# Solutions - Quiz 2

(February 5th @ 5:30 pm)

## Problem 1 (50 pts)

- Complete the following table:

| REPRESENTATION | | | |
|---|---|---|---|
| **Decimal** | **Sign-and-magnitude** | **1's complement** | **2's complement** |
| -11 | 11011 | 10100 | 10101 |
| 7 | 0111 | 0111 | 0111 |
| -16 | 110000 | 101111 | 10000 |
| -8 | 11000 | 10111 | 1000 |

- Convert the following decimal number to its 2's complement representation: -16.625 (5 pts)

  $16.625 = 010000.101_2 \rightarrow -16.625 = 101111.011_2$

## Problem 2 (25 pts)

- Perform the following operations in the 2's complement representation, i.e., provide the summands and the result in 2's complement representation. Use the minimum number of bits to represent both the summands and the result so that the overflow bit is 0.

  ✓ -11 - 27

**n = 6 bits**

$c_6 \oplus c_5 = 1$ Overflow!

| | $c_6$=1 | $c_5$=0 | $c_4$=0 | $c_3$=1 | $c_2$=0 | $c_1$=1 | $c_0$=0 | |
|---|---|---|---|---|---|---|---|---|
| -27 = | 1 | 0 | 0 | 1 | 0 | 1 | | + |
| -11 = | 1 | 1 | 0 | 1 | 0 | 1 | | |
| -38 = | 0 | 1 | 1 | 0 | 1 | 0 | | |

$-27\ -11 = -38 \notin [-2^5, 2^5-1] \rightarrow$ overflow!

**To avoid overflow:**

**n = 7 bits** (sign-extension)

$c_7 \oplus c_6 = 0$ No Overflow

| | $c_7$=1 | $c_6$=1 | $c_5$=0 | $c_4$=0 | $c_3$=1 | $c_2$=0 | $c_1$=1 | $c_0$=0 | |
|---|---|---|---|---|---|---|---|---|---|
| -27 = | 1 | 1 | 0 | 0 | 1 | 0 | 1 | | + |
| -11 = | 1 | 1 | 1 | 0 | 1 | 0 | 1 | | |
| -39 = | 1 | 0 | 1 | 1 | 0 | 1 | 0 | | |

$-27\ -11 = -38 \in [-2^6, 2^6-1] \rightarrow$ no overflow

## Problem 3 (25 pts)

- A microprocessor is able to handle memory addresses between 0x0000 and 0x1FFF. Each memory address occupies one byte. What is the size (in bytes or KB) of the memory space? What is the address bus size of the microprocessor?

  We want to cover all the cases from 0x0000 to 0x1FFF.

  The range from 0x0000 to 0x1FFF is akin to all the possible cases with 13 bits. Thus the address bus size is 13 bits.

  The size of the memory space is $2^{13}$ bytes = 8 KB.