CS/COE 0447 Fall 2009
Homework 1
Solution

1. **(5 pts) How many different values can be represented in 11 binary digits (bits)?**

   $2^{11} = 2048$

2. **(5 pts) How many different values can be represented in 13 hex digits?**

   $16^{13} = 4503599627370496$

3. **(5 pts) Convert the following binary numbers to hexadecimal numbers: 1011100001011010, 11100101011000, 1000111111001110, 1100110101010, 100011001000011.**

   1011 1000 0101 1010 = 0xB85A
   11 1001 0101 1000 = 0011 1001 0101 1000 = 0x3958
   1000 1111 1100 1110 = 0x8FCE
   1 1001 1010 1010 = 0001 1001 1010 1010 = 19AA
   100 0110 0100 0011 = 0x4643

4. **(5 pts) Convert the following hexadecimal numbers to binary numbers: 23FF, 7C13, F277, 5F64, F573.**

   0x23FF = 0010 0011 1111 1111
   0x7C13 = 0111 1100 0001 0011
   0xF277 = 1111 0010 0111 0111
   0x5F64 = 0101 1111 0110 0100
   0xF573 = 1111 0101 0111 0011

5. **(10 pts) Translate the following MIPS instructions to machine code (binary). What is the format of each instruction?**

   add $t0, $t0, $zero: 000000 01000 00000 01000 00000 100000 (R-format)
   addi $t1, $t2, 15: 001000 01010 01001 0000000000001111 (I-format)

6. **(10 pts) Translate the following machine code instructions to MIPS assembly. What is the format of each instruction?**

   101011 10000 01011 0000 0000 0000 0100: sw $11, 4($16) or sw $t3, 0($s0) (I-format)
   100011 01000 01000 0000 0000 0100 0000: lw $8, 64($8) or lw $t0, 0($t0) (I-format)

7. **(10 pts) Write MIPS code that subtracts the constant 27 from register $t1 and puts the result in register $t2.**

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addi $t2, $t1, -27
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8. (10 pts) Write MIPS code for the following computation. Assume that variable A is in register $t0, B is in register $t1, C is in register $t2, D is in register $t3, E is in register $t4 and F is in register $t5.
F = E - (A + ((B - C) + D))

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sub $t5, $t1, $t2
add $t5, $t5, $t3
add $t5, $t5, $t0
sub $t5, $t4, $t5
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9. (10 pts) Write down the names of at least 10 devices you see every day that have processors inside.

Laptop, cellphone, mp3 player, car, alarm clock, camera, TV, modem, router, dishwasher ...

10. (10 pts) Give a brief explanation of what an assembler does.

The assembler translates program written in assembly language (a human readable form to write instructions) to machine language (a machine readable form of instructions).

11. (10 pts) Explain briefly what an immediate operand is. Why are immediate operands in MIPS always the same size (16 bits)?

An immediate operand is an operand that is encoded as part of the instruction. To simplfy the decoding of instructions in hardware, MIPS has only three different formats for encoding instructions. All instructions that have an immediate operands use the I-format, which has space to hold a 16 bit immediate operand (the other formats do not have enough space to hold an operand of a useful size). Therefore, all immediate instructions in MIPS use 16 bit immediate values.

12. (10 pts) Why is there no need of a "subtract immediate" instruction?

The addi instruction treats its immediate operand as a signed number. To subtract an immediate value, we can always us the addi instruction with a negative number.