COMPUTER SYSTEMS FUNDAMENTALS
(4COSC004W)

Lecture: Week 3. Part 2 of 3

In this video we will cover:

- Signed integers
  - *Two's Complement*
  - *Ranges of values*
  - *Binary subtraction*

SIGNED INTEGERS

Negative numbers

Two’s Complement

By the end of this unit, you will:

- Appreciate the significance of signed values
- Be able to represent signed Binary values using Two's Complement
  - *Appreciate the ranges of signed Binary values*
- Be able to perform Binary subtractions
- Revisit primitive arithmetic functions

Negative numbers

- Consider Decimal
  - *Negative 12*
  - -12
- But no *signage* in Binary
- Two's Complement

Two's Complement

- Representation of Negative Binary numbers
  - *We are going to work in an 8-bit system*

- Flip bits (NOT)
- Add the value **1**

Two's Complement -5								
5 :						1	0	1
NOT	1	1	1	1	1	0	1	0
+1								1
-5 :	1	1	1	1	1	0	1	1

Two's Complement -15								
15 :					1	1	1	1
NOT	1	1	1	1	0	0	0	0
+1								1
-15 :	1	1	1	1	0	0	0	1

Two's Complement -16								
16 :				1	0	0	0	0
NOT	1	1	1	0	1	1	1	1
+1								1
-16 :	1	1	1	1	0	0	0	0

Unsigned Binary – Base 2

- 8 Bits
  - *Values: 0 → 255*
    - $0 \rightarrow (2^8 - 1)$
  - 2^8 *values*
- *n* Bits
  - *Values: 0 →* $(2^n - 1)$
  - 2^n *values*

Signed Binary – Base 2

- 8 Bits
  - 2^8 *values*
  - *Values: -128 → 0 → +127*
    - $-(2^{8-1}) \rightarrow 0 \rightarrow ((2^{8-1}) - 1)$
- *n* Bits
  - 2^n *values*
  - *Values:* $-(2^{n-1}) \rightarrow 0 \rightarrow ((2^{n-1}) - 1)$

42 + 13 = 55

	Binary addition: 42 + 13								Dec
			1	0	1	0	1	0	42
					1	1	0	1	13
			1	1	0	1	1	1	55
				1					

55 - 13

	Binary representation of 55								Dec
			1	1	0	1	1	1	55

Two's Complement -13								
13 :					1	1	0	1
NOT	1	1	1	1	0	0	1	0
+1								1
-13 :	1	1	1	1	0	0	1	1

Overflow	Binary addition: 55 + (-13)								Dec
			1	1	0	1	1	1	55
	1	1	1	1	0	0	1	1	-13
	0	0	1	0	1	0	1	0	42
1	1	1	1		1	1	1		

Primitive arithmetic functions performed by the CPU (ALU) - revisited

- Simple, fast Binary operations:
  - *Addition (last week)*
  - *Multiplication by 2 (Left Shift)*
  - *Division by 2 (Right Shift)*
  - *Subtraction (Two's Complement & addition)*

In this video we covered:

- Signed integers
  - *Two's complement*
  - *Range of values*
  - *Subtraction of Binary values*

Further reading:

- Computer Science Illuminated
  - *Chapter 3 (p64.5)*
- Foundation Maths
  - *Chapter 14*