Lab 2 Solution: Numbers

CS 350: Computer Organization & Assembler Language Programming

Was due Sat Feb 9

Problems

1. \texttt{addi} f, h, -5 \quad (Note: There's no \texttt{subi} instruction: You add a negative constant)
   \texttt{add} f, f, g

2. \( f = g + h + i \)


   \begin{verbatim}
   sub $t0, $s3, $s4  # t0 = i - j
   sll $t0, $t0, 2    # t0 = offset for index i-j
   add $t0, $s6, $t0  # t0 = addr of A[0] + i-j
   lw $t1, 0($t0)     # t1 = A[i-j]
   sw $t1, 32($s7)    # B[8] = A[i-j]
   \end{verbatim}

4. There are many solutions. Four elements of \( A[\ldots] \) have to be changed, so you need at least one temporary variable and at least five assignments total. Here's one solution:

   \begin{verbatim}
   temp = A[0]   # A = \{2, 4, 3, 6, 1\}, temp = 2
   A[2] = temp   # A = \{1, 2, 3, 4, 6\}, temp = 2
   \end{verbatim}

Here's another solution (note it uses 4 temporary locations):

   \begin{verbatim}
   # initially, A = \{2, 4, 3, 6, 1\}
   t0 = A[0];   # t0 = 2
   t1 = A[1];   # t1 = 4
   t3 = A[3];   # t3 = 6
   t4 = A[4];   # t4 = 1
   A[0] = t4;   # A = \{1, 4, 3, 6, 1\}
   A[1] = t0;   # A = \{1, 2, 3, 6, 1\}
   A[3] = t1;   # A = \{1, 2, 3, 4, 1\}
   A[4] = t3;   # A = \{1, 2, 3, 4, 6\}
   \end{verbatim}
5. Again, there are many solutions. Here's one that uses 2 temporary registers (one for A[0] and one for array assignments)

\[
\begin{align*}
&\text{lwx t0, 0($s6) \ # t0 = A[0] = 2} \\
&\text{lwx t1, 16($s6) \ # t1 = A[4]} \\
&\text{swx t1, 0($s6) \ # A[0] = A[4] = 1} \\
&\text{lwx t1, 12($s6) \ # t1 = A[3]} \\
&\text{lwx t1, 4($s6) \ # t1 = A[1]} \\
&\text{swx t0, 8($s6) \ # A[2] = t0 = 2}
\end{align*}
\]

Here's a solution that uses 4 temporary registers (which probably makes it less attractive than the previous solution:

\[
\begin{align*}
&\text{lwx t0, 0($s6) \ # t0 = A[0] = 2} \\
&\text{lwx t1, 4($s6) \ # t1 = A[1] = 4} \\
&\text{lwx t3, 12($s6) \ # t2 = A[3] = 6} \\
&\text{lwx t4, 16($s6) \ # t4 = A[4] = 1} \\
&\text{swx t4, 0($s6) \ # A[0] = 1} \\
&\text{swx t0, 4($s6) \ # A[1] = 2} \\
&\text{swx t1, 12($s6) \ # A[3] = 4} \\
&\text{swx t3, 16($s6) \ # A[4] = 6}
\end{align*}
\]

6. \(110111_2 = 55_{10}\). \(100000_2 = 32_{10}\)

7. (a) In 2's complement, \(-110111_2 = 001001_2\). (b) \(001001_2 = 9_{10}\).

8. (a) In sign-magnitude, \(-110111_2 = 010111_2\). (b) \(010111_2 = 23_{10}\).

9. (a) In 2's complement \(-100000 = -100000\), which represents \(-32_{10}\). (b) In sign-magnitude \(-100000 = 000000\) and is "positive" zero. (It's called that to differentiate it from 000000, which is "negative" zero. Both terms refer to 0 \(\in\mathbb{N}\).

10. \(13 - 30 = 001101 - 011110 = 001101 + 100010 = 101111 = -17\)

11. \(-25 - 7 = -011001 - 000111 = 100111 - 000111 = 100111 + 111001 = 100000 = -32\)