Question #1: Binary Numbers

Please convert the following number to/from binary to decimal and complete the missing values in the chart below. Be sure to show your work (you may take pictures/scan your written work or provide typed responses).

Binary	Signedness	Decimal
1101	Unsigned	13
100110	One's Complement	-25
1011010110	Two's Complement	-298
0111011001110	One's Complement	3790
1100000110010	Two's Complement	-974

① $1101_2 = 2^0 + 0 + 2^2 + 2^3 = 13_{10}$.

② $25 = 24 + 2^3 + 2^0 = 011001_2 \Rightarrow$ 1's comp. 100110_2.

③ $298 = 256 + 32 + 8 + 2 = 2^8 + 2^5 + 2^3 + 2^1 =$ 1001 01010

$\Rightarrow$ 1's comp. 0110101 01 $\Rightarrow$ 2's comp. + 0 11 0101 01 / 1

1 011 0101 10$_2$ $= -298$.

1 at the most left means negative

④ 0111 0110 01110 $= 2^1 + 2^2 + 2^3 + 2^6 + 2^7 + 2^9 + 2^{10} + 2^{11} = 3790$.

↑ zero at the most left means the result is positive, so we don't flip 1 & 0.

⑤ 1100 0011 0010

↑ one at the most left means negative, so.

$\Rightarrow$ 1's comp. 0011 1100 1101

$\Rightarrow$ 2's comp + 1

0011 1100 1110$_2$.

$\Rightarrow -(2^1 + 2^2 + 2^3 + 2^6 + 2^7 + 2^8 + 2^9) = (-974)$

Question #2: Hexadecimal Numbers

Please convert the following number to/from hexadecimal to decimal/binary and complete the missing values in the chart below. Be sure to show your work (you may take pictures/scan your written work or provide typed responses).

Hex	Signedness	Decimal	Binary
B2C	Unsigned	2860	1011 0010 1100
E6	One's Complement	-25	1110 0110
AC	Two's Complement	-84	1010 1100
3AFD	One's Complement	15301	0011101011111101
BEE	Two's Complement	-1042	1011 1110 1110

① $B2C_{16} \Rightarrow$ Binary format $= 1011\ 0010\ 1100_2$

$= (2^{11} + 2^9 + 2^8 + 2^5 + 2^3 + 2^2)_{10} = 2860_{10}$

② $E6_{16} \Rightarrow 1110\ 0110_2 \Rightarrow$ 1's comp. $0001\ 1001_2$

leftmost is 1 so result is negative $\Rightarrow (2^0 + 2^3 + 2^4)_{10} = (1+8+16)_{10} = -25_{10}$

③ $-84_{10} = (2^2 + 2^4 + 2^6)_{10} = 0101\ 0100_2 \Rightarrow$ 1's comp. $1010\ 1011_2$

$-84 = \begin{array}{r} 1010\ 1011_2 \\ +\quad\quad\quad 1_2 \\ \hline 1010\ 1100_2 \end{array}$ $\quad 1010\ 1100_2 = AC_{16}$

④ $0011\ 1010\ 1111\ 1101_2$ leftmost is zero so result is positive, we don't flip 1 and 0.

Decimal value $= (2^0 + 2^2 + 2^3 + 2^4 + 2^5 + 2^6 + 2^7 + 2^9 + 2^{11} + 2^{12} + 2^{13})_{10} = 15301_{10}$

$0011\ 1010\ 1111\ 1101_2 \Rightarrow$ Hex. $= 3AFD_{16}$

$2^0+2^1 \quad 2^1+2^3 \quad 2^0+2^1+2^2+2^3 \quad 2^0+2^2+2^3$

⑤ $BEE_{16} = 1011\ 1110\ 1110_2$ leftmost is 1 so result is negative

$\Rightarrow$ 1's comp $0100\ 0001\ 0001_2$

$\Rightarrow$ 2's Comp $\begin{array}{r} 0100\ 0001\ 0001_2 \\ +\quad\quad\quad\quad 1_2 \\ \hline 0100\ 0001\ 0010_2 \end{array}$

decimal value $= (2^1 + 2^4 + 2^{10})_{10} = -1042_{10}$

Question #3: Octal Numbers

Please convert the following number to/from octal to decimal/binary/hex and complete the missing values in the chart below. Be sure to show your work (you may take pictures/scan your written work or provide typed responses).

Octal	Signedness	Decimal	Binary	Hex
1051	Unsigned	553	0010 0010 1001	229
-167	One's Complement	-199	110001000=-001110111	-77
246	Two's Complement	166	10100110	0x00A6
176544	One's Complement	64868	1111110101100100	FD64
-143	Two's Complement	-99	0011101 = -1100011	-63

① $1051 = 001\ 000\ 101\ 001_2$

$= (2^0+2^3+2^5+2^9)_{10} = 553_{10}$.

$= 2^1\ \ 2^1\ \ 2^0+2^3 = 229_{16}$.

② $-167_8 = -001\ 110\ 111_2 = -(2^0+2^1+2^2+2^4+2^5+2^6)_{10} = -119_{10}$.

$\Rightarrow$ 4th=7, 4+2+1=7 $\Rightarrow$ Hex. value $= -77_{16}$.

③ Hex $\rightarrow$ octal, binary

$00A6_{16} = 0000\ 000\ 0\ 1010\ 0110_2 = 246_8$. Leftmost bit is 0, simply convert Binary $\rightleftharpoons$ decimal.

Decimal $\rightarrow$ Octal, binary

$166_{10} = (2^7+2^5+2^2+2^1)_{10} = 0000\ 0000\ 10100110_2 = 246_8$.

④ $1111\ 1101\ 0110\ 0100_2 = (2^2+2^5+2^6+2^8+2^{10}+2^{11}+2^{12}+2^{13}+2^{14}+2^{15})_{10}$

15 13 6 4 $= 64868_{10}$.

$\Rightarrow FD64_{16}$.

$\Rightarrow 001\ 111\ 110\ 101\ 100\ 100_2 = 176544_8$.

⑤ decimal $\rightarrow$ binary

$99 = 64+32+2+1 = 2^6+2^5+2^1+2^0 = 1100011_2 \Rightarrow$

1's comp. $001\ 1100$

$+\quad\quad 1$

2's comp. $001\ 110\ 1_2$

binary $\rightarrow$ Octal, Hex

$-(1100011) = -143_8$

$-(0110\ 0011) = -(4+2\ \ 2+1) = -63_{16}$.

Question #4: Arithmetic and Overflow

Complete the following arithmetic operations and tell whether or not there is overflow and provide a brief justification. Please be sure to show your work (you may take pictures/scan your written work or provide typed responses).

Unsigned, 5-bit binary addition			5-bit Binary Sum	5-bit Decimal Sum	Overflow?
01010	+	01011	10101	21	Not overflow

Justification: We can represent the 5-bit decimal with 5-bit Binary Sum.

$01010_2 = 2^1 + 2^3 = 10_{10}$

$+ \quad 01011_2 = 2^0 + 2^1 + 2^3 = 11_{10}$

$10101 = 2^4 + 2^2 + 2^0 = 21_{10}$

Unsigned, 8-bit binary addition			8-bit Binary Sum	8-bit Decimal Sum	Overflow?
11011001	+	10100110	(1)0111 1111	383	Overflow

Justification: We can't represent the result in 8-bit because it requires 9 bits

$11011001_2 = 2^0+2^3+2^4+2^6+2^7 = 217_{10}$

$+ \quad 10100110_2 = 2^1+2^2+2^5+2^7 = 166_{10}$

$2^8+2^6+2^5+2^4+2^3+2^2+2^1+2^0 = 383_{10}$

$10\,1111111_2$ Here, 1 can't be disregarded, otherwise the decimal value will be 127, which is less than 383

Two's Complement, 16-bit hex addition			16-bit Binary Sum	16-bit Decimal Sum	Overflow?
FACE	+	6EEF	(1)0110 1001 1011 1101	27069	Overflow

Justification: $FACE = 1111\ 1010\ 1100\ 1110_2 \Rightarrow 1's = 0000\ 0101\ 0011\ 0001_2 \Rightarrow 2's \Rightarrow 0000\ 0101\ 0011\ 0010_2$

$6EEF = 0110\ 1110\ 1110\ 1111_2 = 2^{14}\ldots+2^0 = 28399$.

$\Rightarrow -(2^0+2^4+2^5+2^7+2^{14}) = -17330$.

Binary Sum $= 1\ 0110\ 1001\ 1011\ 1101_2$.

If 1 carry-out is disregarded, the result is $2^0+2^4+2^3+2^5+2^6+2^7+2^9+2^{10}+2^{11}+2^{12}+2^{13} = 28399$.

So only when the 1 carry-out is regarded, binary sum $= 27069 = 28339 + (-1330)$

Therefore, overflow.

Two's Complement, 8-bit hex subtraction			8-bit Binary Sum	8-bit Decimal Sum	Overflow?
0x88	-	0x0A	(1)0111 1110	126	Not overflow

Justification:

$88_{16} = 1000\ 1000_2 = (2^7+2^3)_{10} = 136_{10}$

$0A_{16} = 0000\ 1010_2 = (2^1+2^3)_{10} = 10_{10}$. Decimal Sum $= 136-10 = 126_{10}$.

$\Rightarrow 1's = 1111\ 0101$

$\Rightarrow 2's = 1111\ 0110$ (+1)

Binary Sum $= 1000\ 1000 + 0000\ 1010 = 1\,0111\ 1110$

1 carry-out is disregarded and result is $2^1+2^2+2^3+2^4+2^5+2^6 = 126_{10}$

When 1 carry value is disregarded, 8-bit decimal Sum can be represented by 8-bit Binary Sum. Hence, Not overflow.

Question #5: IEEE 754 Floating-point Number

Please convert the following number to its binary and hexadecimal IEEE 754-formatted equivalent:

-8765.125

Sign bit will be 1 as the number is negative

$8765_{10} = 8192 + 512 + 32 + 16 + 8 + 4 + 1$

$= (2^{13} + 2^9 + 2^5 + 2^4 + 2^3 + 2^2 + 2^0)_{10}$

binary format = 1 0001 0001 1101.

$0.125 \times 2 = 0.25 \rightarrow 0$

$0.25 \times 2 = 0.5 \rightarrow 0$ so $0.125_{10} = (0\ 0\ 1)_2$

$0.5 \times 2 = 1.0 \rightarrow 1$.

Combine together, $8765.125 = 1000\ 1000\ 1111\ 01_2 . 001$

$= 1.0001\ 0001\ 1110\ 1001_2 \times 2^{13}$.

exponent $e = 13 + 127$ to account bia, we get

$e = 140_{10} = 128 + 8 + 4 = 2^7 + 2^3 + 2^2$

$= 1000\ 1100_2$

Then we convert fraction, f = 16 bits + 7 zeros

= 0001 0001 1110 1001 0000000

Combine together, -8765.125_{10} in binary is

1100 0110 0001 0001 1110 1001 0000 0000$_2$

12=C 6 0 8 15=F 4 8 0

In hexadecimal,

$-8765.125_{10} = C608F480_{16}$.

Question #6: Converting Bytes to Binary and ASCII Text

Please convert the following string of bytes to:

1. **Binary**
2. **ASCII text**

0x43 0x6F 0x6D 0x70 0x75 0x74 0x65 0x72 0x20 0x4F 0x72 0x67 0x21

Convert Hexadecimal to binary

$43_{16} = 4\,(2+1) = 0100\ 0011$

$6F_{16} = 4+2\ \ 8+4+2+1 = 0110\ 1111$

$6D_{16} = 0110\ 1101$

$70_{16} = 0111\ 0000$

$75_{16} = 0111\ 0101$

$74_{16} = 0111\ 0100$

$65_{16} = 0110\ 0110$

$72_{16} = 0111\ 0010$

$20_{16} = 0100\ 0000$

$4F_{16} = 0100\ 1111$

$72_{16} = 0111\ 0010$

$67_{16} = 0110\ 0111$

$21_{16} = 0010\ 0001$

ASCII/UTF-8 ⟹ Computer Org!