Computer Architecture Theory + Lab (CS 305/341)
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Assignment 4: MIPS ISA Due Date: 22/09/20
(Theory Assignment 2)

1. What are the MIPS instructions or instruction sequences corresponding to each of the following pseudoinstructions?
   subi, li, mov, la, beqz, , ble, bleu, seq
   seq stands for "set if equal to"

Figure these out yourself, then use the SPIM simulator to verify your answer. Note that there may be multiple answers to each of the above.

Subi:
This pseudoinstruction does not exist. One can simply use addi, with the 2's complement (negative) of the number to be subtracted instead of the original number.

Li:
ori rd, $0, NUM
alternately, for -ve numbers (because of the 32bit sign extended convention)
addi rd, $0, NUM

mov:
mov rd, rs is equivalent to:
or rd , $0, rs
alternately:
add rd, $0, rs

la:
la $t0 , M is equivalent to:
lui $t0, M_higher
ori $t0, $t0 , M_lower

beqz:
beqz $t0, label is equivalent to:
beq $t0 $0 label

ble:
ble $t1 $t2 label is equivalent to:
slt $at $t2 $t1 (at = 1 if *t2 < *t1 hence at = 0 if *t1 <= *t2)
beq $at, $0, label

bleu:
bleu $t1 $t2 label is equivalent to:
sltu $at $t2 $t1 (as simply slt cannot handle unsigned numbers)
beq $at $0 label

seq:

seq $t0 $t1 $t2 is equivalent to:

```
                beq $t1 $t2 load1
                ori $t0 $0, 0
                beq $0 $0 moveon
load1:          ori $t0 $0 1
moveon: ... (moves on to next part of code)
```

2. What is the machine code corresponding to each of the following instructions/pseudoinstructions?
   (Answer should be in hex).

   ```
   sub     $t0, $t7, $s5
   andi   $5, $s5, 89
   sll      $s4, $s4, 3
   bge    $s4, $t1,  300
   lb      $s0, 100($t1)
   ```

   Figure these out yourself, then use the SPIM simulator to verify your answer.

   Sub $t0,$t7,$s5
   000000 01111 10101 01000 00000 100010
   = **01F54022**

   andi $5, $s5, 89
   001100 10101 00101 0000000001011001
   = **32A50059**

   sll $s4, $s4, 3
   000000 00000 10100 10100 00011 000000
   = **0014A0C0**

   bge $s4 $t1 300 =
   slt $at $t1 $s4
   bne $at $0 300 =
   000000 01001 10100 00001 00000 101010   =**0134082A**
   000101 00000 00001 0000000100101100   =**1401012C**

   lb $s0, 100($t1) =
   100000 01001 10000 0000000001100100
   = **81300064**

3. Study the following program carefully, then answer the questions below.

```
        .data
arr:    .space 100
        .text
        .globl main
        main: li        $t0, 0
        li        $t1, 0
```

```
        li      $t4, 0
        li      $t5, 4
        li      $s0, 1
        li      $s1, 1
        li      $s3, 6
        sw      $s1, arr($t1)
go:     addi    $t1, 4
        sw      $s1, arr($t1)
        addi    $t1, 4
        sw      $s1, arr($t1)
here:   addi    $t1, 4
        lw      $t6, arr($t4)
        lw      $t7, arr($t5)
L1:     add     $t6, $t6, $t7
        sw      $t6, arr($t1)
        addi    $t4, 4
        addi    $t5, 4
        addi    $t0, 1
        bne     $t0, $s0, here
L2:     addi    $s0, $s0, 1
        addi    $t4, 4
        addi    $t5, 4
        li      $t0, 0
        bne     $s0, $s3, go
        j       $ra
```

- The machine code corresponding to the instruction at label L1 is

  0x01CF7020
  (00000001110011110111000000100000)

- The number of times the instruction at label L1 is executed is **15** .

- The number of times the instruction at label L2 is executed is **5** .

- Upon program termination, the content of array, arr is
  1 1 1 2 1 1 3 3 1 1 4 6 4 1 1 5 10 10 5 1 1 6 15 20 15

- The content of register t4 is **80 (decimal)** .

- The content of register t6 is **6 (decimal)** .

Figure these out yourself, then use the SPIM simulator to verify your answer