b) For the MIPS assembly instructions in **Problem 2 (a)**, rewrite the assembly code to minimize the number if MIPS instructions (if possible) needed to carry out the same function. **(2 points)**

c) Provide the type, assembly language instruction, and binary representation of instruction described by the following MIPS fields: **(2 points)**

op=0x23, rs=1, rt=2, const=0x4

d) Provide a minimal set of MIPS instructions that may be used to implement the following pseudoinstruction: **(2 points)**

not $t1, $t2 // bit-wise invert

***Problem 3* (10 points)**

a) For the following C statement, what is the corresponding MIPS assembly code? Assume that the variables f, g, h, i, and j are assigned to registers $s0, $s1, $s2, $s3, and $s4, respectively. Assume that the base address of the arrays A and B are in registers $s6 and $s7, respectively. **(2 points)**

B[8] = A[i−j];

b) For the following C statement, write a minimal sequence of MIPS assembly instructions that does the identical operation. Assume $t1 = A, $t2 = B, and $s1 is the base address of C. **(2 points)**

A = C[0] << 4;

c) Translate the following loop into C. Assume that the C-level integer i is held in register $t1, $s2 holds the C-level integer called result, and $s0 holds the base address of the integer MemArray.

(4 points)

```
      addi $t1, $0, $0
LOOP: lw $s1, 0($s0)
      add $s2, $s2, $s1
      addi $s0, $s0, 4
      addi $t1, $t1, 1
      slti $t2, $t1, 100
      bne $t2, $s0, LOOP
```

d) Rewrite the loop in **Problem 3 (c)** to reduce the number of MIPS instructions executed. **(2 points)**

University of Rwanda/College of Science and Technology

Department of Computer and Software Engineering

CAT: COE4161 Embedded Computer Systems Engineering

Date: April 19th, 2024

Duration: 2 hours

Total Points: 30

Problem 1 (10 points)

a) Consider three different processors P1, P2, and P3 executing the same instruction set. P1 has a 3 GHz clock rate and a CPI of 1.5. P2 has a 2.5 GHz clock rate and a CPI of 1.0. P3 has a 4.0 GHz clock rate and has a CPI of 2.2.

i. Which processor has the highest performance expressed in instructions per second? **(2 points)**

ii. If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions. **(2 points)**

iii. We are trying to reduce the execution time by 30% but this leads to an increase of 20% in the CPI. What clock rate should we have to get this time reduction? **(2 points)**

b) Consider the following performance measurements for a program:

Measurement	Computer A	Computer B
Instruction count	10 billion	8 billion
Clock rate	4 GHz	4 GHz
CPI	1.0	1.1

i. Which computer has the higher MIPS rating? **(2 points)**

ii. Which computer is faster? **(2 points)**

Problem 2 (10 points)

a) For the MIPS assembly instructions below, what is the corresponding C statement? Assume that the variables f, g, h, i, and j are assigned to registers $s0, $s1, $s2, $s3, and $s4, respectively. Assume that the base address of the arrays A and B are in registers $s6 and $s7, respectively. **(4 points)**

```
sll $t0, $s0, 2 # $t0 = f * 4
add $t0, $s6, $t0 # $t0 = &A[f]
sll $t1, $s1, 2 # $t1 = g * 4
add $t1, $s7, $t1 # $t1 = &B[g]
lw $s0, 0($t0) # f = A[f]
addi $t2, $t0, 4
lw $t0, 0($t2)
add $t0, $t0, $s0
sw $t0, 0($t1)
```