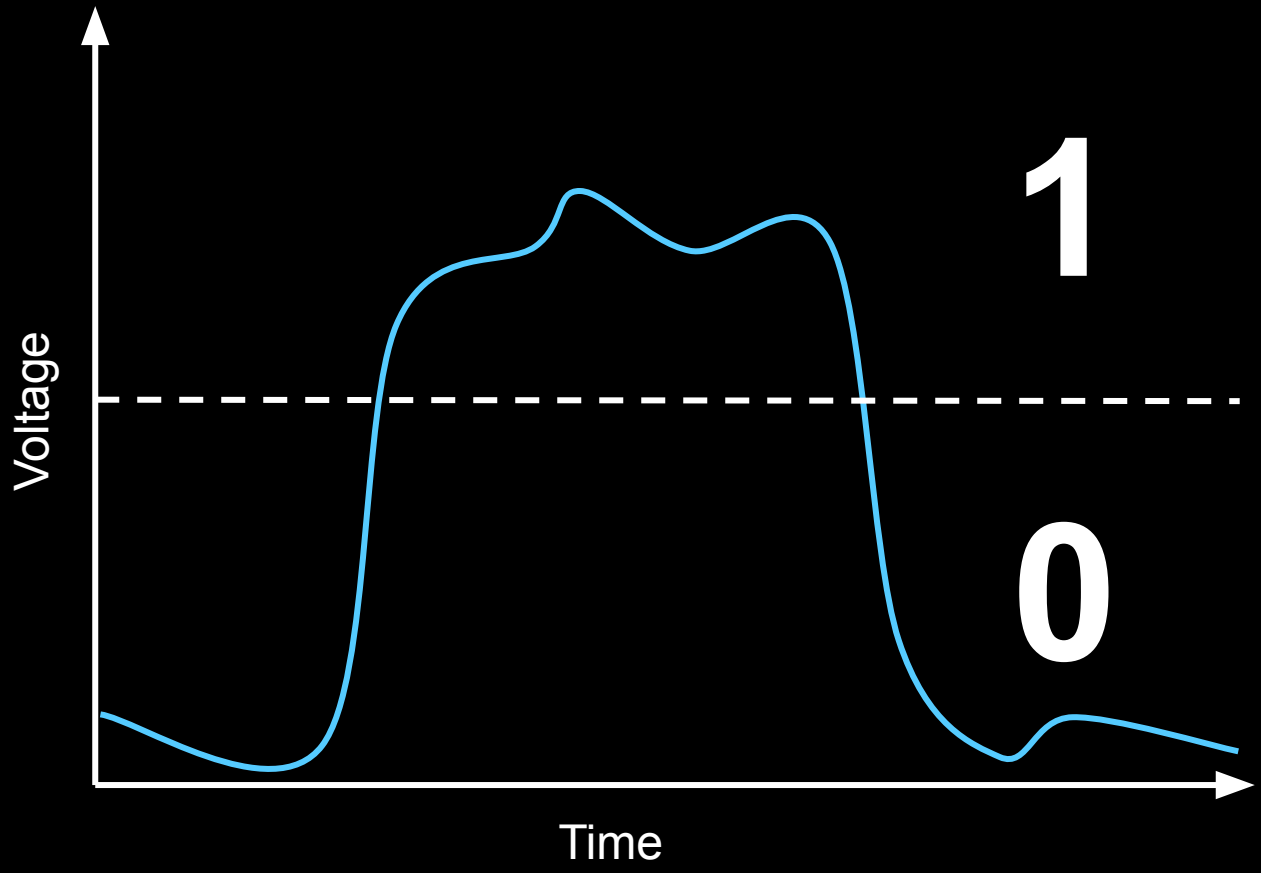

Voltage
Time

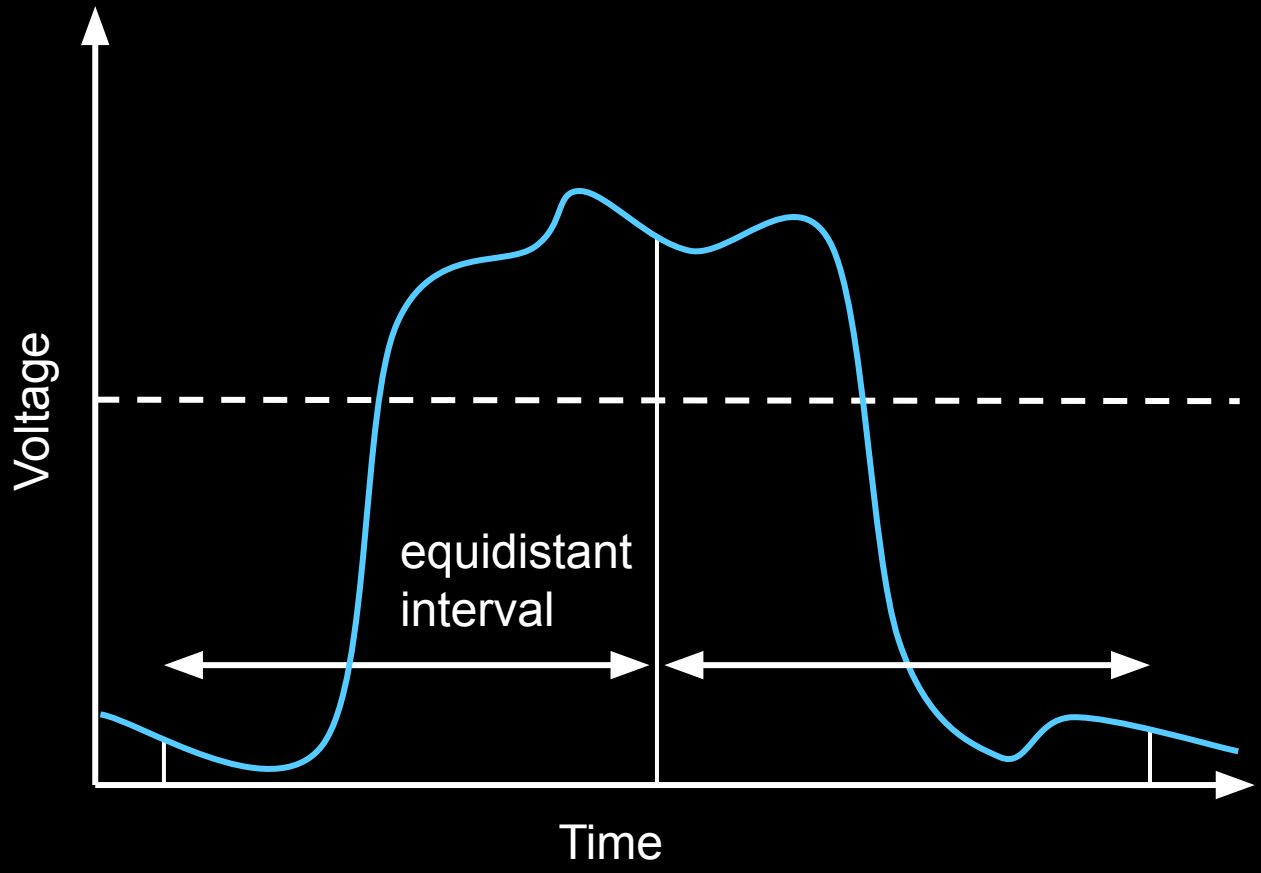

Voltage
Time

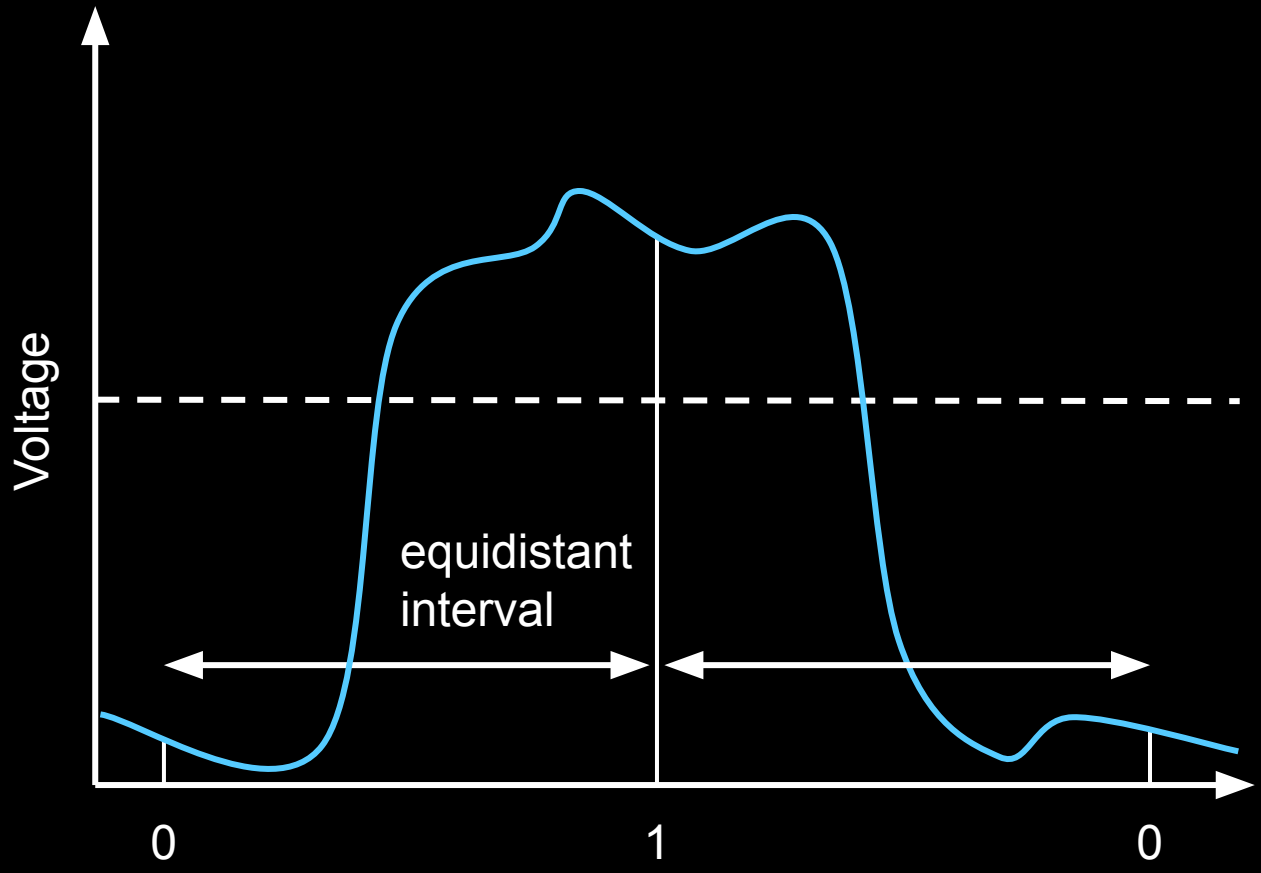

1
Voltage
0
0
Time


Voltage
Time


Voltage
Time

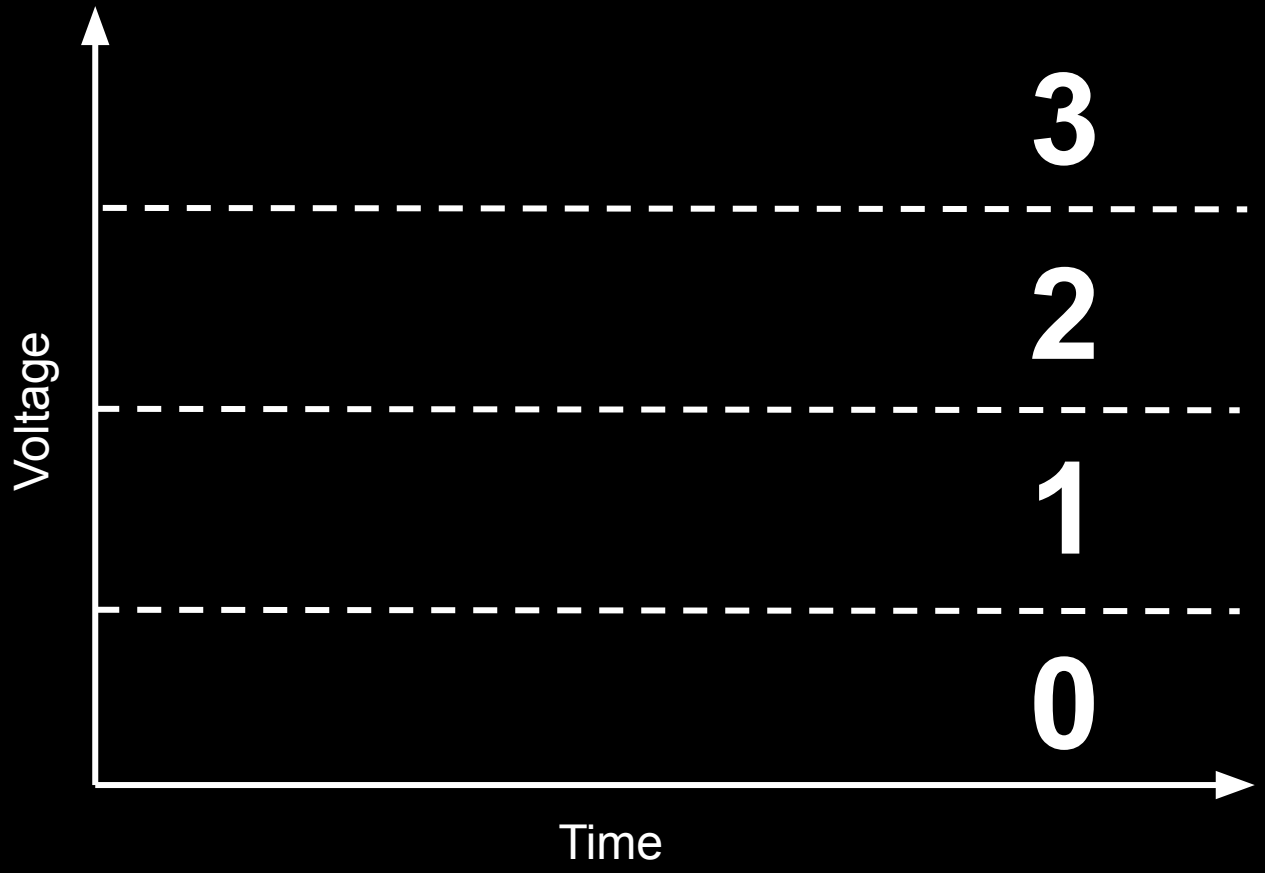

Voltage
Time
1
0

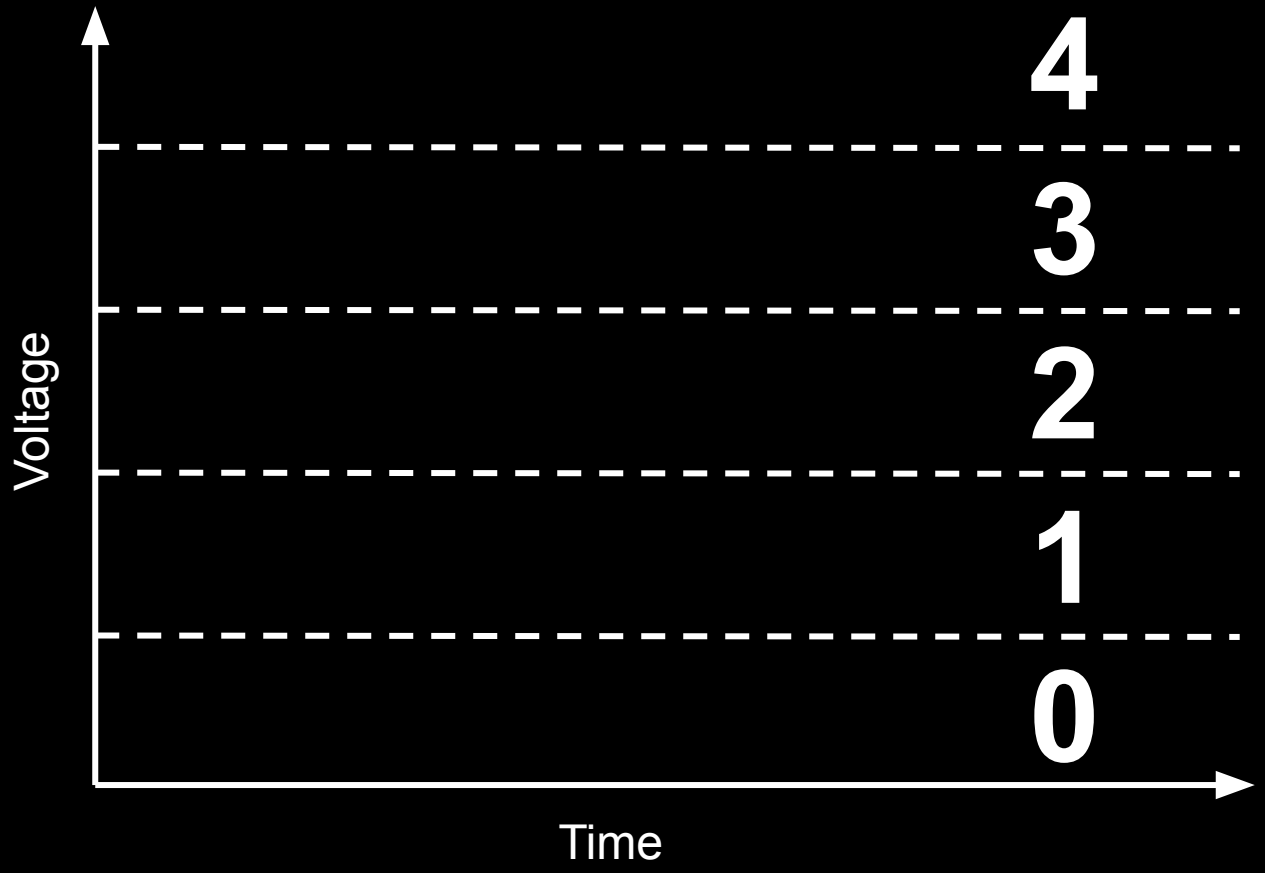

Voltage
equidistant
interval
Time

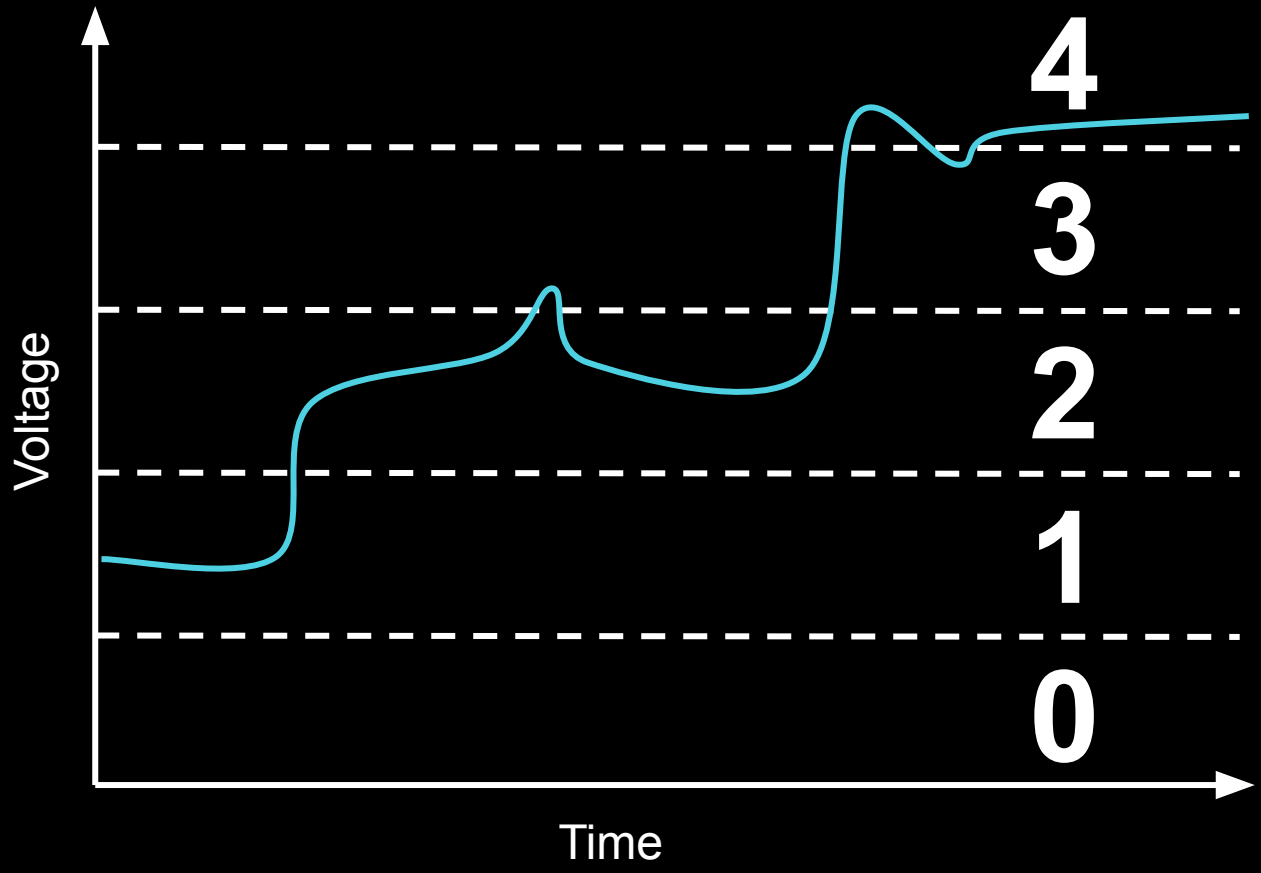

Voltage
equidistant
interval
0
1
0

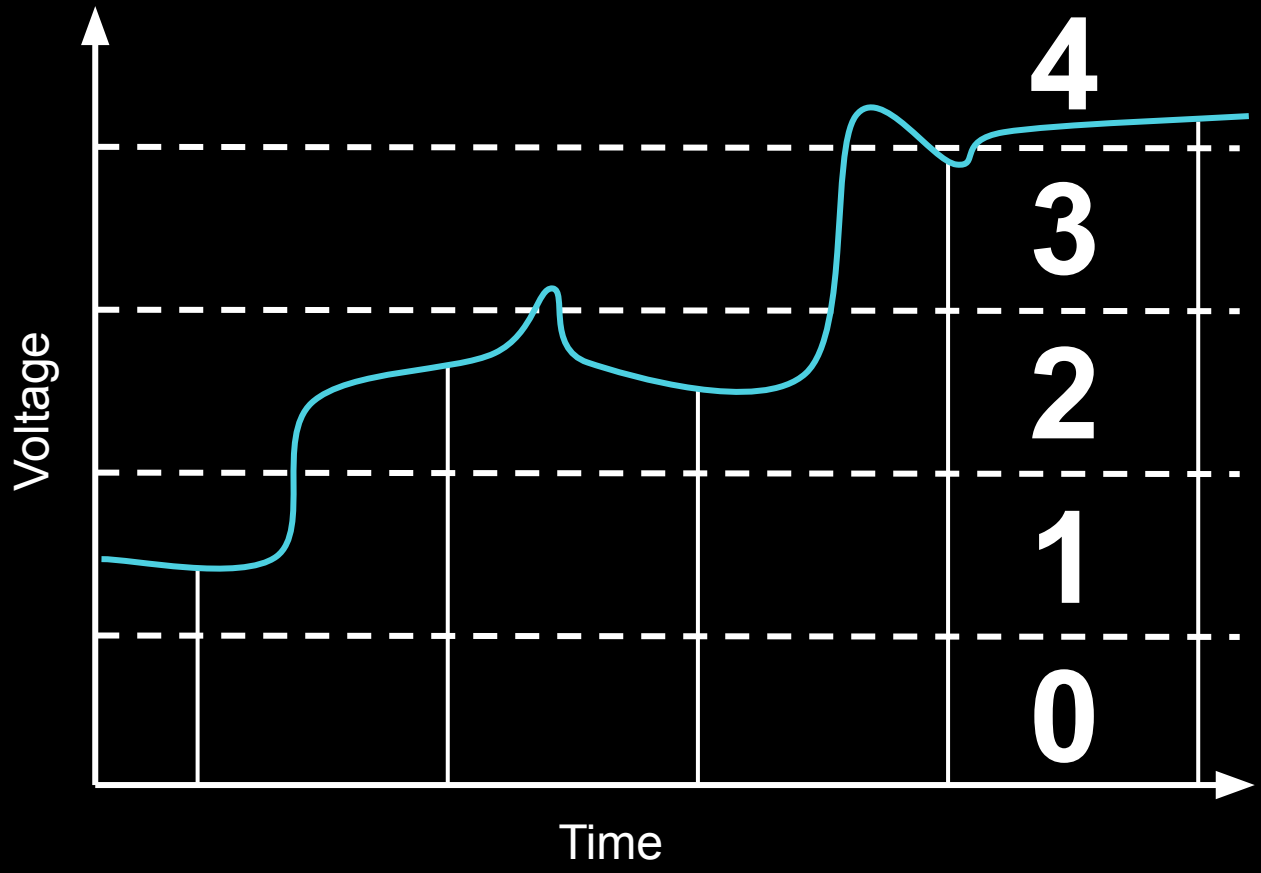
What about ternary?

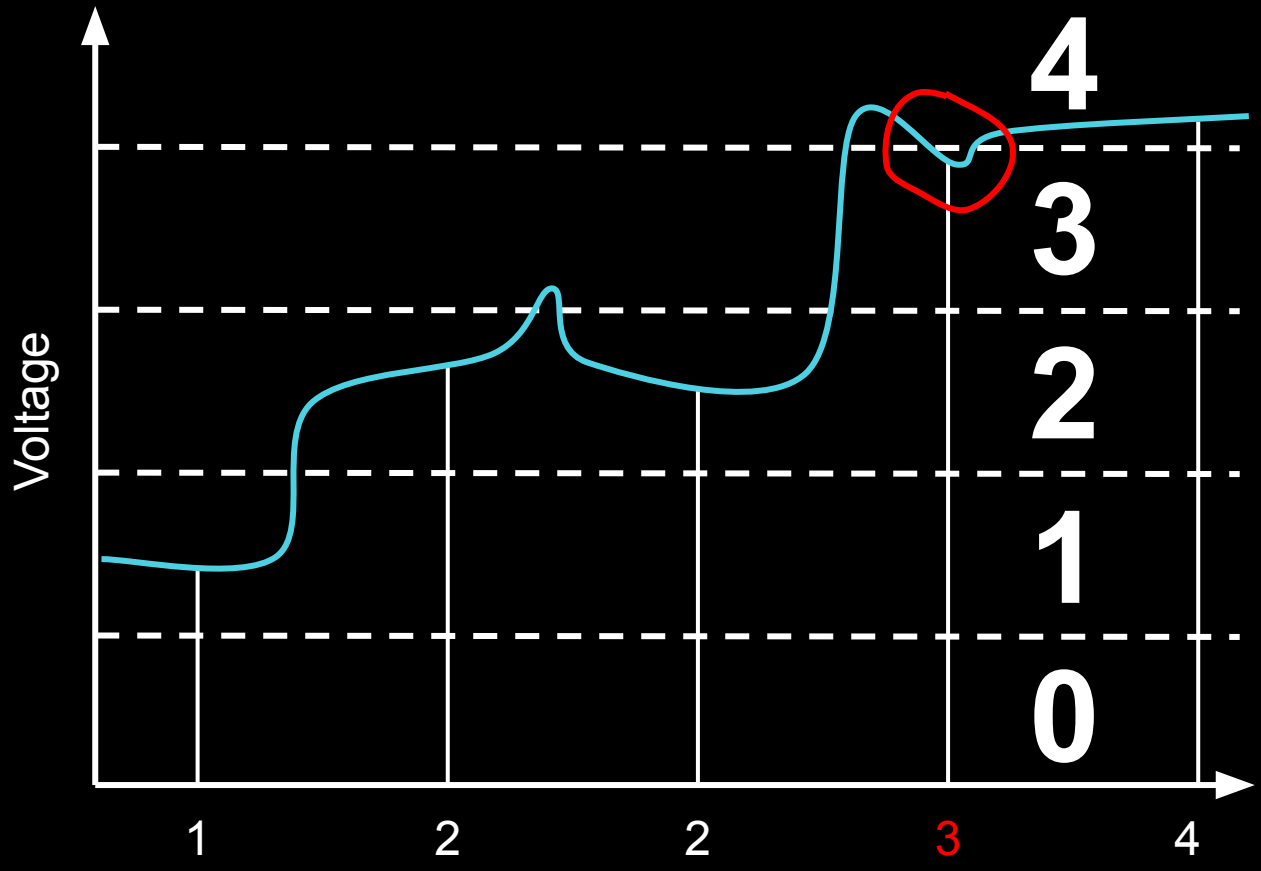

2
1
0
Voltage
Time


3
2
1
0
Voltage
Time

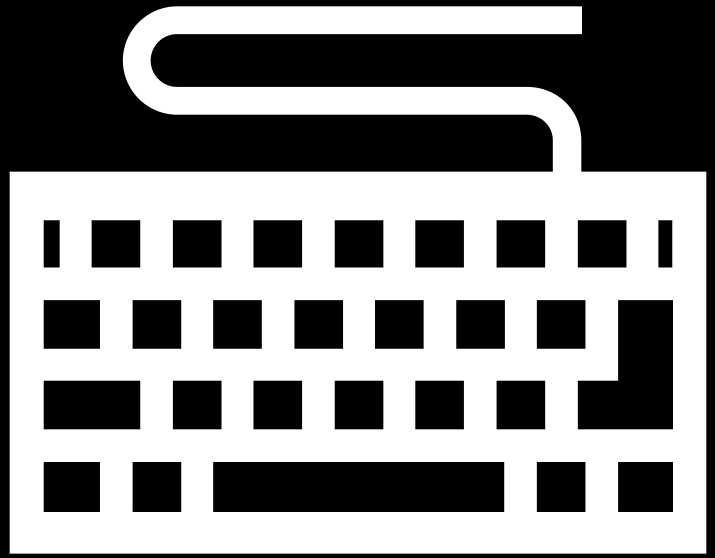

4
3
2
1
0
Voltage
Time


4
3
2
1
0
Voltage
Time


4
3
2
1
0
Voltage
Time


Voltage
4
3
2
1
0
1
2
2
3
4

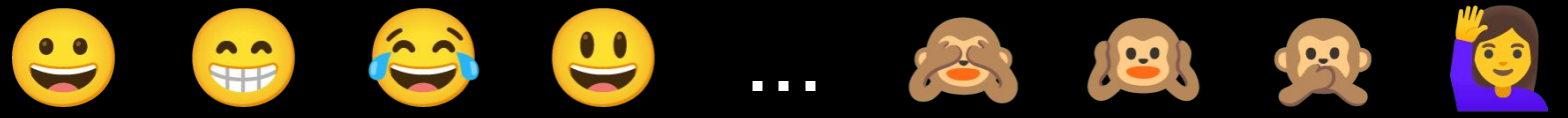
CODES



A	B	C	D	...	a	b	c	d
65	66	67	68		97	98	99	100

ASCII Code

A	B	C	D	...	a	b	c	d
65	66	67	68		97	98	99	100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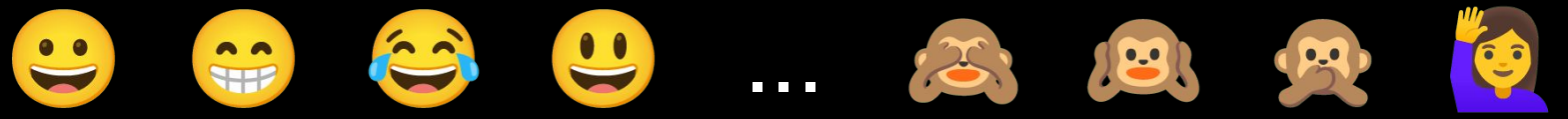
...
1F648
1F649
1F64A
1F64B

Unicode



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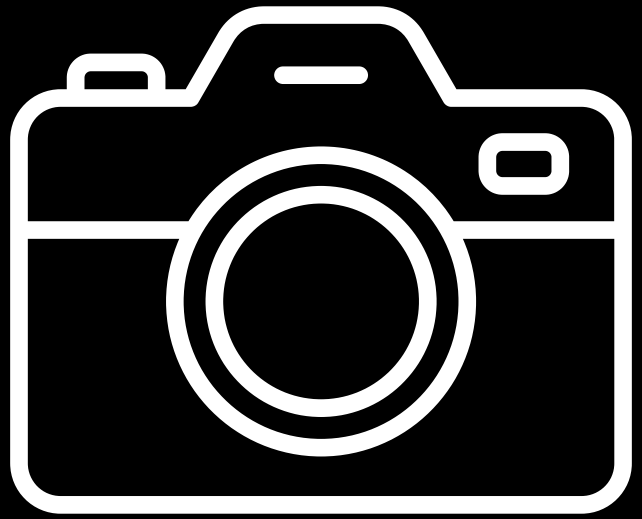
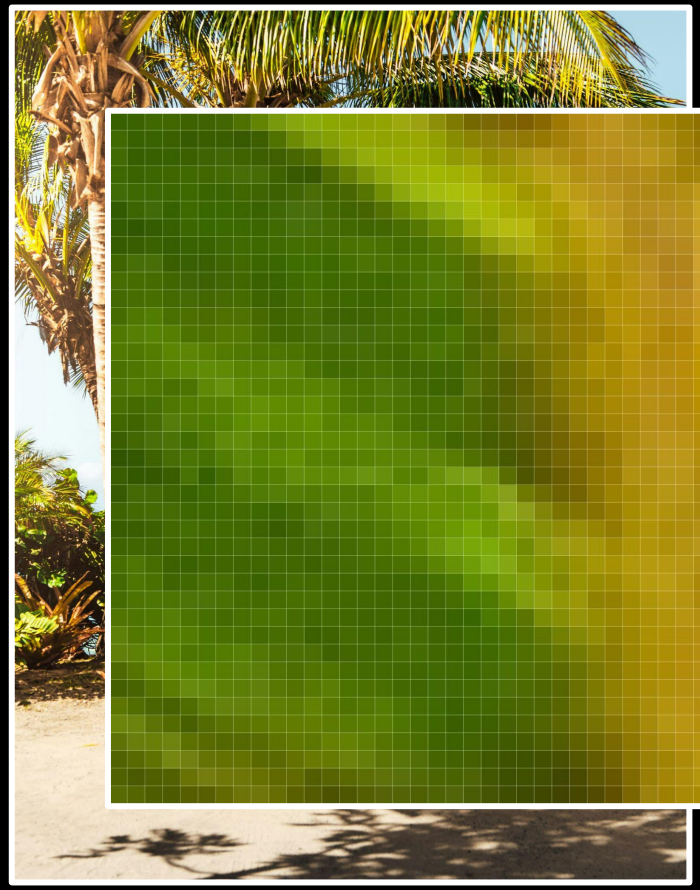
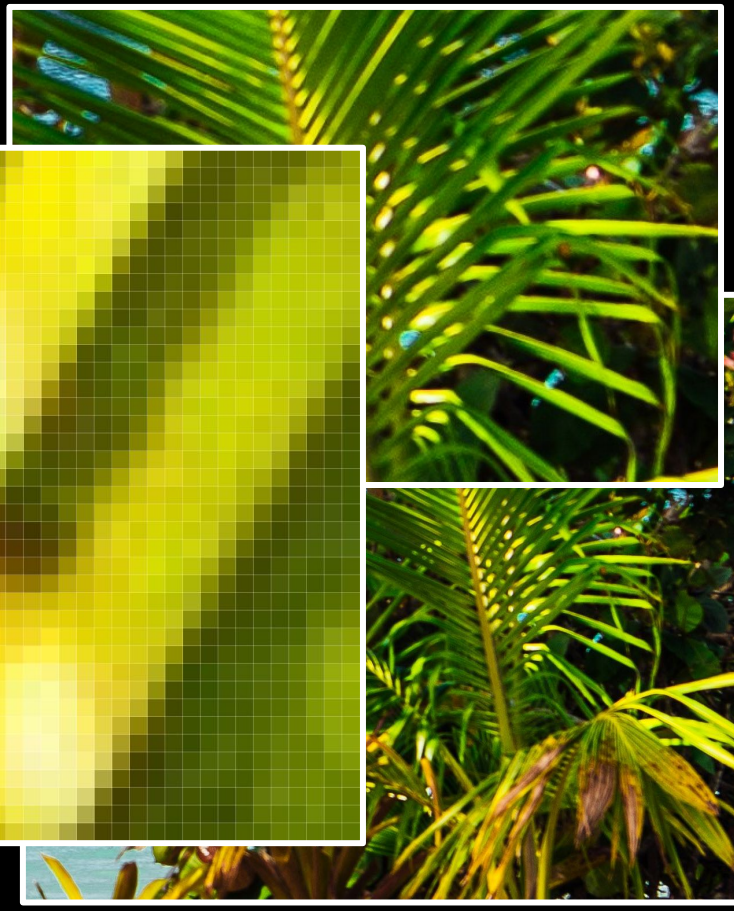
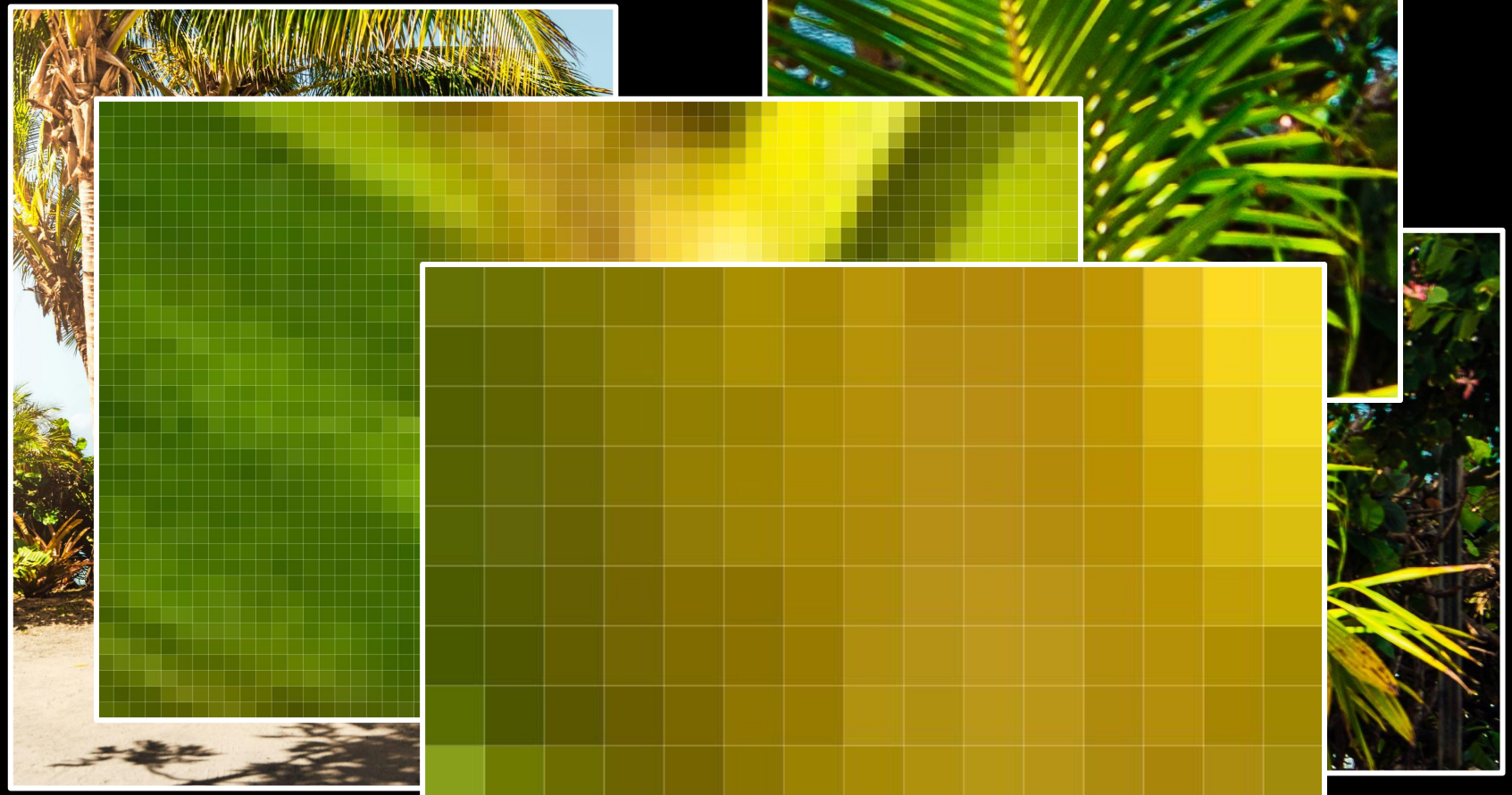
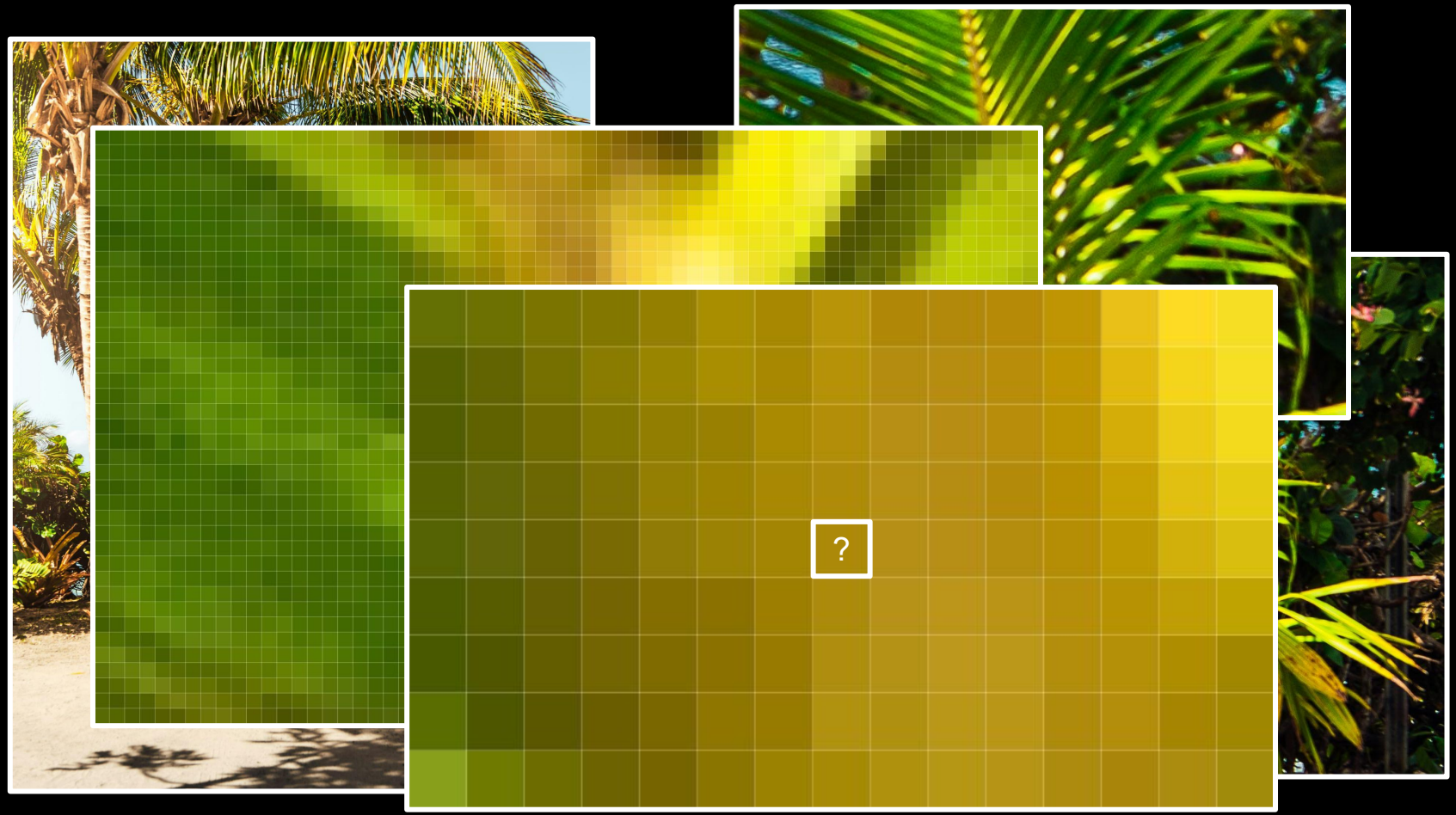
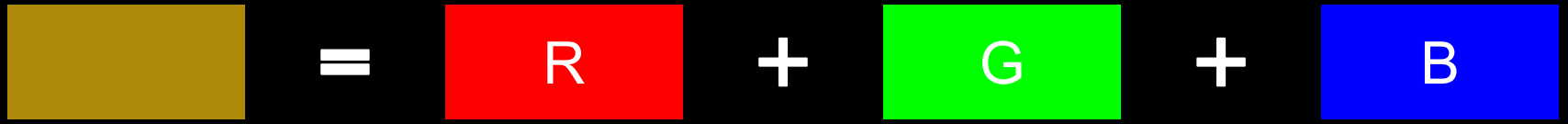


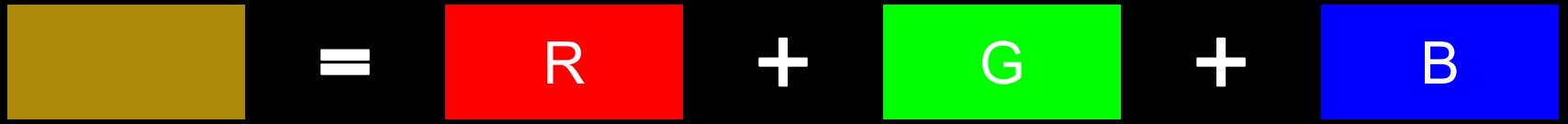









=
R
+
G
+
B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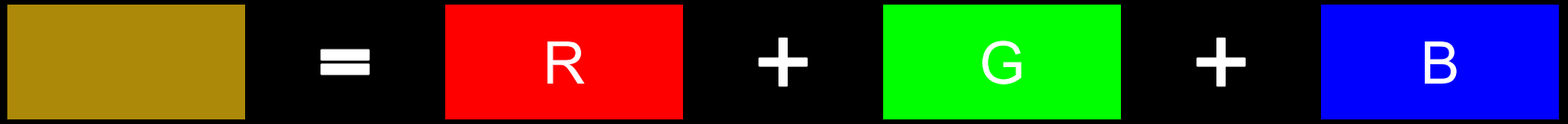
R
+
G
+
B
172
137
9



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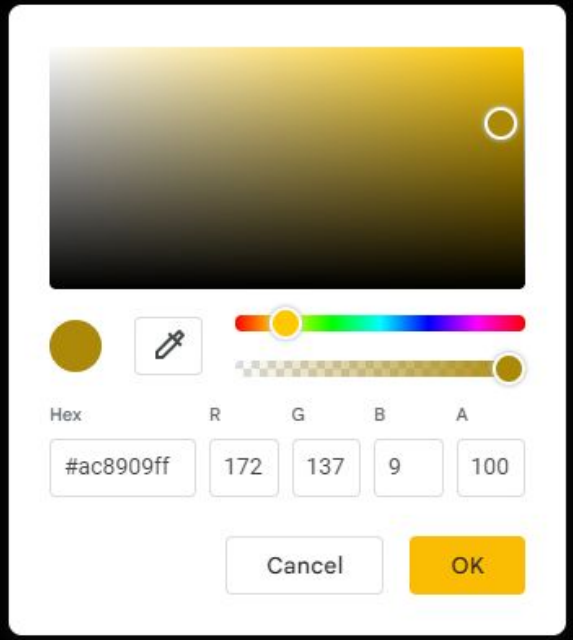
Hex
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G
B
A
#ac8909ff
172
137
9
100
Cancel
OK

= R + G + B

	R	G	B
	172	137	9
#AC8909	AC	89	09

= R + G + B

	R	G	B
	172	137	9
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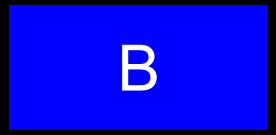
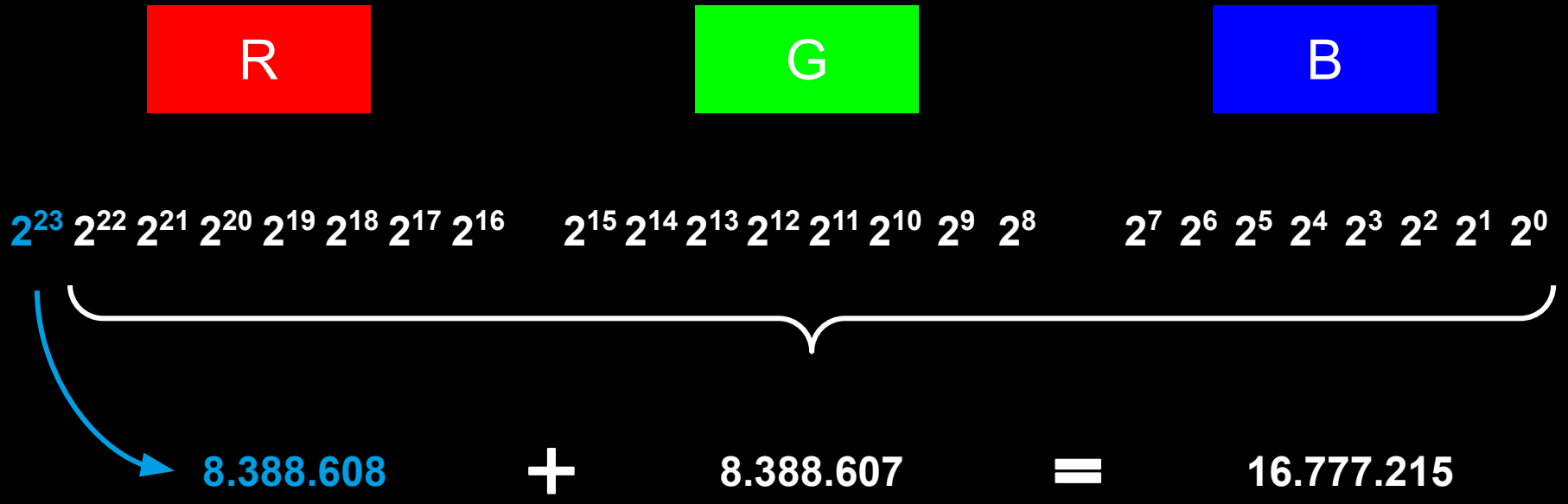
possible colors?

R

2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0



2^{23} 2^{22} 2^{21} 2^{20} 2^{19} 2^{18} 2^{17} 2^{16} 2^{15} 2^{14} 2^{13} 2^{12} 2^{11} 2^{10} 2^{9} 2^{8} 2^{7} 2^{6} 2^{5} 2^{4} 2^{3} 2^{2} 2^{1} 2^{0}


R
G
B
2^{23} 2^{22} 2^{21} 2^{20} 2^{19} 2^{18} 2^{17} 2^{16} 2^{15} 2^{14} 2^{13} 2^{12} 2^{11} 2^{10} 2^{9} 2^{8} 2^{7} 2^{6} 2^{5} 2^{4} 2^{3} 2^{2} 2^{1} 2^{0}
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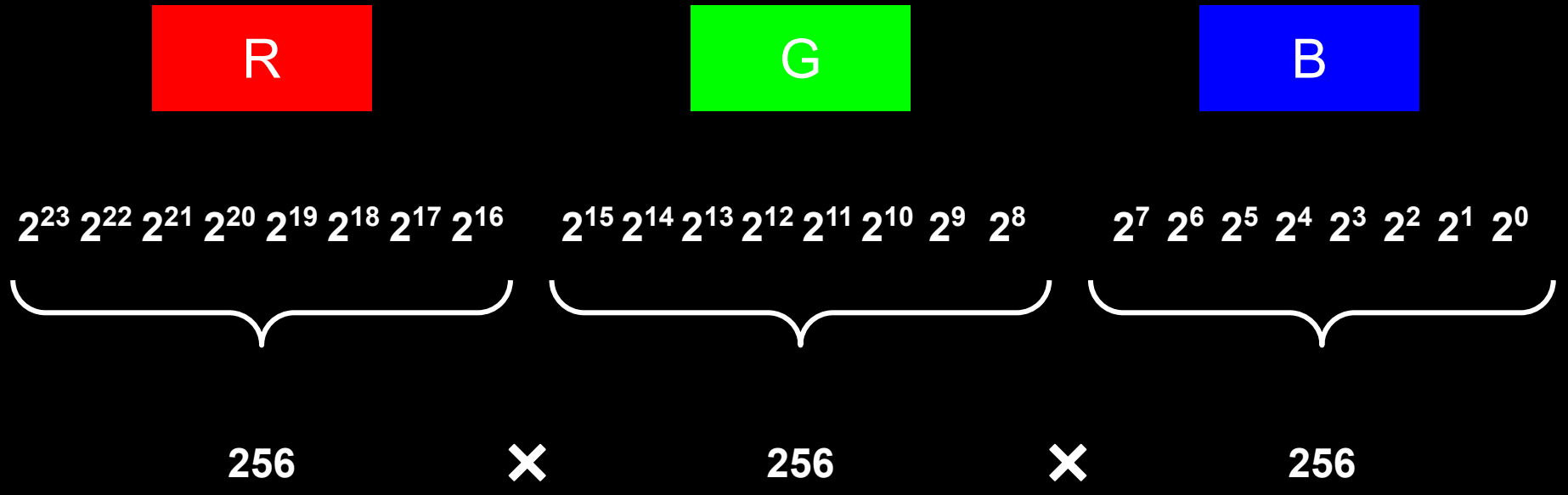
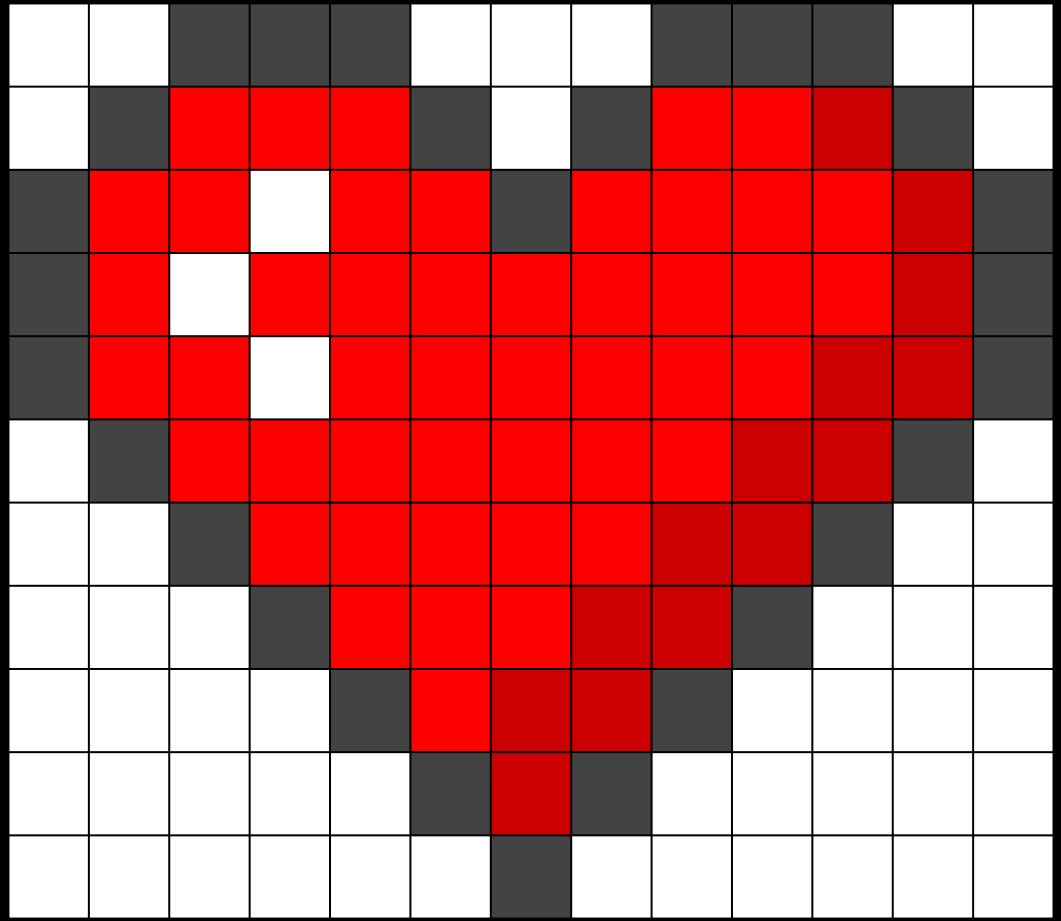
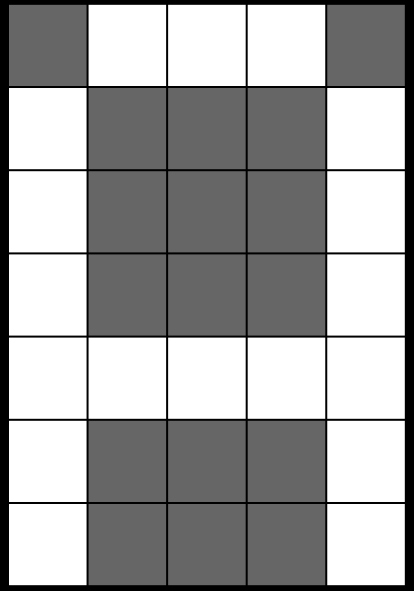
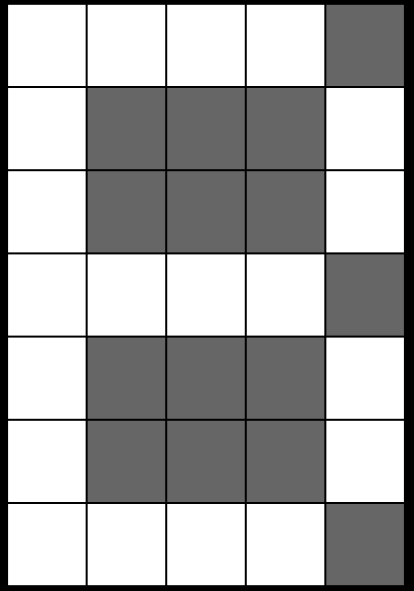
+
8.388.607
=
16.777.215

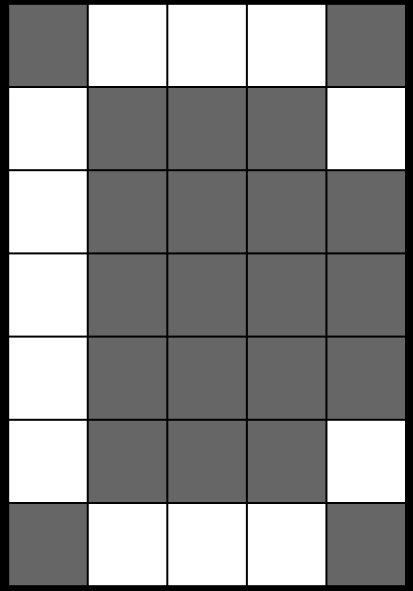

R
G
B
2^{23} 2^{22} 2^{21} 2^{20} 2^{19} 2^{18} 2^{17} 2^{16}
2^{15} 2^{14} 2^{13} 2^{12} 2^{11} 2^{10} 2^{9} 2^{8}
2^{7} 2^{6} 2^{5} 2^{4} 2^{3} 2^{2} 2^{1} 2^{0}
256
×
256
×
256

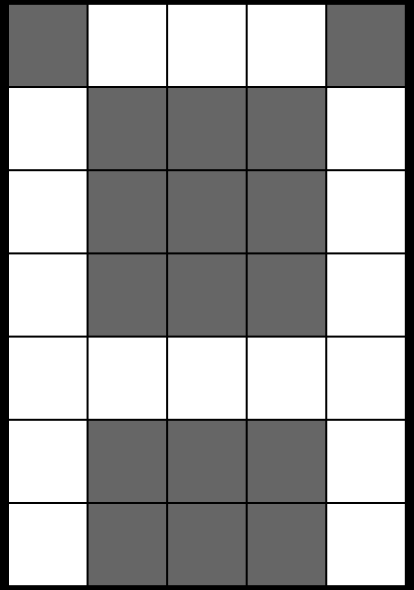


compression









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1	0	0	0	1

0	1	1	1	0
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0 1 1 1 0 1 0 0 0 1 1 0 0 0 1 1 0 0
0 1 1 1 1 1 1 1 0 0 0 1 1 0 0 0 1

5

7

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0 1 1 1 0 1 0 0 0 1 1 0 0 0 1 1 0 0
0 1 1 1 1 1 1 1 0 0 0 1 1 0 0 0 1