

COMP 3350 Project #1

Possible points: 100

Due: January 28th, 2022 11:59pm CST (Central Standard Time)

Goals:

- Get you familiar with data representation and simple logic operations for this course.

Requirements:

- Finish the questions section below. Points for each question included in parenthesis.
- Show your work to get full credit. **ZERO** point without steps for a result.
- Please start early. **ZERO** point for late submission. After the **11:59pm** on the due day, you can't submit your assignment anymore.

Deliverables:

- Save your solutions of questions as a **pdf** document. You can use this document as worksheet.
- Name document as a "**Firstname_Lastname.pdf**".
- Submit your "**Firstname_Lastname.pdf**" through the Canvas system. You do not need to submit hard copies.

Rebuttal period:

- You will be given a period of 2 **business** days to read and respond to the comments and grades of your homework or project assignment. The TA may use this opportunity to address any concern and question you have. The TA also may ask for additional information from you regarding your homework or project.

Questions:

1. (9 points) Convert the following unsigned base 2 numbers (binary) to base 16 numbers (hexadecimal):

$$\begin{array}{l} \text{A. } 0110\ 0001\ 1111 \quad (0110)_2 = (6)_{16} \quad (1111)_2 = (F)_{16} \\ \quad \quad \quad \quad \quad (0001)_2 = (1)_{16} \quad \quad \quad = \boxed{61F} \end{array}$$

$$\begin{array}{l} \text{B. } 1000\ 1111\ 1100 \quad (1000)_2 = (8)_{16} \quad (1100)_2 = (C)_{16} \\ \quad \quad \quad \quad \quad (1111)_2 = (F)_{16} \quad \quad \quad = \boxed{8FC} \end{array}$$

$$\begin{array}{l} \text{C. } 0001\ 0110\ 0100\ 0101 \quad (0001)_2 = (1)_{16} \quad (0101)_2 = (5)_{16} \\ \quad \quad \quad \quad \quad (0110)_2 = (6)_{16} \quad \quad \quad = \boxed{1645} \\ \quad \quad \quad \quad \quad (0100)_2 = (4)_{16} \end{array}$$

2. (27 points) Convert the following **binary numbers** to **base 10 numbers (decimal)**. Each time if binary numbers are represented in:

a) Signed magnitude representation.

negative $2^4 \quad 2^3 \quad 2^1 = 2^4 + 2^3 + 2 = 16 + 8 + 2 = 26 \text{ (negative)}$

- 1) $\rightarrow 1100\ 1010 = \boxed{-74}$
- 2) $\rightarrow 1111\ 0010 = 2^4 + 2^5 + 2^4 + 2 = 16 + 32 + 16 + 2 = 66 \text{ (neg)} = \boxed{-66}$
- 3) $\rightarrow 1000\ 0111 = 2^2 + 2^1 + 2^0 = 4 + 2 + 1 = 7 \text{ (neg)} = \boxed{-7}$

b) One's complement representation.

negative so flip each bit

- 1) $\rightarrow 1100\ 1010 = 0110101 = 2^5 + 2^4 + 2^2 + 2^0 = 32 + 16 + 4 + 1 = 53 \text{ (neg)} = \boxed{-53}$
- 2) $\rightarrow 1111\ 0010 = 0001101 = 2^3 + 2^2 + 2^0 = 8 + 4 + 1 = 13 \text{ (neg)} = \boxed{-13}$
- 3) $\rightarrow 1000\ 0111 = 1111000 = 2^6 + 2^5 + 2^4 + 2^3 = 64 + 32 + 16 + 8 = 120 \text{ (neg)} = \boxed{-120}$

c) Two's complement representation.

negative

- 1) $\rightarrow 1100\ 1010 = \begin{array}{r} 00110101 \\ + \quad 11 \\ \hline \end{array} = 00110110 = 2^5 + 2^4 + 2^2 + 2^1 = \boxed{-54}$
- 2) $\rightarrow 1111\ 0010 = [00001101 + 11] = 00001110 = 2^3 + 2^2 + 2^1 = 6 + 4 + 2 = 12 \text{ (neg)} = \boxed{-12}$
- 3) $\rightarrow 1000\ 0111 = [01111000 + 1] = 01111001 = 2^6 + 2^5 + 2^4 + 2^3 + 2^0 = 121 \text{ (neg)} = \boxed{-121}$

For example, question A, if 1100 1010 is a binary number represented in signed magnitude representation, what is the decimal value? Also do it again if 1100 1010 is a binary number in one's complement representation and two's complement representation. There are 9 separate answers in total.

3. (36 points) Convert the following **base 10 (decimal)** values to **binary numbers (8-bits)**. Each binary result represented in:

a) Signed magnitude representation.

- 1) $-100_d = \begin{array}{r} R0 \\ 100 / 2 = 50 / 2 = 25 / 2 = 12 / 2 = 6 / 2 = 3 / 2 = 1 \\ \hline \end{array} = \boxed{11100100}$
- 2) $-16_d = \begin{array}{r} R0 \\ 16 / 2 = 8 / 2 = 4 / 2 = 2 / 2 = 1 \\ \hline \end{array} = 10000 \rightarrow \boxed{10010000}$
- 3) $-21_d = \begin{array}{r} R1 \\ 21 / 2 = 10 / 2 = 5 / 2 = 2 / 2 = 1 / 2 = 0 \\ \hline \end{array} \rightarrow 10101 \rightarrow \boxed{10010101}$
- 4) $-0_d = \boxed{10000000}$

b) One's complement representation.

- 1) $-100_d = 1100100 \rightarrow 0011011 \rightarrow \boxed{10011011}$
- 2) $-16_d = 10000 \rightarrow 01111 \rightarrow 101111 \rightarrow \boxed{11101111}$
- 3) $-21_d = 10101 \rightarrow 01010 \rightarrow 101010 \rightarrow \boxed{11101010}$

4) $-0_d = \boxed{11111111}$

c) Two's complement representation.

1) $-100_d = 1100100 \rightarrow 0011100 \rightarrow \boxed{10011100}$

2) $-16_d = 10000 \rightarrow 110000 \rightarrow \boxed{11110000}$

3) $-21_d = 10101 \rightarrow 01011 \rightarrow 101011 \rightarrow \boxed{11101011}$

4) $-0_d = \boxed{10000000}$

(There are 12 separate answers in total.)

4. (4 points) What is the range of:

A. An unsigned 7-bit number? $0 \text{ to } (2^7 - 1) = 0 \text{ to } (128 - 1) = \boxed{0 \text{ to } 127}$

B. A signed 7-bit number? $(-2^{7-1} \text{ to } 2^{7-1}) - 1 = -2^6 \text{ to } 2^6 - 1 = \boxed{-64 \text{ to } 63}$

5. (12 points) Solve following bitwise operations (\wedge = AND, \vee = OR)

e.g. $0101 \wedge 0011 = 0001$

1. $1000 \wedge 1110 = \boxed{1000}$

2. $1000 \vee 1110 = \boxed{1110}$

3. $(1000 \wedge 1110) \vee (1001 \wedge 1110) = \boxed{1000}$

6. (9 points) Please demonstrate each step in the calculation of the arithmetic operation $25 - 65$. (both 25 and 65 are signed decimal numbers)

$(25)_{10} = (11001)_2$
 $(65)_{10} = (1000001)_2$

change to 8-bit: $(01000001)_2$
 one's complement - inverse: $(10111110)_2$
 two's complement - add 1: $(10111111)_2$

$\begin{array}{r} 00011001 \\ + 10111111 \\ \hline 11011000 \end{array}$

7. (3 points) Mathematically the answer in Q6 is -40_d . Please verify your answer in Q6 using a conversion of 2's and decimal numbers.

$40/2 = 20 \text{ R0} \rightarrow 101000$
 $20/2 = 10 \text{ R0} \rightarrow 00101000 \text{ (8-bit)}$
 $10/2 = 5 \text{ R0} \rightarrow 11010111 \text{ (flip)}$
 $5/2 = 2 \text{ R1} \rightarrow 11011000 \text{ (added 1)}$
 $2/2 = 1 \text{ R0}$
 $1/2 = 0 \text{ R1}$