COMP 2421 Computer Organization
Homework 1

Firm Deadline: 11:59 pm, Feb. 19 (Sunday), 2023.
Note: please submit a PDF file with file name: "Name_ID.pdf".

1 Questions with Short Answers [10 pts]

1.1 Suppose we have a number $X = (124)_6$ in a number system with base 6. Write this number in a number system with base 7. [**2 pts**]

1.2 Suppose we use 9 bits to represent numbers in 2's complement form. (1) What's the binary form of decimal value -19? (2) What's the decimal value of the binary number 110101001? [**2 pts**]

1.3 Suppose that we use 4 bits to represent integers in 2's complement form. Consider the following two cases of binary addition. First, calculate the result. Second, decide whether there is overflow and explain why. [**2 pts**]

1) Case 1: $0111 + 1111$
2) Case 2: $1110 + 1000$

1.4 Consider two memory addresses A = 0x00000042 and B = 0x00FA0700. Which address(es) can be used as the address for an instruction? Why? [**2 pts**]

1.5 Using Boolean algebra to simplify this function $f = x'y' + xy + x'y$ such that the result is a sum of two terms and each term contains a single variable or its complement (e.g., x or x'). Show the steps. [**2 pts**]

2 Answering the following two questions about MIPS. You need to explain your answer in detail. [10 pts]

2.1 Consider the following two code blocks A and B. What are the values in $8 after the execution of A and B, respectively? Why? [**4 pts**]

```
Code Block A:
addiu $6, $0, 34
addiu $7, $0, -34
slt $8, $6, $7

Code Block B:
addiu $6, $0, 34
addiu $7, $0, -34
sltu $8, $6, $7
```

2.2 For each of the following two Pseduo-instruction with comment, translate it into actual MIPS instructions as specified in the requirement. [**6 pts**]

```
(1) instruction 1:
addiu $t1, $t2, 0x1234abcd # add a 32-bit constant with $t2,
                           # and store the result in $t1

Requirement: use a sequence of three instructions:
             lui, ori, addu, and another register.

(2) instruction 2:
bgt $t1, $t2, Label  #branch greater than: if $t1 > $t2, branch to Label

Requirement: use a sequence of two instructions:
             slt, bne, and another register $t3.
```

3 Converting C program into MIPS [10 pts]

Suppose we have three variables `a,b,c` that are already stored at the register `$t0`, `$t1`, `$t2`. We also have two arrays `U` and `V`, where each element in the array is a 32-bit unsigned integer. Assume the base address of the array `U` and `V` are stored in registers `$t5` and `$t6`, respectively. Note: the base address of an array `U` is the address of its first element `U`[0].

(1) For this C statement `a = b + c + V[3]`, write MIPS instructions to implement it.

Requirement: use **three instructions in this required order** "`addu`, `lw`, `addu`" to implement it. Store the result in `$t0`. Write comment for each instruction of your code. Ignore any overflow. [**4 pts**]

(2) For this C statement `a = b +U[V[3]]`, write MIPS instructions to implement it.

Requirement: use **five instructions in this required order** "`lw`, `sll`, `addu`, `lw`, `addu`" to implement it. Store the result in `$t0`. Write comment for each instruction of your code. Ignore any overflow. [**6 pts**]

4 MIPS: Understand MIPS Code [20pts]

An array of integers S is defined in the following code. Try to understand the code and answer the following questions.

```
S: .word 14, -29, 18, 30, -12, 12, 106, -7

la $a0, S   # load address of S into $a0; suppose $a0 = 0x20060000
addi $a1, $a0, 28
move $v0, $a0  #move the value of $a0 into $v0
lw $v1, 0($v0)
move $t0, $a0
loop: addi $t0, $t0, 4
lw $t1, 0($t0)
ble $t1, $v1, skip # go to skip if $t1 <= $v1
move $v0, $t0
move $v1, $t1
skip: bne $t0, $a1, loop
```

(1) What flow-control statement does `ble $t1, $v1` implement? [**2 pts**]

(2) To show that you fully understand the function of this program, briefly explain the usage of the following 4 registers in the program. That is, what are these registers used for in the program. For example, for register `$a1`, it stores the address of the last element of array, indicating the end of array. [**4 pts**]

Registers: `$t0, $t1, $v0, $v1`

(3) Briefly explain the usage of the two instructions `move $v0, $t0; move $v1, $t1`. [**4 pts**]

(4) Briefly explain the usage of the instruction `bne $t0, $a1, loop`. [**2 pts**]

(5) Briefly explain the function of this program, suppose the desired outputs of the program are the contents of the registers `$v0` and `$v1`. [**4 pts**]

(6) Determine the contents of the registers `$v0` and `$v1` after executing the code. [**4 pts**]