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COMP 3353 Project #1

Questions:

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

A. 0110 0001 1111 **…**

0110 = $2^2 + 2^1 = 6$

0001 = $2^0 = 1$

1111 = $2^3 + 2^2 + 2^1 + 2^0 = 15 = F$

*** FINAL ANSWER = $(61F)_H$**

B. 1000 1111 1100 **…**

1000 = $2^3 = 8$

1111 = $2^3 + 2^2 + 2^1 + 2^0 = 15 = F$

1100 = $2^3 + 2^2 = 12 = C$

*** FINAL ANSWER = $(8FC)_H$**

C. 0001 0110 0100 0101 **…**

0001 = $2^0 = 1$

0110 = $2^2 + 2^1 = 6$

0100 = $2^2 = 4$

0101 = $2^2 + 2^0 = 5$

*** FINAL ANSWER = $(1645)_H$**

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.

1) 1100 1010 = **$-(2^6 + 2^3 + 2^1) = -74_d$**
2) 1111 0010 = **$-(2^6 + 2^5 + 2^4 + 2^1) = -114_d$**
3) 1000 0111 = **$-(2^2 + 2^1 + 2^0) = -7_d$**

b) One's complement representation.

1) 1100 1010 = **0011 0101 = $2^5 + 2^4 + 2^2 + 2^0$ = -53$_d$**

2) 1111 0010 = **0000 1101 = $2^3 + 2^2 + 2^0$ = -13$_d$**

3) 1000 0111 = **0111 1000 = $2^6 + 2^5 + 2^4 + 2^3$ = -120$_d$**

c) Two's complement representation.

1) 1100 1010 = **1100 1010 - 1 = !(1100 1001) = 0011 0110 = $2^5 + 2^4 + 2^2 + 2^1$ = -54$_d$**

2) 1111 0010 = **1111 0010 - 1 = !(1111 0001) = 0000 1110 = $2^3 + 2^2 + 2^1$ = -14$_d$**

3) 1000 0111 = **1000 0111 - 1 = !(1000 0110) = 0111 1001 = $2^6 + 2^5 + 2^4 + 2^3 + 2^0$ = -121$_d$**

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$_d$ = **100 ÷ 2 = 50 … 50 ÷ 2 = 25 … 25 ÷ 2 = 12 … 12 ÷ 2 = 6 … 6 ÷ 2 = 3 … 3 ÷ 2 = 1 … 1 ÷ 2 = 0 ===> -100$_d$ = 1110 0100**

2) -16$_d$ = **16 ÷ 2 = 8 … 8 ÷ 2 = 4 … 4 ÷ 2 = 2 … 2 ÷ 2 = 1 … 1 ÷ 2 = 0 ===> -16$_d$ = 1001 0000**

3) -21$_d$ = **21 ÷ 2 = 10 … 10 ÷ 2 = 5 … 5 ÷ 2 = 2 … 2 ÷ 2 = 1 … 1 ÷ 2 = 0 ====> -21$_d$ = 1001 0101**

4) -0$_d$ = **1000 0000**

b) One's complement representation.

1) -100$_d$ = **100 ÷ 2 = 50 … 50 ÷ 2 = 25 … 25 ÷ 2 = 12 … 12 ÷ 2 = 6 … 6 ÷ 2 = 3 … 3 ÷ 2 = 1 … 1 ÷ 2 = 0 ====> = !(0110 0100) = 1001 1011**

2) -16$_d$ = **16 ÷ 2 = 8 … 8 ÷ 2 = 4 … 4 ÷ 2 = 2 … 2 ÷ 2 = 1 … 1 ÷ 2 = 0 ====> !(0001 0000) = 1110 1111**

3) -21$_d$ = **21 ÷ 2 = 10 … 10 ÷ 2 = 5 … 5 ÷ 2 = 2 … 2 ÷ 2 = 1 … 1 ÷ 2 = 0 ====> !(0001 0101) = 1110 1010**

4) -0$_d$ = **!(0000 0000) = 1111 1111**

c) Two's complement representation.

1) -100$_d$ = **!(0110 0100) = 1001 1011 + 1 = 1001 1100**

2) -16$_d$ = **!(0001 0000) = 1110 1111 + 1 = 1111 0000**

3) -21$_d$ = **!(0001 0101) = 1110 1010 = 1110 1010**

4) -0$_d$ = **!(0000 0000) = 1111 1111 + 1 = 1 0000 0000**

(There are 12 separate answers in total.)

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

A. An unsigned 7-bit number? **The range of an unsigned n-bit number is from 0 to 2^n - 1, hence the range of an unsigned 7-bit number is from 0 to 2^7 - 1 = 0 to 127.**

B. A signed 7-bit number? **The range of a signed n-bit number is from -2^{n-1} to 2^{n-1} - 1, hence the range of a signed 7-bit number is from -2^{7-1} to 2^{7-1} - 1 = -2^6 to 2^6 - 1 = -64 to 63.**

5. (12 points) Solve following bitwise operations (∧ = AND, ∨ = OR)

e.g. 0101 ∧ 0011 = **0001**

1. 1000 ∧ 1110 = **1000**

A	B	A ∧ B
1	1	1
0	1	0
0	1	0
0	0	0

2. 1000 ∨ 1110 = **1110**

A	B	A ∨ B
1	1	1
0	1	1
0	1	1
0	0	0

3. (1000 ∧ 1110) ∨ (1001 ∧ 1110) = **1000**

A	B	A ∧ B	C	D	C ∧ D	(A ∧ B) ∨ (C ∧ D)
1	1	1	1	1	1	1
0	1	0	0	1	0	0
0	1	0	0	1	0	0
0	0	0	1	0	0	0

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_d = 25 ÷ 2 = 12 … 12 ÷ 2 = 6 … 6 ÷ 2 = 3 … 3 ÷ 2 = 1 … 1 ÷ 2 = 0**

===> **25_d = 0001 $1001_{2's}$**

===> **65_d = 65 ÷ 2 = 32 .. 32 ÷ 2 = 16 .. 16 ÷ 2 = 8 .. 8 ÷ 2 = 4 .. 4 ÷ 2 = 2 .. 2 ÷ 2 = 1 .. 1 ÷ 2 = 0**

===> **-65_d = !(0100 0001) = 1011 $1110_{1's}$ + 1 = 1011 $1111_{2's}$**

===> ***Calculate 25 - 65 = 0001 1001**

$$
\begin{array}{r}
0001\ 1001 \\
+\ \underline{1011\ 1111} \\
1101\ 1000 = -40_d
\end{array}
$$

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_d = 40 ÷ 2 = 20 … 20 ÷ 2 = 10 … 10 ÷ 2 = 5 … 5 ÷ 2 = 2 … 2 ÷ 2 = 1 … 1 ÷ 2 = 0

===> **-40_d = !(0010 1000) = 1101 $0111_{1's}$ + 1 = 1101 $1000_{2's}$**