

NUMBER CONVERSION

Problem Solving with Computers-I

C++

```
#include <iostream>
using namespace std;

int main()
cout<<"Hola Facebook!";
return 0;
}
```

GitHub



External vs. Internal Representation

- **External representation:**
 - Convenient for programmer
 - Decimal (base 10)
- **Internal representation:**
 - Actual representation of data in the computer's memory:
Always binary (1's and 0's)



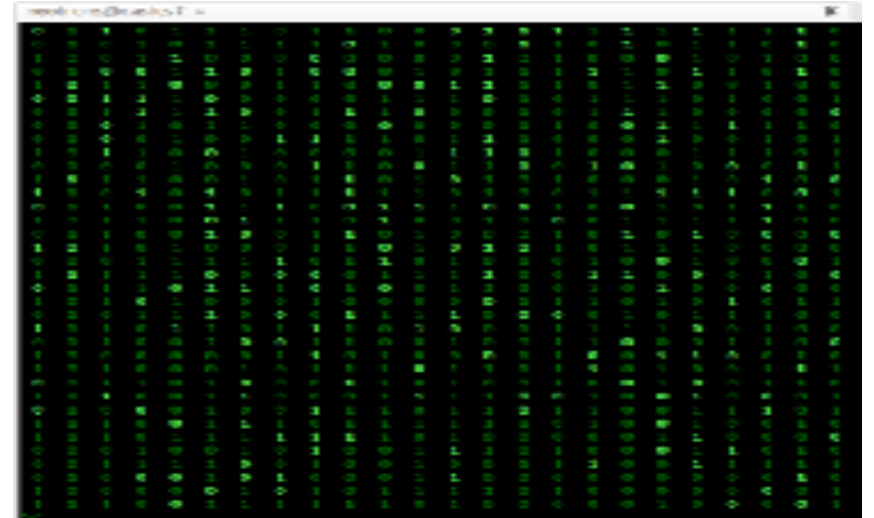
Positional encoding for non-negative numbers

- Each position represents some power of the base

Why is each base important??

Binary representation (base 2)

- On a computer all data is stored in binary
- Only two symbols: 0 and 1
- Each position is called a *bit*
- *Bits take up space*
- 8 bits make a *byte*
- *Example of a 4-bit number*



- Actually the data is voltages
- We use the abstraction:
 - High voltage: 1 (true)
 - Low voltage: 0 (false)

$101_5 = ?$ In decimal

A. 26

B. 51

C. 126

D. 130

Converting between binary and decimal

Binary to decimal: $1\ 0\ 1\ 1\ 0_2 = ?_{10}$

Decimal to binary: $34_{10} = ?_2$

Hex to binary

- Each hex digit corresponds directly to four binary digits
- Programmers love hex, why?

binary

$25B_{16} = ?$ In

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

Hexadecimal to decimal

$$25B_{16} = ? \text{ Decimal}$$

Hexadecimal to decimal

- Use polynomial expansion
- $25B_{16} = 2*256 + 5*16 + 11*1 = 512 + 80 + 11$
 $= 603$
- Decimal to hex: $36_{10}=?_{16}$

Binary to hex: 1000111100

A. 8F0

B. 23C

C. None of the above

BIG IDEA: Bits can represent anything!!

Numbers	Binary Code
----------------	--------------------

0	
---	--

1	
---	--

2	
---	--

3	
---	--

How many (minimum) bits are required to represent the numbers 0 to 3?

BIG IDEA: Bits can represent anything!!

Colors



Binary code

How many (minimum) bits are required to represent the three colors?

BIG IDEA: Bits can represent anything!!

Characters

'a'

'b'

'c'

'd'

'e'

N bits can represent at most 2^N things

What is the minimum number of bits required to represent all the letters in the English alphabet in lower case?

- A. 3
- B. 4
- C. 5
- D. 6
- E. 26

BIG IDEA: Bits can represent anything!!

- Logical values?
 - 0 \Rightarrow False, 1 \Rightarrow True
- colors ?
- Characters?
 - 26 letters \Rightarrow 5 bits ($2^5 = 32$)
 - upper/lower case + punctuation \Rightarrow 7 bits (in 8) (“ASCII”)
 - standard code to cover all the world’s languages \Rightarrow 8,16,32 bits (“Unicode”)
www.unicode.com
- locations / addresses? commands?
- **MEMORIZE:** N bits \Leftrightarrow at most 2^N things

Red

Green

Blue



What is the maximum positive value that can be stored in a byte?

A. 127

B. 128

C. 255

D. 256

Data types

Binary numbers in memory are stored using a finite, fixed number of bits typically:

8 bits (byte)

16 bits (half word)

32 bits (word)

64 bits (double word or quad)

Data type of a variable determines the:

- exact representation of variable in memory
- number of bits used (fixed and finite)
 - range of values that can be correctly represented