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CS/ECE 252 Introduction to Computer Engineering

Fall 2018
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Homework 2
Deadline: 09/19/2018

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For each question below you need to show the complete working to receive full points. Please utilize the space provided under each question and upload a **PDF** version of your answers on canvas.

Problem 1 **(12 pts)**

Convert these decimal numbers to 8-bit Signed Magnitude, 1's Complement and 2's Complement binary number: (1 point for each entry)

Decimal Number	Signed Magnitude	1's Complement	2's Complement
21	00010101	00010101	00010101
126	01111110	01111110	01111110
-3	10000011	11111100	11111101
-117	11110101	10001010	10001011

2|21
2|10 1
2|5 0
2|2 1
2|1 0
0 1

2|126
2|63 0
2|31 1
2|15 1
2|7 1
2|3 1
2|1 1
0 1

2|3
2|1 1
0 1

2|-117
2|-58 1
2|-29 0
2|-14 1
2|-7 0
2|-3 1
2|-1 1
0 1

Problem 2 **(2 pts)**

Convert the 2's complement integer 10101010_2 to a decimal integer value.
(Correct answer with calculation steps: 2 points; Anything else: 1 point)

$2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

1 0 1 0 1 0 1 0

two's complement shortcut 0 1 0 1 0 1 1 0

$2^6 + 2^4 + 2^2 + 2^1$

$= 64 + 16 + 4 + 2$

$= 86$

$= -86$

$2's\ C\ 10101010_2 = -86$

Problem 3 **(9 pts)**

a) Add the following 2's complement numbers together and represent the answers in 8 bits.

i. $10001001_2 + 110001_2$
(Correct answer with calculation steps: 2 points; Anything else: 1 point)

```
  10001001
+ 11110001
 101111010
```

01111010_2

ii. $011100_2 + 0111_2$
(Correct answer with calculation steps: 2 points; Anything else: 1 point)

```
  011100
+ 000111
 001000011
```

00100011_2

b) Which question in (a) creates overflow (if any)? (1 point)

the first (i) question

c) Why is sign-extension important when performing arithmetic with 2's complement number? (2 points)

When performing addition, both numbers must have the same amount of bits. Also, be wary of simply padding with zeroes, as this could incorrectly turn a negative number positive.

d) Solve 30 - 9 using 2's complement subtraction in 8 bits.
(Correct answer with calculation steps: 2 points; Anything else: 1 point)

$30 = 00011110_2$
$9 = 00001001_2$
$-9 = 11110111_2$

$$\begin{array}{rl} 30 & 00011110_2 \\ -9 & +11110111_2 \\ \hline 1 & 00010101_2 \end{array}$$

$\boxed{00010101_2}$

Problem 4: **(3 pts)**

Compute the following operations:

1. (NOT 10011001_2) OR (NOT 01010110_2) (1 point)

01100110_2 $\quad$ 10101001_2

$$\begin{array}{rl} & 01100110 \\ \text{OR} & 10101001 \\ \hline & 11101111 \end{array}$$

$\boxed{11101111_2}$

2. (0110_2 AND 1101_2) OR 1001_2 (1 point)

0110_2
AND 1101_2
0100_2 → 0100_2
OR 1001_2
1101

1101_2

3. (NOT 10101111_2) XOR 01101011_2 (1 point)

↓

01010000_2

01010000_2
XOR 01101011_2
00111011_2

00111011_2

Problem 5: **(4 pts)**

Convert the following IEEE floating point number into decimal.

1 (B: 10000101) (C: 11011000000000000000000$_2$)
(A)

(Correct answer with calculation steps: 4 points; Anything else: you may get point deduction depending on the correctness and completeness of your calculation steps)

Sign A = −1

Exponent B = $10000101 = 2^7 + 2^2 + 2^0 = 128 + 4 + 1 = 133 - 127 = 6 \rightarrow 2^6$

Fraction C = $2^{-1} + 2^{-2} + 2^{-4} + 2^{-5} \rightarrow .5 + .25 + .0625 + .03125$

.5
.25
.0625
+ .03125
.84375

Sign −1 → .84375

-1.84375×2^6

↓

$-1.84375 \times 64 = -118$

Problem 6 **(4 pts)**

a) In 2's complement, how many distinct numbers can be represented using 8 bits? (1 point)

-2^{n-1} through $2^{n-1}-1$

-2^7 through 2^7-1 → -128 through 127

255 not including 0
256 including 0

b) What is the largest unsigned integer that may be represented using 16 bits? (1 point)

signed integer would be 32,767

$2^{16} = 65,536$

c) Convert the following to their hex equivalent.

a. The decimal number 31 (1 point)

16 | 31
16 | 1 15 = F
0 1

$1F_{16}$

b. The ASCII string **Computer** (1 point)

C o m p u t er
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
43 6F 6D 70 75 74 65 72

$43\ 6F\ 6D\ 70\ 75\ 74\ 65\ 72_{16}$