**Hosam Abdeltawab** **Homework 7** **Due: Tuesday, Oct. 17, 2017**

**1**. Convert each of the following into a 32-bit two's complement binary number:

(a) $512_{ten}$

a) Converting from binary to decimal:

- $\frac{512}{2}$ = 256 with remainder 0
- $\frac{256}{2}$ = 128 with remainder 0
- $\frac{128}{2}$ = 64 with remainder 0
- $\frac{64}{2}$ = 32 with remainder 0
- $\frac{32}{2}$ = 16 with remainder 0
- $\frac{16}{2}$ = 8 with remainder 0
- $\frac{8}{2}$ = 4 with remainder 0
- $\frac{4}{2}$ = 2 with remainder 0
- $\frac{2}{2}$ = 1 with remainder 0
- $\frac{1}{2}$ = 0 with remainder 1 $\Uparrow$

b) Then you put the remainders next to each other starting from the most significant bit with is the las one. Then, I add zeros the left of the number to complete it to be 32-bit number.

c) $512_{ten} = 00000000000000000000001000000000_{two}$

(b) $-1{,}023_{ten}$

- To do this: first I convert $1{,}023_{ten}$ to binary, then get the 1's complement of that number, and add 1 to the 1's complement to get the 2's complement. To get the 2's complement right away after getting the decimal value, I start from the right of the number and copy all the zeros till the first 1 then, I copy the 1 then, I flip every 0 to a 1 and every 1 to a 0 then I just, add the sign.

  - $1{,}023_{ten} = 0000\ 0000\ 0000\ 0000\ 0000\ 0011\ 1111\ 1111_{two}$
  - 1's complement = $1111\ 1111\ 1111\ 1111\ 1111\ 1100\ 0000\ 0000_{two}$
  - 2's (adding 1) =$1111\ 1111\ 1111\ 1111\ 1111\ 1100\ 0000\ 0001_{two}$

(c) $-4{,}000{,}000_{ten}$

- $4{,}000{,}000_{ten} = 0000\ 0000\ 0011\ 1101\ 0000\ 1001\ 0000\ 0000_{two}$
- 1's complement = $1111\ 1111\ 1100\ 0010\ 1111\ 0110\ 1111\ 1111_{two}$
- 2's complement = $1111\ 1111\ 1100\ 0010\ 1111\ 0111\ 0000\ 0000_{two}$

**2**. Write the decimal number represented by each of the following two's complement binary numbers:

(a) $(1111\ 1111\ 1111\ 1111\ 1111\ 1110\ 0000\ 1100)_{two}$
- The sign is negative, change to normal decimal then add the sign.
- $0000\ 0000\ 0000\ 0000\ 0000\ 0001\ 1111\ 0100_{two} = 500_{ten}$
- $1111\ 1111\ 1111\ 1111\ 1111\ 1110\ 0000\ 1100_{two} = -500_{ten}$

(b) $(1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111)_{two}$
- Sign is negative.
- $0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0001_{two} = 1_{ten}$
- $1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111_{two} = -1_{ten}$

(c) $(0111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111)_{two}$
- The sign is positive.
- $0111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111_{two} = 2{,}147{,}483{,}647_{ten}$

**3**.

(a) For the hexadecimal number 0x 7FFF FFFA, what binary number does it represent?
- 0x7FFF FFFA = $0111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1010_{two} = 2{,}147{,}483{,}642_{ten}$

(b) Write the hexadecimal number represented by the following binary number:

$(1100\ 1010\ 1111\ 1110\ 1111\ 1010\ 1100\ 1110)_{two}$
- The sign is negative
- $1100\ 1010\ 1111\ 1110\ 1111\ 1010\ 1100\ 1110_{two}$ = 0xCAFE FACE

**4.** Two friends, Harry and David, are arguing. Harry says, "All integers greater than zero and exactly divisible by six have exactly two 1s in their binary representation." David disagrees. He says, "No, but all such numbers have an even number of 1s in their binary representation." Do you agree with Harry or with David, or with neither? Justify your answer with a proof or counterexamples.
- Both are wrong.
- For example 42 = 101010
- Which proves both of them are wrong since 42 is divisible by 6 and has three 1's in its binary representation.

**5.** Bits in the memory of a computer have no inherent meaning. They mean something only under an interpretation.

Given the bit pattern:

1000 1111 1110 1111 1100 0000 0000 0000

What does it represent under each of the following interpretations?

(a) A two's complement integer?

- The sign is negative.
- 0111 0000 0001 0000 0100 0000 0000 $0000_{two}$ = $1,880,113,152_{ten}$
- 1000 1111 1110 1111 1100 0000 0000 $0000_{two}$ = $-1,880113152_{ten}$

(b) An unsigned integer?

- 1000 1111 1110 1111 1100 0000 0000 $0000_{two}$ = $2,414,854,144_{ten}$

(c) A MIPS instruction?

- The first six bits are the operation code which is $(35)_{ten}$ which is $(100011)_{two}$ which is Load Word (LW rt d(rs))
- The second five bits are (rs) which are $(11111)_{two}$ which are $(-16)_{ten}$
- The third five bits are (rt) which are $(01111)_{two}$ which are $(15)_{ten}$
- The last sixteen bits are (d) which are $(1100\ 0000\ 0000\ 0000)_{two}$ which are $(-16,384)_{ten}$
- (35, -16, 15, -16,384) or (LW 15 -16,384(-16))