

# Computer Architecture

## Tutorial 3 – Number Representation and Binary Arithmetic - Answers

- 1) Convert the following binary numbers to decimal:  
(a) 0110 = 6, (b) 1011 = 11, (c) 10101010 = 170
- 2) Convert the following binary numbers to hexadecimal:  
(a) 1110 = E, (b) 11011 = 1B, (c) 1010111101110010 = AF72
- 3) Convert the following decimal numbers to binary and hexadecimal:  
(a) 12 = 1100 & C, (b) 27 = 11011 & 1B, (c) 96 = 1100000 & 60
- 4) For an 8-bit group, work out the representation for  $-37_{10}$  in

$$37_{10} = 100101$$

- a) Sign & Magnitude      10100101
- b) One's Complement      011010
- c) Two's Complement      11011011
- d) Excess-255       $37 = -37 + 255 = 218 = 11011010$
- e) Excess-128       $-37 = -37 + 128 = 91 = 01011011$

- 5) Express 9876510 in Binary Coded Decimal

9	8	7	6	5	1	0
1001	1000	0111	0110	0101	0001	0000

- 6) Form the negative equivalent of the following 8-bit Two's Complement numbers.

(a) 00011001, (b) 00011110, (c) 01101000, (d) 01110100

(a)  $00011001 = 16 + 8 + 1 = 25_{10}$

“invert the bits and add 1”  $11100110 + 1 = 11100111$

check:  $11100111 = -128 + (64 + 32 + 4 + 2 + 1) = -25_{10}$

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(b)  $00011110 = 16 + 8 + 4 + 2 = 30_{10}$

“invert the bits and add 1”  $11100001 + 1 = 11100010$

check:  $11100010 = -128 + (64 + 32 + 2) = -30_{10}$

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(c)  $01101000 = 64 + 32 + 8 = 104_{10}$

“invert the bits and add 1”  $10010111 + 1 = 10011000$

check:  $10011000 = -128 + (16 + 8) = -104_{10}$

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(d)  $01110100 = 64 + 32 + 16 + 4 = 116_{10}$

“invert the bits and add 1”  $10001011 + 1 = 10001100$

check:  $10001100 = -128 + (8 + 4) = -116_{10}$

by comparing the resulting bit patterns to the originals, can you spot a “short cut” method for the conversion?

Take another look at the bit patterns:

positive: 00011001 00011110 01101000 01101000

negative: 11100111 11100010 10011000 10001100

“starting from the rightmost bit (lsb), copy each bit unchanged up to and including the first 1 then invert all the remaining bits”

7) Perform the following 12-bit two’s complement subtraction

$$1010\ 1010\ 1011 - 1011\ 0000\ 1101$$

Two's Complement subtraction: “negate the subtrahend and add”

Two's Complement negation: “invert the bits and add 1”

$$101100001101 = 010011110010 + 1 = 010011110011$$

$$\begin{array}{r} 1010\ 1010\ 1011 \\ + 0100\ 1111\ 0011 \\ \hline 1111\ 1001\ 1110 \end{array}$$

Check your answer by determining the decimal representation of the numbers and the result

$$\begin{array}{r}
 1010\ 1010\ 1011 = -2048 + 683 = -1365 \\
 -1011\ 0000\ 1101 = -(-2048 + 781) = -1267 \\
 \hline
 1111\ 1001\ 1110 = -2048 + 1950 = -98
 \end{array}$$

8) Perform the binary multiplication 10011 x 1101

$$\begin{array}{r}
 10011 \times \\
 1101 \\
 \hline
 1101 + \\
 1101 \\
 \hline
 10011 + \\
 1101 \\
 \hline
 11110111
 \end{array}$$

In decimal:  $19 \times 13 = 247$

9) Divide the binary number 1011111 by 101

$$\begin{array}{r}
 10011 \\
 \hline
 101 \overline{) 1011111} \\
 \underline{- 101} \phantom{1111} \\
 001111- \\
 \underline{101} \phantom{11} \\
 101
 \end{array}$$

In Decimal:  $95 / 5 = 19$

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