ECE/CS 252
Intro to Computer Engineering

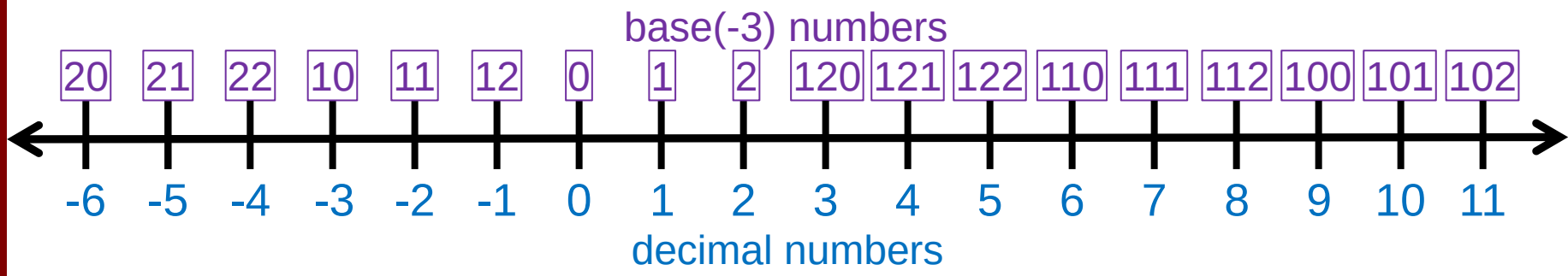
Week 02 Discussion

Positional Notation

- It works the same in all bases

$$D_{N-1}\ldots D_1 D_0 = D_{N-1} \times r^{N-1} + \ldots + D_1 \times r^1 + D_0 \times r^0$$

- What about base -3?
  - Uses digits 0, 1, 2, but the radix is negative!
  - Let's consider a three-digit number
    - The weight of the least significant digit is $(-3)^0 = \mathbf{1}$
    - The weight of the middle digit is $(-3)^1 = \mathbf{-3}$
    - The weight of the most significant digit is $(-3)^2 = \mathbf{9}$



- Relax – we won't be testing you on negative bases! The point is that ALL number bases work the SAME way

Remember…

- When converting between base 2, 8, and 16 (any combination, any direction)…

Do NOT convert to decimal!

- Converting between binary and any other base that is a power of 2 is **EASY**

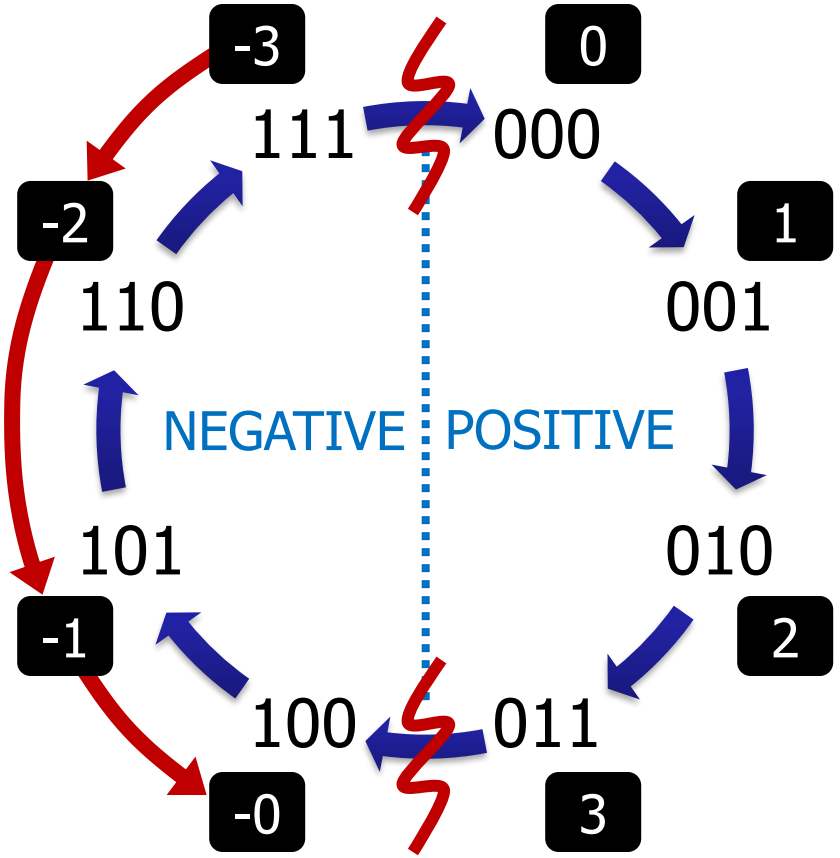
01001101110_2 | $5C_{16}$ | 26_8

Hexadecimal vs Octal

- Hexadecimal is pervasive throughout the computing fields
- Octal has fallen out of use generally, but there's one place it is used every day (but most people don't realize it)… in airplanes!

- The aircraft transponder setting (squawk code) is a 4-digit octal number representing a 12-bit binary code
  - Aircraft are assigned a code by ATC, or squawk special codes for emergencies (e.g., Mayday = 7700)

Why Not Use Signed-Magnitude?



Binary Representations

Unsigned	2's-comp
11	
10	
01	
00	

Unsigned	2's-comp
11111	
11110	
⋮	
10001	
10000	
01111	
01110	
⋮	
00001	
00000	

Binary Numbers – 3 Bits

- Quantity of **unique values** represented

Unsigned	2's-Complement	Signed-Magnitude

- **Range** of representation

Unsigned	2's-Complement	Signed-Magnitude

Complement then +1 **Negates**

- "Complement then add 1" does NOT convert a number to 2's-complement – it **NEGATES**
- There are 3 reasons you would negate a number:
  - You have a negative 2's-complement number and want to know its value
  - You need to express a negative decimal number in 2's-complement format
  - You actually need to negate a number, e.g. for subtraction: A – B = A + (-B)

- Do not negate when converting a positive number to 2's-complement format!

Overflow

- **Key idea:** the correct result value can not be represented, so the result we see is incorrect

	011 + 001	111 + 111	100 + 100
unsigned			
2's-comp			

Overflow Happens…

- A 32-bit signed integer would overflow if used to count # views for some YouTube videos…
- In 2004, Comair airlines had to ground over a thousand flights because flight crew scheduling software used a 16-bit integer to count crew changes
- Several flavors of Unix use 32-bit signed integers to count time (in seconds) since January 1, 1970, so times on/after Jan 19, 2038 cause overflow
- Boeing 787 electrical system could shut down power if left on for 248 days straight because generators enter failsafe mode due to a software counter overflowing
  - FAA told airlines they must turn the plane off every 120 days…

How Many Possibilities?

- If you have **N** locations, each of which has **P** possibilities, then the total number of unique sequences is: $\mathbf{P^N}$
  - Lights: **3** lights, **2** possibilities per light
    - $\mathbf{2^3}$ = 8 different lighting options
  - Lights: **8** lights, **2** possibilities per light
    - $\mathbf{2^8}$ = 256 different lighting options
  - Braille: **6** locations, **2** possibilities per location
    - Up to $\mathbf{2^6}$ = 64 different possibilities, but only 63 useful ones (because we have to subtract the one that is "all flat")
  - Decimal numbers: **6** digits, **10** possibilities per digit
    - $\mathbf{10^6}$ = 1,000,000 unique numbers (0 through 999,999)

What's Next?

- Week 03:
  - Fixed-point and floating-point representations
  - Character representation (ASCII)
  - **Assessment A1 on Wednesday**
    - Covers content from weeks 1 and 2
    - **Review the Educational Objectives!**
    - **Review Assessment Info & Procedures**
      (link below assessment date table in Canvas)

- **HW02 due tomorrow at 10pm**
- **Video Quiz 03 due tomorrow at 11:55pm**

- Questions?