Lab 10 GRS

Number systems

Housekeeping

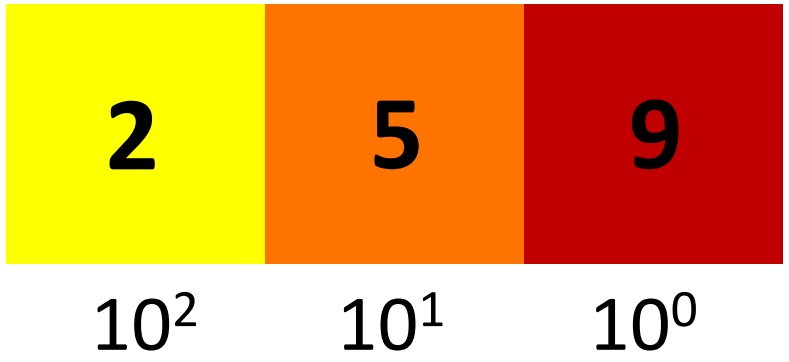
- Exam grades are out
- Project 2 is being graded right now
  - Project 2 grades will be released after December 4th
- The final is on **Friday December 13th** (rip) from **6 PM-8 PM**
  - If you have a schedule conflict or 3 finals on the same day, you can reschedule
  - Room assignments TBA (not the usual lecture location)
- **No class, lab, or grs next week**

How numbers are represented

- We use the decimal number system to represent numbers
  - AKA base 10
- What does base 10 mean?
  - Each place has a symbol, called a **digit**, from 0-9
  - Each digit is multiplied by a power of 10

Number systems

- Base 10 (the decimal system)
  - Each “place” holds a symbol called a **digit**
    - Each **digit** is **from 0-9**
    - The place determines the power of **10** the number will be multiplied by
  - The rightmost **digit** is multiplied by 10^0



$$= 2*10^2 + 5*10^1 + 9*10^0$$

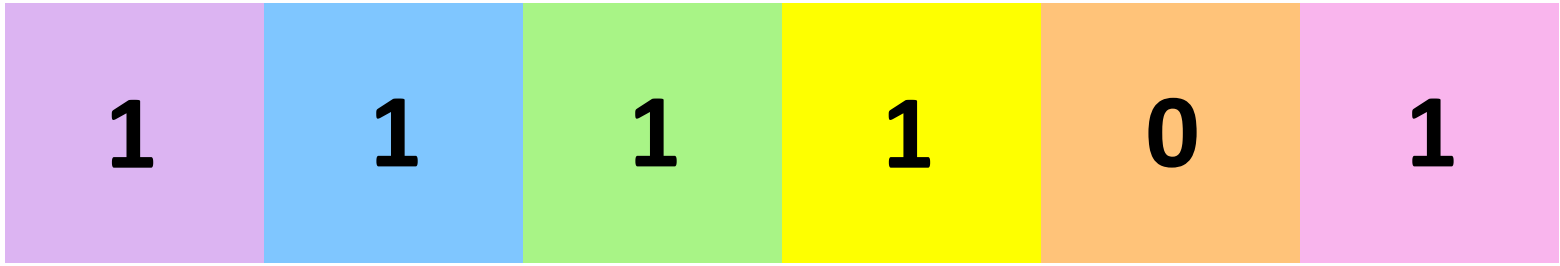
$$= 200 + 50 + 9$$

$$= \mathbf{259}$$

Number systems

- Base 2 (the **binary** system)
  - Each “place” holds a symbol called a **bit**
    - Each **bit** is from **0-1**
    - The place determines the power of 2 the bit will be multiplied by
  - The rightmost digit is multiplied by $\mathbf{2^0}$
- Typically grouped in sets of 4 bits

Number systems



2^5 2^4 2^3 2^2 2^1 2^0

$1*2^5 + 1*2^4 + 1*2^3 + 1*2^2 + 0*2^1 + 1*2^0$

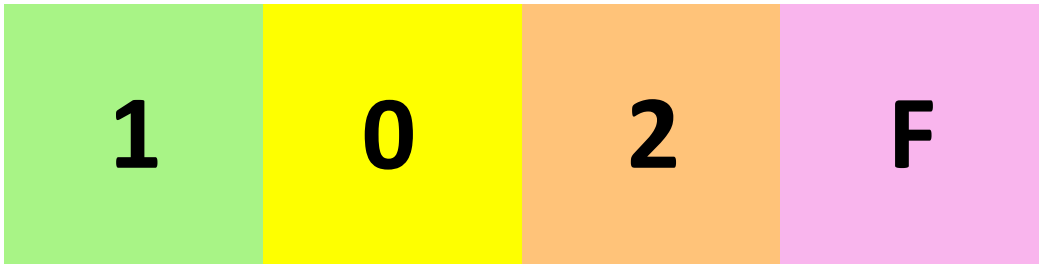
$= 1*32 + 1*16 + 1*8 + 1*4 + 0*2 + 1*1$

$= 32 + 16 + 8 + 4 + 0 + 1 = \mathbf{61}$

Number systems

- Base 16 (the **hexadecimal** system)
  - Each “place” holds a number
    - Each **number** is **hexadecimal digit from 0-15**
      - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, **A, B, C, D, E, F**
    - The place determines the power of 16 the number will be multiplied by
  - The rightmost digit is multiplied by $\mathbf{16^0}$

Number systems



A = 10
B – 11
C = 12
D = 13
E = 14
F = 15

$= 1*16^3 + 0*16^2 + 2*16^1 + 15*16^0$

$= 1*4096 + 0*256 + 2*16 + 15*16$

$= 4096 + 0 + 32 + 240 = \mathbf{4368}$

Converting between different bases

- Base N → Decimal (Base 10)
  - Convert each place by multiplying by power
  - Add places together

$$1001_2 = \underset{2^3}{8} + \underset{2^2}{0} + \underset{2^1}{0} + \underset{2^0}{1} = 9_{10}$$

Converting between different bases

- Decimal (Base 10) → Base N
  - Step 1: Divide number by base (using integer division), **keep track of remainder**
  - Step 2: repeat step 1 (keep dividing answer) until you get 0 as an answer
  - Your remainders in “reverse” order is the base N number

Base 10 to Base N

518_{10} to binary

$$518 / 2 = 259\, r0$$
$$259 / 2 = 129\, r1$$
$$129 / 2 = 64\, r1$$
$$64 / 2 = 32\, r0$$
$$32 / 2 = 16\, r0$$
$$16 / 2 = 8\, r0$$
$$8 / 2 = 4\, r0$$
$$4 / 2 = 2\, r0$$
$$2 / 2 = 1\, r0$$
$$1 / 2 = 0\, r1$$

$$= 0100\ 0000\ 1100$$

Note: the leading 0 does not affect the value of the number

- *(200 = 0200)*

Converting between different bases

- Hex → to binary
  - Each hex digit is a 4 bit binary number

$$AB3D_{16} \rightarrow Binary$$
$$10 \quad 11 \quad 3 \quad 13$$
$$= \ 1010\ 1011\ 0011\ 1101$$

A = 10
B – 11
C = 12
D = 13
E = 14
F = 15

Converting between different bases

- Binary → Hex
  - Each set of 4 binary bits is 1 hexadecimal number
    - Convert each set of bits to decimal, then hex

$$1100\ 1111\ 1101\ 0001$$
$$12\ 15\ 13\ 1$$
$$= CFD1$$

A = 10
B – 11
C = 12
D = 13
E = 14
F = 15

Facts to know about number systems

- The last bit of a binary number tells you if it’s odd (or even)
- Base 1 number system is just tallies
- Base 0 number system doesn’t exist
  - Why?

Why do we learn about binary and hex?

- Memory addresses are 8-byte hexadecimal numbers
  - 1 byte = 8 bits
  - Each byte is 1 hexadecimal digit
- At a lower level, computers communicate in binary
- Circuits communicate in binary

Activity

- Today’s activity is on my Github
  - github.com/agathaturya/201_grs/blob/master/lab10/activity.md